

## Installation, Operation, and Maintenance Guide

### Active Harmonic Filter All Models

This manual covers the recommendations for the installation, operation and maintenance of all Active Harmonic Filter Models. It is emphasized that these abbreviated instructions should be used in conjunction with all local and National codes and should be referenced accordingly.

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The pictures used in this guide are only a representation and may vary from the actual product.

#### Disclaimer of Liability

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\*Note: this guide is  
in English only

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# 1. INTRODUCTION

## 1.1. INTRODUCTION TO THE HPS TRUWAVE AHF

The **HPS TruWave Active Harmonic Filter** (AHF) is an active harmonic filter that filters “undesirable by-product” harmonic currents drawn by 3-phase delta non-linear loads, so the power source (electric utility or on-site generator) does not have to supply them. In addition, the HPS TruWave AHF can also provide “undesirable” reactive fundamental currents drawn by 3-phase delta loads, so they too do not have to be supplied by the power source. The elimination of these “undesirable” current components results in a nearly pure sinusoidal current with a reduced rms magnitude drawn from the power source. This can result in substantial overall power savings, increased reliability of power distribution equipment, and conformance to ANSI/IEEE 519-2014.

The HPS TruWave AHF has several features to easily adapt it to a variety of installations. These include:

- 1) Units may be supplied in Type 1 wall mount or floor mount stand-alone units, or as panel mount units that can be installed in customer specified enclosures.
- 2) Units are small in size allowing easier installation in tight spots.
- 3) Exhibit industry leading high operating efficiency, resulting in reduced power utility costs, reduced air conditioning needs, and higher system reliability.
- 4) Wiring to units can be from either the top or the bottom of the unit.
- 5) Units can be paralleled (up to several units) to provide higher current capacities.
- 6) Units will continue to operate indefinitely if overloaded. If the load draws more harmonic current (and/or reactive current if unit is being relied on to correct linear displacement as well as harmonic currents) than the unit is rated for, unit will electronically self-limit its correction current to its rated capacity. The excess harmonic or reactive current that is beyond its rated current would come from the utility.
- 7) External Current Transformers (CTs) come in a variety of shapes and sizes, and can be installed on either the line or load side. Note: paralleled AHFs must have CTs installed on the load side.
- 8) A large amount of operating information and several operator configurable parameters can be communicated with the unit in multiple ways:
  - Via the 7” diagonal 800x480 Full Color resistive touch screen display.
  - From a computer using Ethernet.
  - Over an Ethernet/IP or MODBUS/TCP industrial Ethernet network.
- 9) The ability to disable a unit from running via the touch-screen display, via Ethernet communications, or with an externally generated dry contact.
- 10) Systems save “historical” operational information in non-volatile flash memory to greatly assist in diagnosing a problem (both internal and external to the unit), should one occur.

Later sections of this manual contain details of how to take advantage of these features.

## 1.2. INTRODUCTION TO HARMONIC CURRENTS

Electronic equipment and controls, such as computers, computer peripherals, AC and DC motor drives and many other commonly used electronic hardware in the market place today, can overburden the electric utilities with various harmonic distortions. Such equipment (referred to as nonlinear loads) is characterized by high current crest factors (C.F.) and low power factor (P.F.). Such loads are referred to as non-linear because they draw harmonic currents in addition to the fundamental current. The

fundamental current is at the same frequency (e.g. 60 Hz) as the voltage supply. These harmonic currents drawn by 3-phase loads are at integer multiples (predominantly odd integer multiples, not divisible by 3) of the fundamental frequency, and are superimposed onto the fundamental current. Examples of these harmonic currents in a 60 Hz supply are the 5<sup>th</sup> harmonic (at 300 Hz frequency), 7<sup>th</sup> (420 Hz), 11<sup>th</sup> (660 Hz), 13<sup>th</sup> (780 Hz), etc. Since these current components are at a different frequency than the 60 Hz voltage supply, they do not contribute at all to the useful work done by the load. These “extra” harmonic current components have the following adverse effects on the power grid that has to supply them:

- 1) Harmonic currents cause distortion in the voltage signal. This voltage distortion can result in adverse effects on other loads powered from the grid, especially equipment that expects to see a sine-wave voltage. For example, the distorted voltage could cause AC motors powered directly from the grid to have higher losses and possibly experience torque pulsations.
- 2) The total rms current drawn from the power grid is increased. The increased current will increase the losses in transmission lines, transformers, breakers, etc. that supply the nonlinear loads. These undesirable harmonic currents are at much higher frequencies than the useful fundamental current these components are designed for. Higher frequency currents cause disproportionately higher losses than the fundamental current, especially in transformers, thus placing a much higher burden on those components. These extra “transmission” losses will cause extra heating along the transmission path, resulting in additional cost due to “lost” power and premature failures in the transmission equipment.

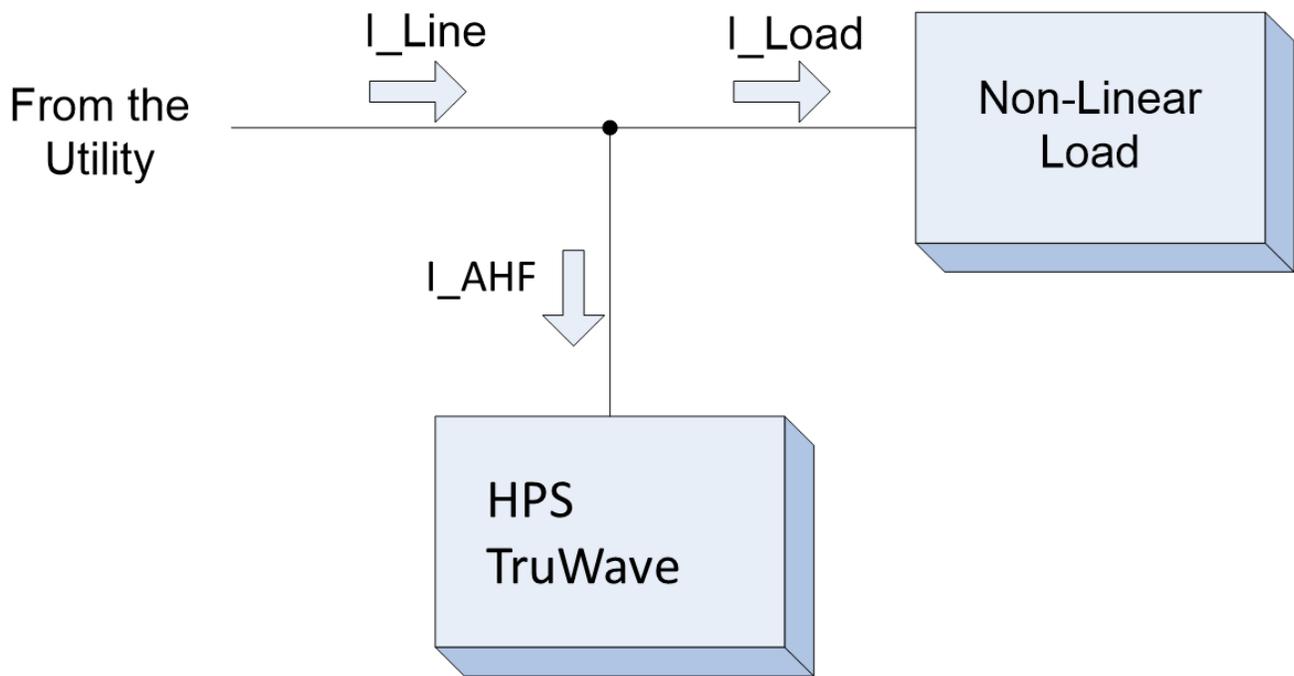
To combat this additional cost, electric utilities are using more sophisticated metering equipment to monitor for harmonics in addition to the traditional power usage and displacement power factor monitoring. This can result in substantial penalty charges on a plant's electric bill, or in some cases being dropped from the grid until the problem is corrected. Power consultants, computer and communications specialists are therefore compelled to include in their specifications compliance to ANSI/IEEE 519-2014 stringent requirements, which define the maximum amount of harmonic distortion that newly installed equipment and controls are allowed to inject into the utility lines.

Many approaches have been devised in the past, aimed to minimize the harmonic distortion. Special zigzag transformers, phase shift transformers, and passive filters have all brought some type of harmonic relief, but not without severe limitations. Since the generated harmonics are a function of the actual load, and can vary during the course of the operation, it is very difficult to design such a filter in advance, which will cover any and all loads (both present and future) and the corresponding harmonic conditions.

### 1.3. HOW THE HPS TRUWAVE AHF WORKS

Unlike the passive harmonic correction methods listed in the previous section, the **HPS TruWave Active Harmonic Filter** (AHF) is a true active filter. Its design does not necessitate extensive knowledge regarding the harmonic profile of the load or electrical characteristics of the environment. Only the Total Current Distortion and phase displacement are required in sizing the AHF to an existing or proposed non-linear load.

The HPS TruWave AHF is wired in parallel with the loads it is correcting the harmonics and/or correcting linear power factor for. Since it is in parallel with the load, and not in series with the load, as is required for many other harmonic correction methods, the AHF can be turned off for maintenance or repair without affecting the operation of the load. A simplified 1-line diagram of an AHF correcting a Non-linear load is shown in Figure 1.1. Without the AHF present, the current drawn by the load ( $I_{Load}$ ) is supplied totally by the utility ( $I_{Line}$ ). In this case  $I_{Line} = I_{Load}$ , so whatever undesirable harmonic and/or reactive currents the Non-linear load draws must come from the utility.



**Figure 1.1: Simplified 1-line Diagram of an AHF Installation**

An AHF installed in parallel with the load changes the situation. The AHF provides a path for these undesirable harmonic and/or reactive currents, so the utility no longer needs to supply them. In Figure 1.1 the AHF draws a current  $I_{AHF}$  which is effectively the opposite of those undesirable currents drawn by the load. Since  $I_{Line} = I_{Load} + I_{AHF}$ , the resultant  $I_{Line}$  current coming from the utility consists primarily of just the “useful” in-phase fundamental portion of the current drawn by the load.

Figure 1.2, Figure 1.3, and Figure 1.4 that follow are current waveforms taken from a system that consists of a very harsh 3-phase non-linear load (similar to a motor drive with very little DC choke or AC line reactor inductance) and a 300 amp HPS TruWave AHF powered from 3-phase, 480 Vac, 60 Hz utility power. Only the current of one of the three phases is shown for simplicity; however, the other 2 phases are very similar to this phase. The load is drawing harmonic currents that are between 60 and 65% of the total load current. This is referred to as having a current THDR (Total harmonic distortion in reference to total rms) of between 60 and 65%. Most non-linear loads will have higher inductance in their input circuitry, resulting in a much lower THDR of between 30 and 40%, and thus easier to correct for; however, this very harsh load was selected to demonstrate how effective the HPS TruWave AHF is in correcting harmonic currents. To correct this load current, the 300 amp AHF is utilizing about 2/3 of its 300-amp capacity or about 200 amps of correction.

Figure 1.2 shows the load current over two 60 Hz periods. The load, having a rectifier bridge at its input to convert the AC voltage to a DC voltage, draws high peak currents instead of a nice sine-wave current. The difference between the waveform displayed and a sine-wave are made up of the harmonic currents (5<sup>th</sup>, 7<sup>th</sup>, 11<sup>th</sup>, 13<sup>th</sup>, etc. harmonics). The primary task of the AHF is to draw current that is equal and opposite to these harmonic currents, so the resultant current supplied by the utility does not need to provide them. Figure 1.3 shows the current drawn by the AHF. At the start of the waveform, the AHF draws current from the line, reaching a peak of about 250 amps. During this time, the load is drawing no current. Then the load draws a spike of current reaching a peak of 650 amps. During this time, the AHF draws the opposite of this spike in order to cancel its affect. Figure 1.4 shows the resultant  $I_{Line}$  current ( $I_{Load} + I_{AHF}$ ) drawn from the utility – the desired sine-wave with the harmonic currents reduced to a little over 3%. Without the AHF, the current from the utility would look like the  $I_{Load}$  current waveform. Since we’ve effectively removed the harmonic current components from the line current, the line current is reduced to 260 amps rms even though the load current is at about 325 amps rms. The power factor of the line improved from about 0.8 to more than 0.99.

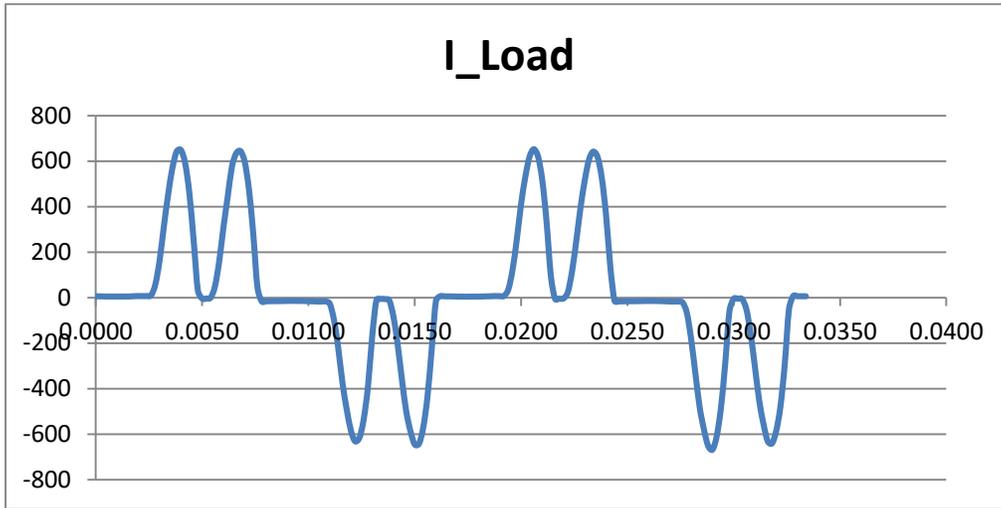


Figure 1.2: Load Current Waveform

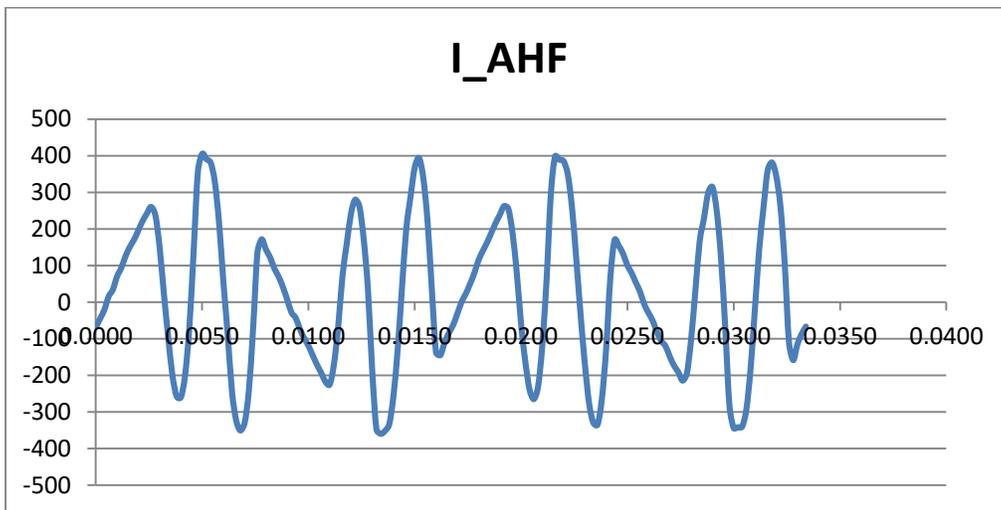


Figure 1.3: AHF Current Waveform

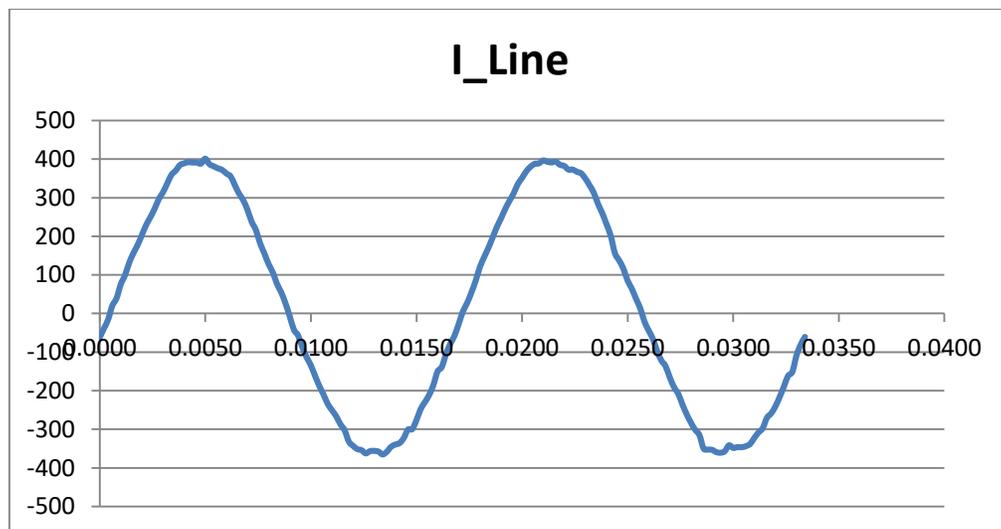


Figure 1.4: Line Current Waveform

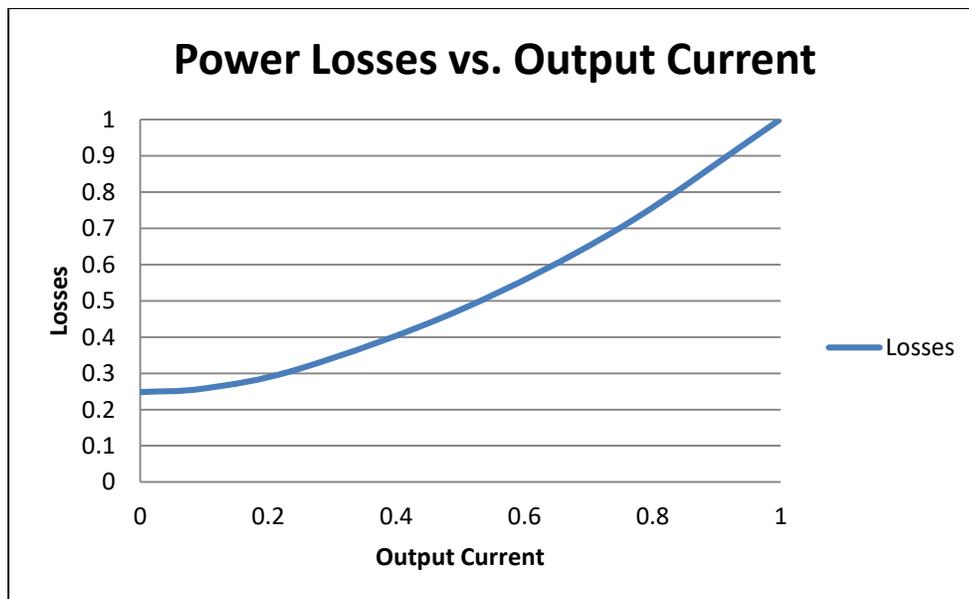
The HPS TruWave AHF uses a four quadrant inverter, utilizing a modulation frequency of many thousand cycles per second, to produce the current waveform shown in Figure 1.3 that accurately cancels the currents drawn by the load so that the utility doesn't have to supply them. The AHF uses a sophisticated hybrid control that uses a combination of fast immediate response along with information stored from the recent past to accomplish the extremely fast current changes needed. In the example waveforms for the harsh 60-65% harmonic load just examined, the AHF had to change its current output at times as much as 500 amps in .0005 seconds to cancel the harmonic currents drawn by this load.

Another advantage of an Active Harmonic Filter over passive solutions is that if the harmonic currents present exceed the capabilities of the Active Filter, it simply limits its corrective current to its rating by adjusting its control. The remaining harmonic current that is beyond the rating of the Active Filter then must be supplied by the utility. The Passive Filter has no means to limit itself; therefore the currents increase until the circuit protection breakers trip or fuses open. If the Passive Filter is in series with the load, the load goes down with the filter.

#### 1.4. POWER SAVING FEATURES OF THE HPS TRUWAVE AHF

Not only does the HPS TruWave AHF have extremely high performance, but it achieves it at industry leading power efficiency. A 300 Amp AHF operating at full capacity of cancelling 300 amps of harmonics on all 3 lines typically dissipates 5100 watts of power. Other Active Harmonic Filter systems on the market dissipate as much as an additional 5000 watts or more under the same conditions. A HPS TruWave unit operating 24/7 at these conditions results in almost 44,000 KW-hrs less in power losses in a year. At an average rate of 10 cents per KWH, this represents a savings of \$4,400 in utility costs in a year. Of course, you may not need the full rated capabilities of the AHF 24/7. In the case of a system operating at less than full operating capacity, the HPS TruWave AHF still offers industry leading efficiencies.

**Figure 1.5** shows typical Losses vs. Output Current. In this graph, the horizontal axis shows the Output Current of an AHF normalized to the full load current (e.g. for a 300 amp AHF, 1 represents 300 amps, 0.5 represents 150 amps, etc.). The vertical axis shows the Losses of an AHF normalized to the full load losses (e.g. for a 300 amp AHF, 1 represents 5100 watts, 0.5 represents 2550 watts, etc.). This graph shows that a system operating at 50% of the rated current will have about 50% of the full rated power losses.



**Figure 1.5: Power Losses vs. Output Current**

There is also the case where a facility may shut down for several hours in a day. As can be seen in **Figure 1.5** there are appreciable losses when no corrective current is being supplied by the AHF. Such losses in the HPS TruWave AHF are lower than the industry norm for active harmonic filters; however,

they do represent losses for doing little or no useful current correction. For such a condition, HPS offers a power saving mode that can be programmed by an operator via the front panel or over the Ethernet link. If this feature is selected, when the load is shut off or greatly reduced, the AHF will shut off its power inverter and cooling fans, but keep its internal components charged and ready to go. When the load returns, the system will automatically start full operation within a fraction of a second (no initialization or pre-charging cycle required). While in this "idle" state, the system's losses are reduced to less than 100 watts for all models. The Front Panel will display "IDLE" as the control mode while in this state. To utilize this power saving mode, should your facility have significant periods of time when the load the AHF is correcting for is shut off, see the "UNIT DISABLED IF LOAD POWER BELOW THIS %" parameter in section **Error! Reference source not found..1** of this manual for information on setting up this feature.

## 2. SAFETY PRECAUTIONS

This equipment should be installed, operated and maintained only by **qualified personnel**. The only time that the unit should be opened is for initial installation or routine maintenance. The following warnings apply to the equipment and should be read and fully understood by qualified personnel before they begin working on the unit:

### WARNING

Risk of Electric Shock exists inside the Active Harmonic Filter (AHF) enclosure. The AC Disconnect should be in the OFF position for 5 minutes prior to opening the door of the unit. For additional safety, if possible, the external AC breaker feeding the AHF should also be locked in the OFF position. If not, the top terminals of the disconnect inside the unit will be electrically hot, and must be avoided. Even with the disconnect turned off, hazardous voltages may exist within the unit for several minutes after the disconnect is turned off. **THESE HAZARDOUS VOLTAGES REPRESENT A POSSIBLE SHOCK HAZARD THAT COULD RESULT IN DEATH OR INJURY TO PERSONNEL.**

### WARNING

Always keep the front door closed and locking screws in the locked position. Leaving the unit's door open may expose personnel to an electrical shock hazard that could result in death or injury, or damage to the equipment. The AC Disconnect **MUST** remain in the OFF position at all times while the door to the system is open. Turning the AC Disconnect on after the door has been opened will result in hazardous voltages being present at many locations within the unit. **SUCH HAZARDOUS VOLTAGES COULD CAUSE ELECTRIC SHOCK THAT COULD RESULT IN DEATH OR INJURY.**

### WARNING

The Active Harmonic Filter (AHF) contains capacitive components that remain energized for several minutes after power to the AHF has been removed. The AC disconnect should be in the OFF position for 5 minutes prior to opening the door of the unit. Of particular interest are the large can capacitors mounted in front of the heat sink. Two red lights mounted on the High Voltage Interface PC Board indicate if these capacitors are charged to hazardous levels. If either of these two red lights is lit, potentially deadly voltage exists on these capacitors. While these capacitors are charged, hazardous voltage exists in several places within the unit (including, but not limited to all DC filter capacitors; bus bars associated with the capacitors; the components on the heatsink; several other components located on the back panel; and the High Voltage Interface PC Board). The capacitors have circuits to discharge them. Do not proceed into the unit until the capacitors have been sufficiently discharged, signified by both red lights being off. Once the red lights are off, carefully measure the voltage across a far left capacitor and the capacitor directly to the right of that capacitor using a DC voltmeter, making sure you do not come in contact with any other metal objects within the cabinet. Make certain that both voltages you have measured are below 10 vdc before proceeding within the cabinet.

### WARNING

Do not rely entirely on the red lights for safety. A failure in the lights or circuits that drive the lights could result in no lights being lit when a hazardous voltage exists. However, never proceed into the unit if the lights are on. Always use a DC voltmeter to measure the actual capacitor voltage once the lights are dim or off. Do not come in contact with any metal objects that are not grounded to the frame while making this measurement.

 **WARNING**

Do not open the output circuit of a current transformer (CT) unless the circuit the CT monitoring is de-energized or the CT has been physically removed from the circuit. This includes not removing any connections from, or the connectors themselves from P1 or P2 of the CT Interface boards inside the AHFs. Opening the output circuit of a CT could result in very high voltage that can cause the CT to fail and represent an extremely dangerous condition to personnel. Exception: If CTs are first connected to a shorting terminal block prior to being wired to an AHF, and shorts are applied across each CT's pair of output wires on that block, then CT related wiring continuing from the block to the AHF may be opened without harm.

### 3. INSTALLATION

This section contains instructions for installing self-contained type 1 enclosed wall-mount or floor-mount AHFs, or installing open panels inside an industrial enclosure. Type 1 enclosed systems are identified by a letter A suffix in the model number and open panel systems are identified by a letter F suffix in the model number (e.g. WAHF1K050A is a 50 amp, 480-volt type 1 enclosed system. An open panel system would simply substitute the letter A with a letter F).

During the installation, please find and consult in section 10 of this manual the drawings pertaining to your particular system. Section 3.1 should be consulted for all systems. Consult Section 3.2 if installing a type 1 enclosed system or Section 3.3 if installing a panel inside your own enclosure. Section 3.4 is to be consulted for all systems and contains instructions for connecting the power wires and external current transformers (CTs) to your AHF. Finally, Section 3.5 contains information about using and connecting to optional control inputs & outputs.

#### 3.1. PRE-INSTALLATION PLANNING

Prior to installation and even procuring a HPS TruWave AHF, perform the following checklist:

- Make sure that the voltage rating of the HPS TruWave AHF matches the voltage rating of the AC power driving the loads.
- Make sure that the current rating of the HPS TruWave AHF is adequate to correct enough of the harmonics (and reactive currents if so desired) drawn by the load to reduce these undesirable current components to the necessary levels. Multiple AHFs can be installed in parallel to increase the corrective current capability. Also, if there is room for external line reactors to be installed in front of the non-linear loads, and adding such reactors is cost effective, the additional inductance provided by such reactors will reduce the harmonic currents drawn by the loads, which may result in a lower number of AHFs required or a smaller sized AHF needed.
- The CTs need to be selected. CT current ratios are specified as  $n/5$  where 5 represents 5 amps of output current when “n” amps of current is being monitored. “n” should be chosen so that it is greater than or equal to the maximum rms of the current that can flow in the wire being monitored. Usually, select “n” to be equal to or greater than the breaker rating protecting that wire. There exist conditions, such as CT wiring distance, that may warrant a higher “n” value being chosen. Refer to section 3.4 for additional information. If using flexible CTs from HPS, “n” should normally be at least 600, as CTs with ratios less than 600/5 have lower accuracy and are difficult to extend the lead wires due to their low VA power capability. If using other CTs, the CTs should be “meter” grade or at least be capable of accurately reading 400 Hz current. The tradeoff of using higher current ratios CTs will be reduced resolution of the current produced by the CT (e.g. a 2000/5 CT produces only half of the signal that a 1000/5 CT produces). However, the HPS TruWave AHF is designed with excellent current resolution. Even 50 amp AHFs have been shown to operate well with 2000/5 CTs. At all times, the “n” value in the  $n/5$  ratio should never be less than the maximum rms current that can flow in the wires being monitored by the CTs.
- Units should be installed where they will NOT be exposed to rain or dripping liquids, corrosive gases or liquids, conductive airborne particles, or excessive dirt and dust.
- Make sure the space allocated for the unit(s) is adequate to accommodate the dimensions of the unit while maintaining the necessary clearances around the unit as specified in a later section.
- The ambient temperature where the unit(s) is to be placed should be maintained between 0 and 40°C. It is possible to operate the systems in temperatures that exceed this range; however, de-rating and other means may need to be implemented which will require contacting the factory for assistance.

If air conditioning is needed to cool the room where the unit is to be installed, make sure the power losses of the unit are incorporated into the air conditioning needs. Power losses of the unit at full

load can be found in the specifications for the unit. In addition, if the unit will operate at less than full load,

- **Figure 1.5** can be used in conjunction with the full load loss information to determine actual power losses.
- Determine number of, model of, and eventual placement of Current Transformers (CTs) that will be needed with the AHF(s). This is highly dependent on how the AHF(s) will be installed as discussed in following sections of this manual.

The HPS TruWave AHF works very well with a variety of loads; however, there are some instances where special considerations are needed:

- If line-to-neutral loads exist along with the 3-phase loads, external CTs monitoring all 3 line phases may be needed instead of the usual 2. If line-to-neutral loads draw appreciable current (more than 25% of the rated AHF current) through the neutral, some or all of those loads may need to be removed from the current that the CTs monitor. If you think this is a possible issue, contact the factory for assistance.
- Make sure there are no power factor corrective capacitors, passive filters (other than simple line reactors), harmonic trap filters, or other equipment containing sizable AC capacitor components in the load. Small amounts of line-to-line AC capacitance (e.g. used for emc reduction in some equipment) are acceptable. If you believe this is a possible issue, contact the factory for assistance.
- If operating from a generator or other high impedance source, sizable phase controlled loads (e.g. soft starters, some DC drives, etc.) may present a challenge. Also, very large types of these loads from even lower impedance sources may also present a challenge. If such loads are present, contact the factory for assistance.

### 3.2. PLACING AND WIRING A TYPE 1 ENCLOSED HPS TRUWAVE AHF

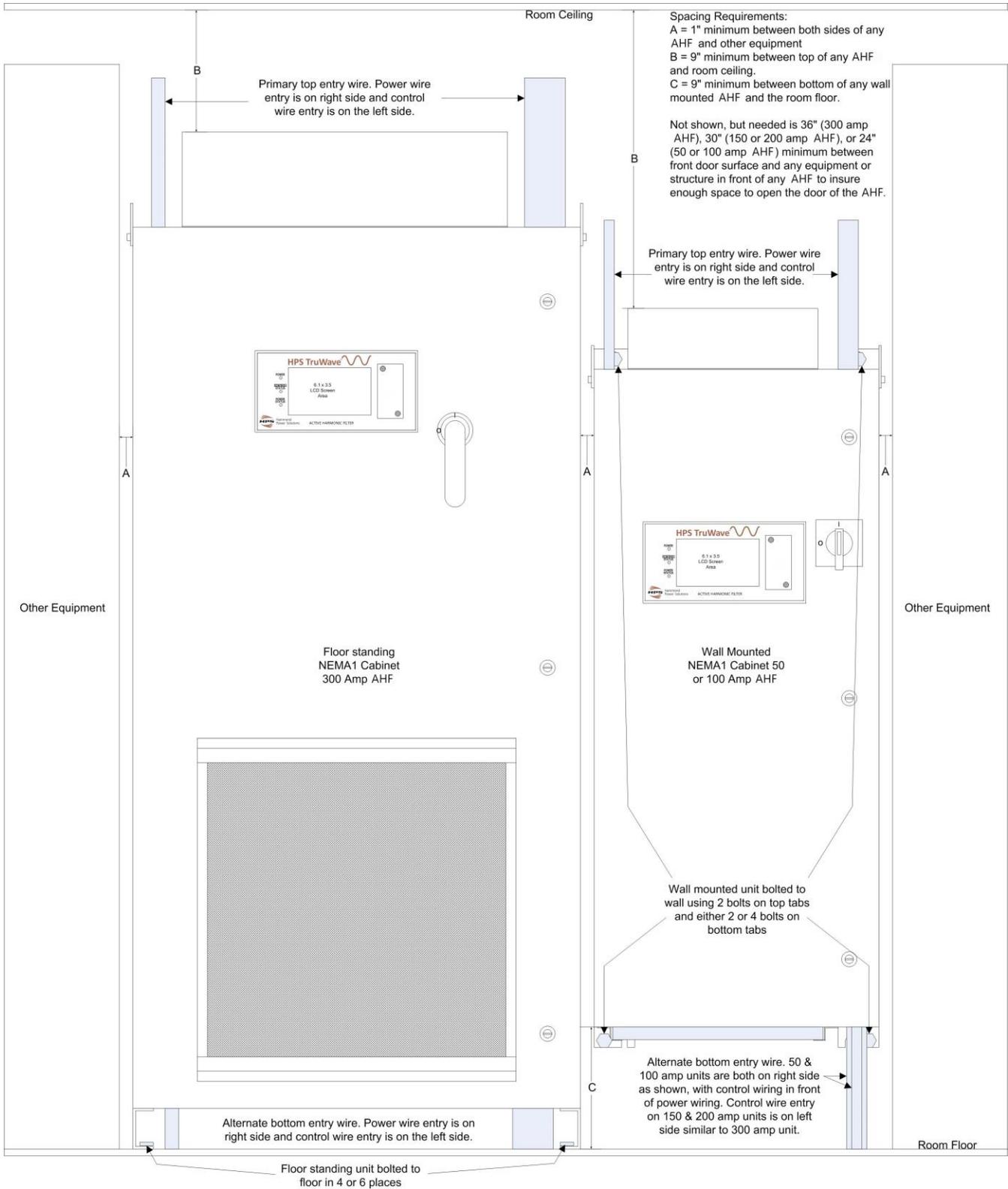
**This equipment should only be installed by qualified personnel that have been trained to work with potentially hazardous voltages and associated electrical equipment.**

The Type 1 enclosed AHF may be placed in an industrial environment that is protected from water, metal filings or other conductive impurities and corrosive chemicals. The area should not be subjected to an overwhelming amount of dust or dirt; otherwise, frequent cleaning of the system and replacement of the input air filter will be required.

Wall mounted systems must be mounted to a sturdy wall. They have 2 tabs on the top and 2 tabs on the bottom of the unit, on the back of the enclosure for bolting the unit to the wall. If a sturdy wall is not available, as an alternative, wall mounted systems may be bolted to a stand. Units bolted to a floor stand and floor-standing units (300 Amp AHFs) must be placed on a level surface. To provide mechanical stability, either the stand or floor-standing unit should be bolted to the floor using the holes provided, or the unit should otherwise be secured to insure the unit cannot tip over.

The wall-mounted units should be mounted so that there is a gap of at least 9" between the bottom of the enclosure and the floor. This distance is necessary to insure sufficient airflow into the box from the bottom. All units need a minimum of 9 inches of clearance between the top of the enclosure and any significant obstructions to allow adequate airflow out of the top of the box. The box should be positioned so that AC, chassis ground, and control wires can readily enter the top or bottom of the box on the right and left sides, indicated in the wiring instructions that follow. A minimum of 36" for a 300 amp, 30" for a 150 or 200 amp, and 24" for a 50 or 100 amp AHF of clearance in front of the unit is necessary to allow opening the door sufficiently to service the unit. A minimum of 1 inch of clearance is required on the left and right sides of all units.

Power wiring (consisting of conductors for the 3 phases and a chassis grounding wire) may enter the cabinet from either the top or the bottom of the enclosure. Top entry is preferred, but bottom entry is also acceptable. Wire sizes and conduit needs should be selected referring to Table 3.1 and to applicable electrical codes. Any power or ground wire selected that is larger than 3 awg should be derated, according to National Electric Code, to allow for the high frequency (400Hz) current produced by the AHF. CT wiring (and other optional control wiring) can also enter the cabinet from either the top or bottom of the enclosure. Again, top entry is preferred, but bottom entry is also acceptable. Figure 3.1 reviews all of the clearance specifications and shows top and bottom wire entry options into the enclosures.



**Figure 3.1: Installation Showing Clearances and Wire Entry**

Pilot holes exist where the entrance to the enclosure for all wiring is to occur. These pilot holes can be enlarged, using a standard punch, to accommodate conduit fittings for the power and/or CT wiring to be used. Drilling or filing should be avoided, as any metal particles that fall inside the unit could interfere with

the operation of the electrical/electronic components of the system. Although the Type 1 enclosed AHFs have UL listed power fuses and a disconnect switch, electrical codes will probably require a 3-phase breaker or a fused disconnect at the point 3-phase power is tapped for the AHF to protect the wiring between the tapped point and the AHF. Table 3.1 includes power wiring information for all Type 1 packaged AHFs. The 2<sup>nd</sup> column contains the rating of the internal power fuses, which is also the recommended rating of the external feeder breaker or fuses to use.

The 3<sup>rd</sup> column shows the maximum size wire that the unit can accommodate. In the case of the 300 amp system, if conductors larger than 300kcmil need to be used, 2 equal sized conductors (each up to 300kcmil in size) must be used for each phase instead of a single very large conductor. The 300 amp AHF power switch requires the wires to be terminated with ring-type terminals. If using more than one conductor per phase, one wire gets bolted to the front of the switch terminal and the 2<sup>nd</sup> wire to the back of the switch terminal. All other units use one wire (with no terminal) per phase.

If electrical code requires the wires to be housed within conduit, the 4<sup>th</sup> and 5<sup>th</sup> columns show the maximum amount the diameter that any conduit hardware can occupy before that hardware could start to interfere with enclosure items. The 4<sup>th</sup> column is for wires/conduit entering from the top and the 5<sup>th</sup> column is for wires/conduit entering from the bottom of the enclosure. These dimensions assume that the pilot hole is enlarged so that the center of the enlarged hole is the same as the center of the original pilot hole. Slightly less room is available when using bottom entry for units up to 200 amps because of the bottom mounted filter on those units. The 6<sup>th</sup> column indicates the maximum conduit trade size that “should” be able to be used without the conduit hardware interfering with enclosure items. The conduit size shown again assumes concentrically enlarged pilot holes and use of “standard” conduit hardware. Before settling on a conduit size, make sure all of the conduit hardware will fit within the diameter shown in column 4 or 5. For the 300 amp AHF, 2 conduit pilot holes are provided on both the top and bottom of the unit for the power wiring. The 7<sup>th</sup> column indicates the torque needed to properly tighten the power wires to the power switch. The 8<sup>th</sup> column indicates the torque needed to bolt the power fuses to the blocks.

The following sub-sections provide details about wire entry into and within the enclosure for the 3 different enclosure sizes: 50 or 100 amp, 150 or 200 amp, and 300 amp systems. Refer to section 3.4 for details of where to connect the power wires and the CT wires.

AHF Size (Amps)	Circuit breaker or fused current rating	Maximum Wire Gage (Use 75C or equiv. copper wire only)	Max. Conduit hardware Dia. box allows		Maximum Conduit Size*	Torque (in-lbs)	
			Top Entry	Bottom Entry		Power Switch	Bolts for power fuses
50	70	1/0	4.3"	3.8"	2 ½ - 3	27	72
100	125	3/0	4.3"	3.8"	2 ½ - 3	132	132
150	200	250kcmil	4.8"	4.5"	3 - 3 ½	132	132
200	250	250kcmil	4.8"	4.5"	3 - 3 ½	228	228
300	400	2 conductors, each 300kcmil max	5.0"	5.0"	3 ½ - 4	228	228

\*Make sure conduit hardware will fit in “Max. Conduit hardware Dia. box allows” for your unit.

**Table 3.1: Type 1 Enclosure Power Wiring Information**

**3.2.1. WIRING A 50 OR 100 AMP TYPE 1 ENCLOSED AHF**

Figure 3.2 shows the position of the pilot holes in the top of the 50 or 100 amp AHF enclosure when using top entry into the enclosure for both the power and CT wiring (and possibly other optional control wiring). Top entry is preferred over bottom entry because the wiring for both the power and CTs is a direct shot. The 1.125" diameter pilot hole on the right side is for the 3 power wires and the chassis ground, and is large enough for ¾" conduit. This will have to be enlarged to the size needed to meet the electrical code using a punch. Care should be taken that no metal shavings are allowed to fall into the interior of the enclosure when using the punch. The punch should be centered within the pilot hole to

insure that the new hole has its center in the same place. Failing to center the punch may result in less space being available for conduit mounting hardware. Power wires will be connected, in almost a straight shot, from this opening to the top terminals of the power switch. The chassis ground wire should be terminated to a ¼" ring terminal or similar. A ¼-20 stud is available inside the upper right side of the cabinet for connecting this chassis ground wire.

The 7/8" diameter pilot hole on the left side is for CT wiring (and possibly other optional control wiring) to enter the box, and is large enough for ½" conduit. If necessary, this hole can also be enlarged using a punch to accommodate a larger conduit size. CT wiring will be connected, in almost a straight shot, from this opening to the green P1 connector on the CT Interface PC board.

Figure 3.3 shows the position of the pilot holes in the bottom of the 50 or 100 amp AHF enclosure when using bottom entry into the enclosure for both the power and CT wiring (and possibly other optional control wiring). If using bottom entry power wiring, the back 7/8" pilot hole on the right side of the bottom will need to be enlarged with a punch to the size needed. The power wires and chassis ground should be routed from this enlarged opening as follows. The chassis ground wire should be terminated to a ¼" ring terminal or similar. A ¼-20 stud is available inside the lower right side of the cabinet for connecting this chassis ground wire. The power wires should be routed up the right side of the rear of the enclosure to beyond the top of the power switch. Utilize the space above the power switch to bend the wires so they may be connected into the top terminals of the switch. Figure 3.8 shows the power wire routing in a 300 amp AHF. The internal power wire routing is similar for the 50 or 100-amp unit as well.

On the way up to the power switch, the power wires need to pass behind the "Divider panel" within the unit. The section above this panel has warmer air that will be exhausted out the top of the enclosure, while the section below this panel has cooler air drawn in through the unit's air filter. This panel acts as a barrier to prevent the warm air remixing with the cooler input air. Figure 3.9 shows a top view of this divider. To make room for the power wires to pass, a section "B", of the rubber insulation material will have to be removed. In addition, a portion of the insulating piece "A (right)", marked "C" in the figure may need to be trimmed off. If so, remove screw holding "A (right)", trim only enough off the end indicated by "C" in the figure using tin-snips or heavy-duty scissors, then re-attach "A (right)" with the screw.

The front 7/8" diameter pilot hole on the right side of the bottom is for CT wiring (and possibly other optional control wiring), and is large enough for ½" conduit. If necessary, this hole can also be enlarged using a punch to accommodate a larger conduit size. CT wiring should be immediately routed over to the internal left side and up the left side of the rear of the enclosure to the CT Interface board. This path is very similar to the one shown in Figure 3.8, except the pilot hole for the CT Interface wires is on the right side of the bottom in the 50 or 100 amp AHF and on the left side on the bottom in the 300 amp AHF. A portion of the rubber insulation, marked "D" in Figure 3.9, will need to be removed to accommodate the wiring to pass behind the "Divider Panel".

Any optional control wires can be either routed on the left side of the back panel, up to the top of the unit for top entry or down to the bottom for bottom entry similar to what is shown in Figure 3.8. The CT and optional control wires should not enter/exit the enclosure through the same hole as the power wiring. The optional control wires may enter/exit the enclosure through a different hole than the CT wiring. Neither the CT or optional control wires have to enter the same end (top or bottom) that the power wiring enters.

Units equipped with floor stands do not normally have bottom entry for wiring as a possibility. Consult the factory beforehand if bottom entry for a system to be equipped with a floor stand is needed.

### 3.2.2. WIRING A 150 OR 200 AMP TYPE 1 ENCLOSED AHF

Figure 3.4 shows the position of the pilot holes in the top of the 150 or 200 amp AHF enclosure when using top entry into the enclosure for both the power and CT wiring (and possibly other optional control wiring). Top entry is preferred over bottom entry because the wiring for both the power and CTs is a direct shot. The 1.375" diameter pilot hole on the right side is for the 3 power wires and the chassis ground, and is large enough for 1" conduit. This will have to be enlarged to the size needed to meet the electrical code using a punch. Care should be taken that no metal shavings are allowed to fall into the interior of the enclosure when using the punch. The punch should be centered within the pilot hole to insure that the new hole has its center in the same place. Failing to center the punch may result in less space being available for conduit mounting hardware. Power wires will be connected, in almost a straight shot, from this opening to the top terminals of the power switch. The chassis ground wire should be terminated to a ¼" ring terminal or similar. A ¼-20 stud is available inside the upper right side of the cabinet for connecting this chassis ground wire.

The 7/8" diameter pilot hole on the left side is for CT wiring (and possibly other optional control wiring) to enter the box, and is large enough for ½" conduit. If necessary, this hole can also be enlarged using a punch to accommodate a larger conduit size. CT wiring will be connected, in almost a straight shot, from this opening to the green P1 connector on the CT Interface PC board.

Figure 3.5 shows the position of the pilot holes in the bottom of the 150 or 200 amp AHF enclosure when using bottom entry into the enclosure for both the power and CT wiring (and possibly other optional control wiring). If using bottom entry power wiring, the 7/8" pilot hole on the right side of the bottom will need to be enlarged with a punch to the size needed. The power wires and chassis ground should be routed from this enlarged opening as follows. The chassis ground wire should be terminated to a ¼" ring terminal or similar. A ¼-20 stud is available inside the lower right side of the cabinet for connecting this chassis ground wire. The power wires should be routed up the right side of the rear of the enclosure to beyond the top of the power switch. Utilize the space above the power switch to bend the wires so they may be connected into the top terminals of the switch. Figure 3.8 shows the power wire routing in a 300 amp AHF. The internal power wire routing is similar for the 150 or 200 amp unit as well.

On the way up to the power switch, the power wires need to pass behind the "Divider panel" within the unit. The section above this panel has warmer air that will be exhausted out the top of the enclosure, while the section below this panel has cooler air drawn in through the unit's air filter. This panel acts as a barrier to prevent the warm air remixing with the cooler input air. Figure 3.10 shows a top view of this divider. To make room for the power wires to pass, a section "B", of the rubber insulation material will have to be removed. In addition, a portion of the insulating piece "A (right)", marked "C" in the figure may need to be trimmed off. If so, remove screw holding "A (right)", trim only enough off the end indicated by "C" in the figure using tin-snips or heavy-duty scissors, then re-attach "A (right)" with the screw.

The 7/8" diameter pilot hole on the left side of the bottom is for CT wiring (and possibly other optional control wiring), and is large enough for ½" conduit. If necessary, this hole can also be enlarged using a punch to accommodate a larger conduit size. CT wiring should be routed up the left side of the rear of the enclosure to the CT Interface board. This path is very similar to the one shown in Figure 3.8 for a 300 amp AHF. A portion of the rubber insulation, marked "D" in Figure 3.10, will need to be removed to accommodate the wiring to pass behind the "Divider Panel".

Any optional control wires can be either routed on the left side of the back panel, up to the top of the unit for top entry or down to the bottom for bottom entry similar to what is shown in Figure 3.8. The CT and optional control wires should not enter/exit the enclosure through the same hole as the power wiring. The optional control wires may enter/exit the enclosure through a different hole than the CT wiring. Neither the CT or optional control wires have to enter the same end (top or bottom) that the power wiring enters.

Units equipped with floor stands do not normally have bottom entry for wiring as a possibility. Consult the factory beforehand if bottom entry for a system to be equipped with a floor stand is needed.

### 3.2.3. WIRING A 300 AMP TYPE 1 ENCLOSED AHF

Figure 3.6 shows the position of the pilot holes in the top of the 150 or 200 amp AHF enclosure when using top entry into the enclosure for both the power and CT wiring (and possibly other optional control wiring). Top entry is preferred over bottom entry because the wiring for both the power and CTs is a direct shot. The 1.375" diameter pilot hole on the right side is for the 3 power wires and the chassis ground, and is large enough for 1" conduit. This will have to be enlarged to the size needed to meet the electrical code using a punch. Care should be taken that no metal shavings are allowed to fall into the interior of the enclosure when using the punch. The punch should be centered within the pilot hole to insure that the new hole has its center in the same place. Failing to center the punch may result in less space being available for conduit mounting hardware. Since the power wires for a 300 Amp AHF will undoubtedly consist of two paralleled wires per phase, the option exists for bringing all six power conductors and the chassis ground through either one large conduit/hole or 2 smaller conduits/holes. If 2 are to be used, a 2<sup>nd</sup> pilot hole (7/8" diameter) is provided behind the 1.375" diameter pilot hole which can be enlarged with a punch. When using 2 conduits to bring in the power wires, one set of all 3 phases should occupy one conduit and the 2<sup>nd</sup> (paralleled) set of 3 phases should occupy the other conduit. This will minimize lead inductance compared to splitting the phases between the 2 conduits. Power wires will be connected, in almost a straight shot, from this opening to the top terminals of the power switch. All wires will need to be terminated with 3/8" ring terminals or equivalent. The 2 wires of each phase will be bolted to a power switch terminal such that one wire is mounted to the front of the terminal and the other is mounted to the back of the terminal. The chassis ground wire should be terminated to a 1/4" ring terminal or similar. A 1/4-20 stud is available inside the upper right side of the cabinet for connecting this chassis ground wire.

The 7/8" diameter pilot hole on the left side is for CT wiring (and possibly other optional control wiring) to enter the box, and is large enough for 1/2" conduit. If necessary, this hole can also be enlarged using a punch to accommodate a larger conduit size. CT wiring will be connected, in almost a straight shot, from this opening to the green P1 connector on the CT Interface PC board.

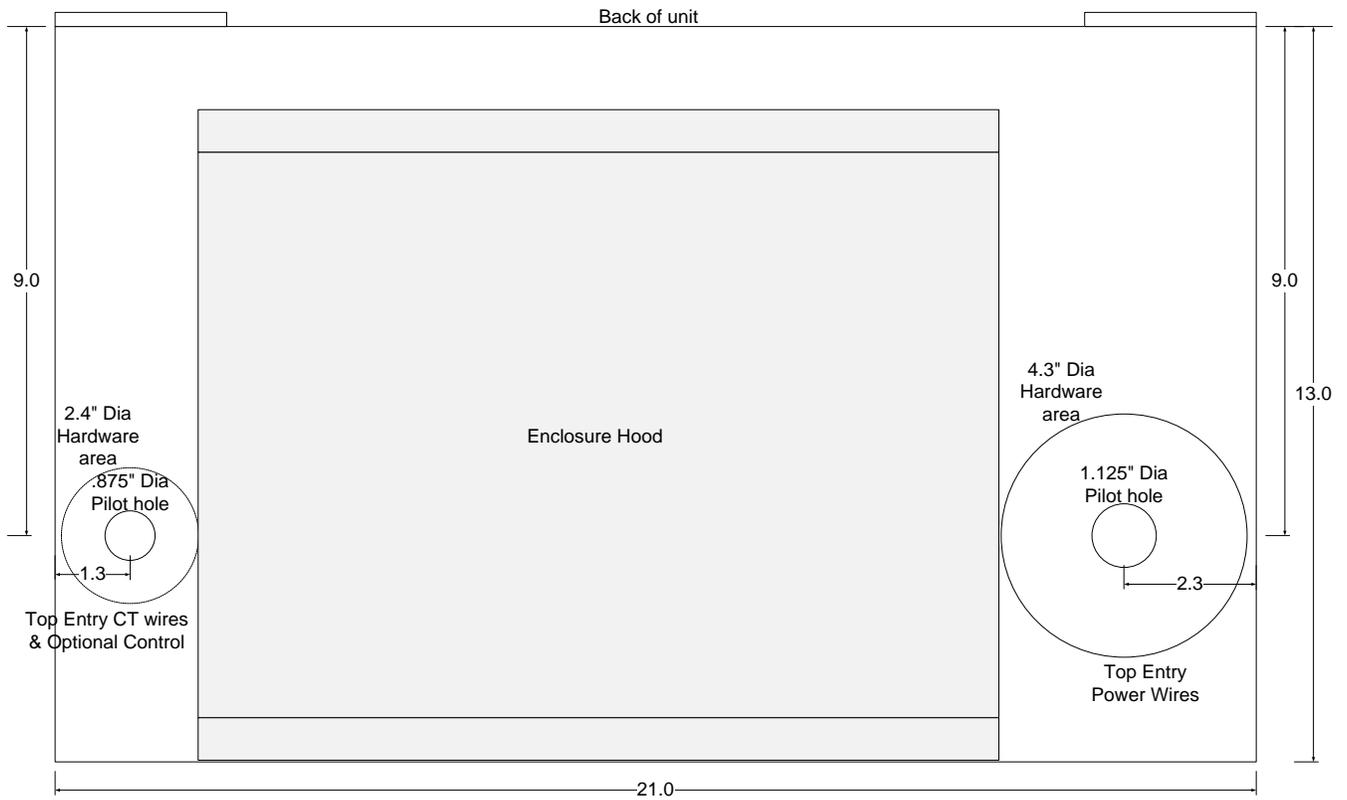
Figure 3.7 shows the position of the pilot holes in the bottom of the 300 amp AHF enclosure when using bottom entry into the enclosure for both the power and CT wiring (and possibly other optional control wiring). Two 7/8" pilot holes are provided on the right side of the bottom panel for power wiring entry. If only one large conduit is used for the power wiring, either pilot hole can be enlarged for that conduit. If 2 smaller conduits are used for the power wiring, both will need to be enlarged for power wire entry. When using 2 conduits to bring in the power wires, one set of all 3 phases should occupy one conduit and the 2<sup>nd</sup> (paralleled) set of 3 phases should occupy the other conduit. This will minimize lead inductance compared to splitting the phases between the 2 conduits. The power wires and chassis ground should be routed from this enlarged opening(s) as follows. The chassis ground wire should be terminated to a 1/4" ring terminal or similar. A 1/4-20 stud is available inside the lower right side of the cabinet for connecting this chassis ground wire. The power wires should be routed up the right side of the rear of the enclosure to beyond the top of the power switch. Utilize the space above the power switch to bend the wires so they may be connected into the top terminals of the switch. Figure 3.8 shows the power wire routing in a 300 amp AHF.

On the way up to the power switch, the power wires need to pass behind the "Divider panel" within the unit. The section above this panel has warmer air that will be exhausted out the top of the enclosure, while the section below this panel has cooler air drawn in through the unit's air filter. This panel acts as a barrier to prevent the warm air remixing with the cooler input air. Figure 3.11 shows a top view of this divider. To make room for the power wires to pass, a section "B", of the rubber insulation material will have to be removed. In addition, a portion of the insulating piece "A (right)", marked "C" in the figure

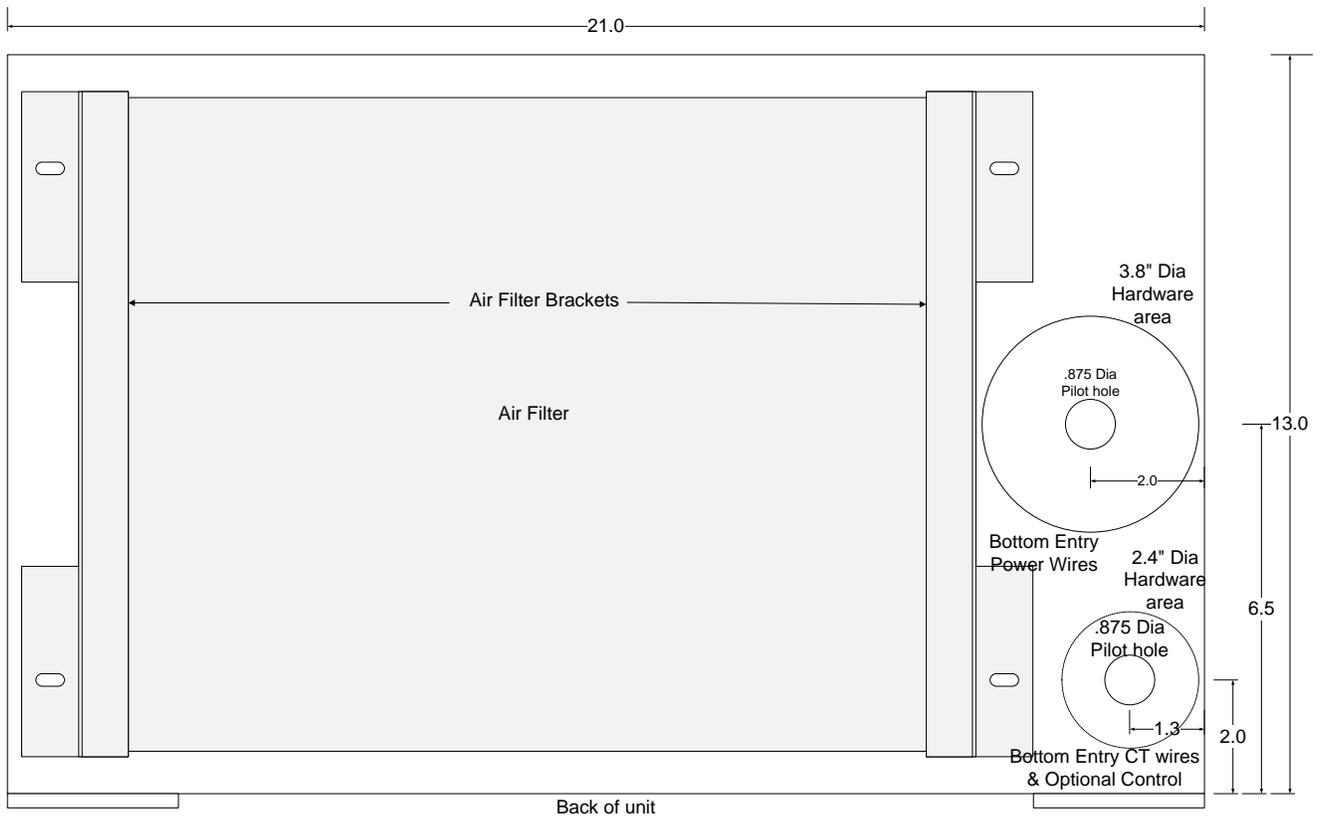
may need to be trimmed off. If so, remove screw holding "A (right)", trim only enough off the end indicated by "C" in the figure using tin-snips or heavy-duty scissors, then re-attach "A (right) with the screw.

The 7/8" diameter pilot hole on the left side of the bottom is for CT wiring (and possibly other optional control wiring), and is large enough for 1/2" conduit. If necessary, this hole can also be enlarged using a punch to accommodate a larger conduit size. CT wiring should be routed up the left side of the rear of the enclosure to the CT Interface board. This path is shown in Figure 3.8 for a 300 amp AHF. A portion of the rubber insulation, marked "D" in Figure 3.11, will need to be removed to accommodate the wiring to pass behind the "Divider Panel".

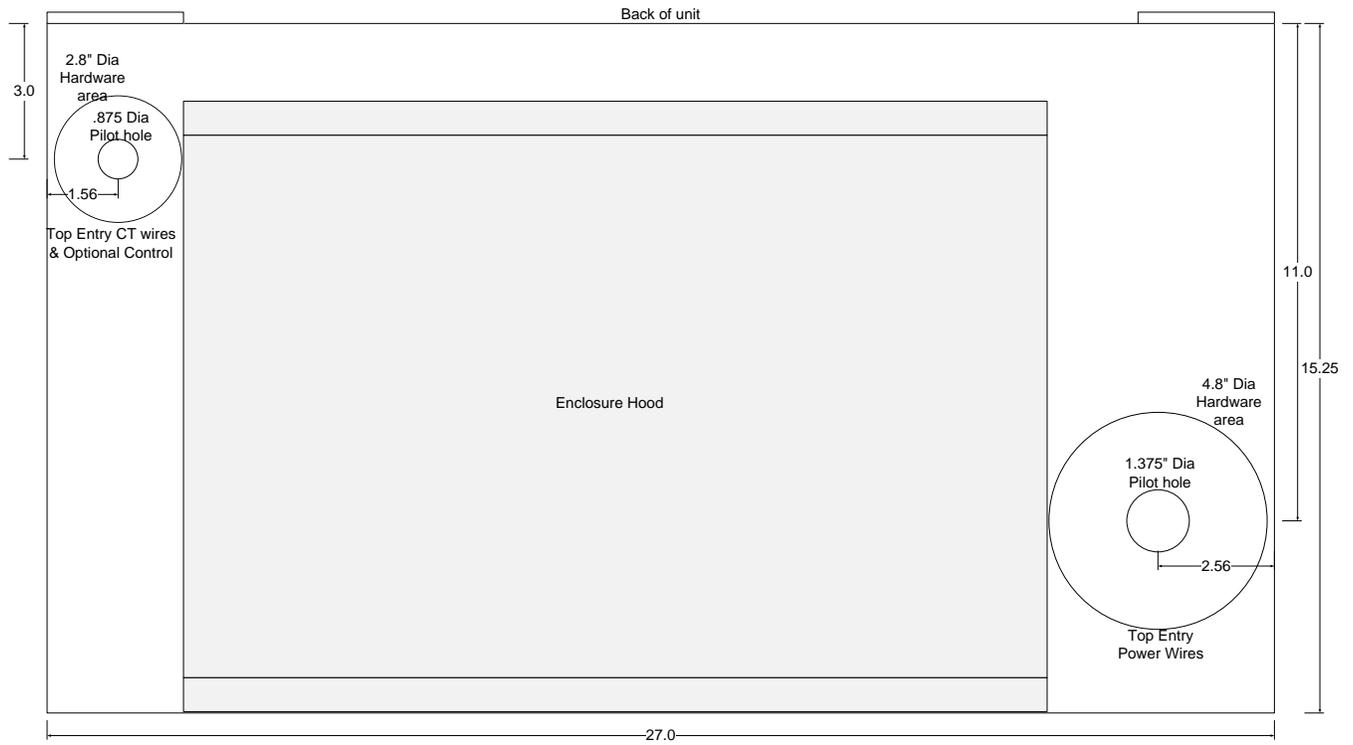
Any optional control wires can be either routed on the left side of the back panel, up to the top of the unit for top entry or down to the bottom for bottom entry as shown in Figure 3.8. The CT and optional control wires should not enter/exit the enclosure through the same hole as the power wiring. The optional control wires may enter/exit the enclosure through a different hole than the CT wiring. Neither the CT or optional control wires have to enter the same end (top or bottom) that the power wiring enters.



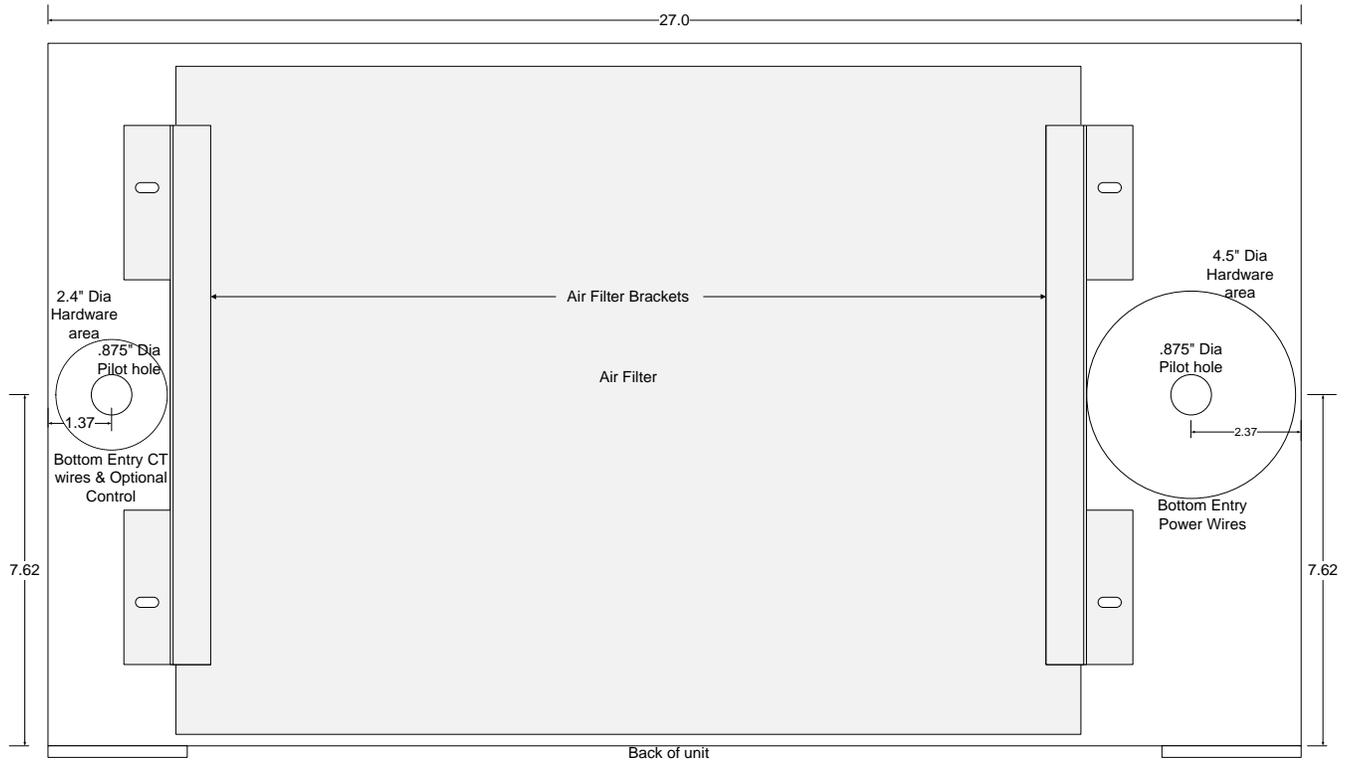
**Figure 3.2: 50 or 100 Amp AHF TYPE 1 Cabinet Top Wire Entry**



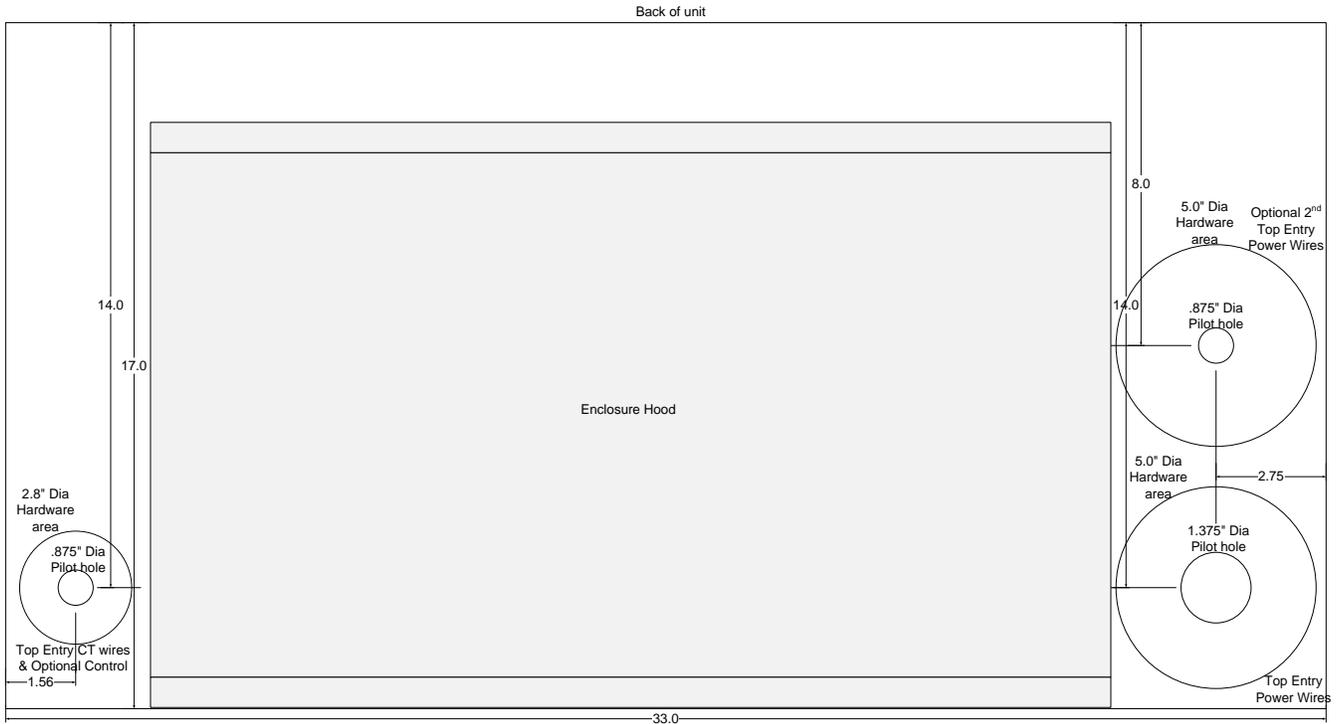
**Figure 3.3: 50 or 100 Amp AHF TYPE 1 Cabinet Bottom Wire Entry**



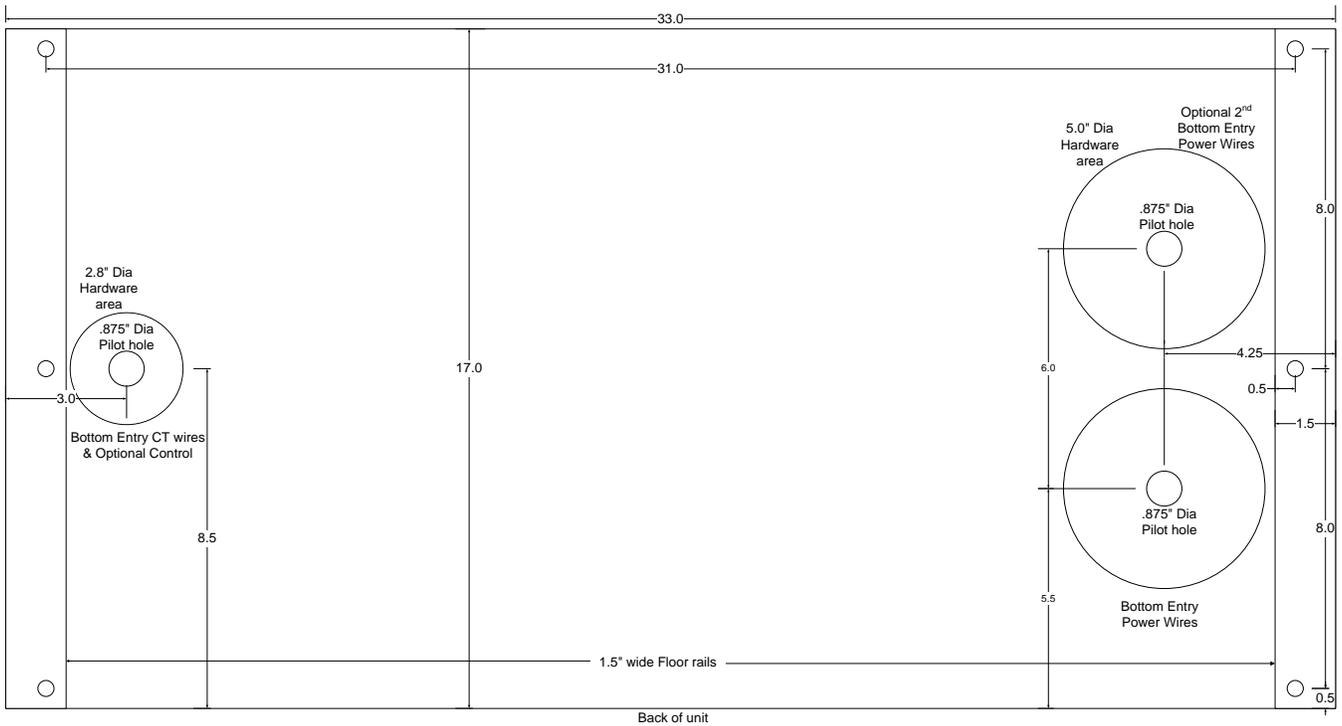
**Figure 3.4: 150 or 200 Amp AHF TYPE 1 Cabinet Top Wire Entry**



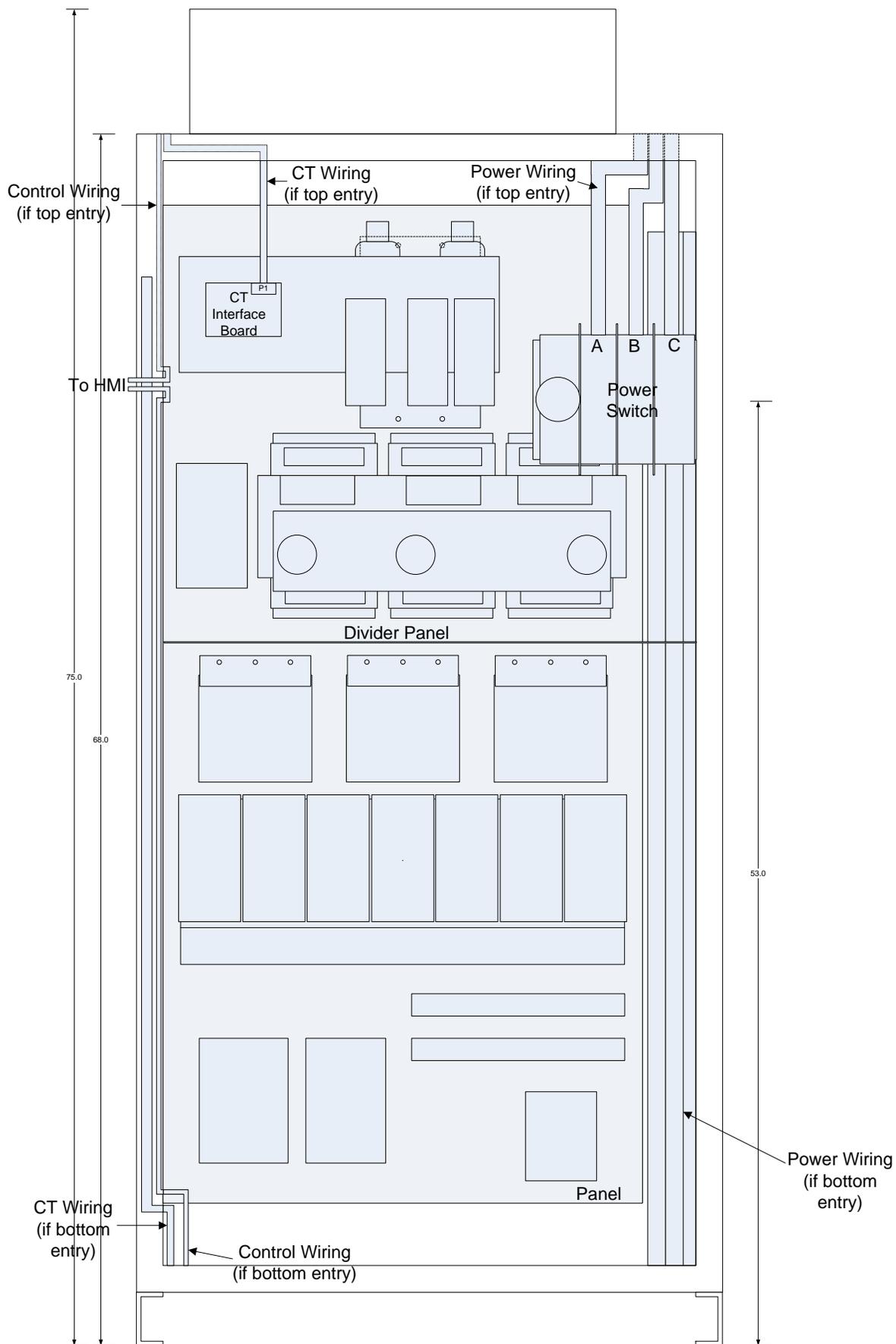
**Figure 3.5: 150 or 200 Amp AHF TYPE 1 Cabinet Bottom Wire Entry**



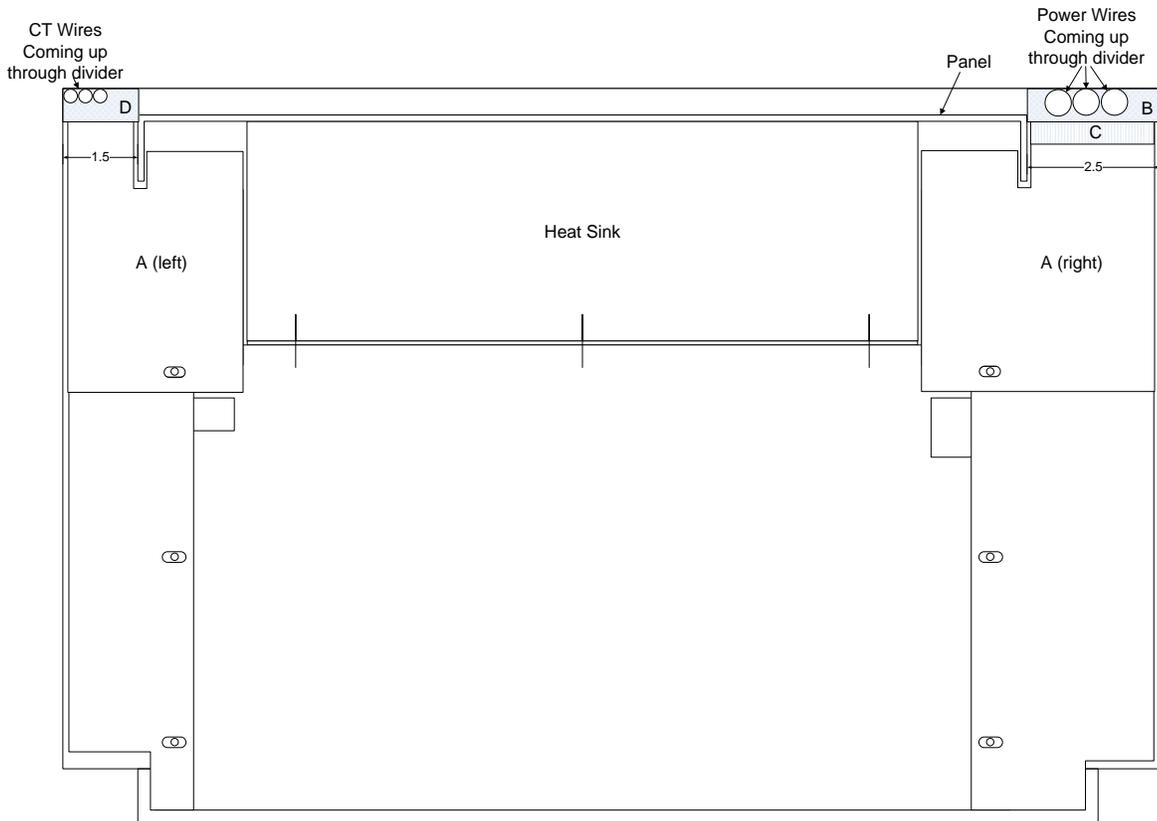
**Figure 3.6: 300 Amp AHF TYPE 1 Cabinet Top Wire Entry**



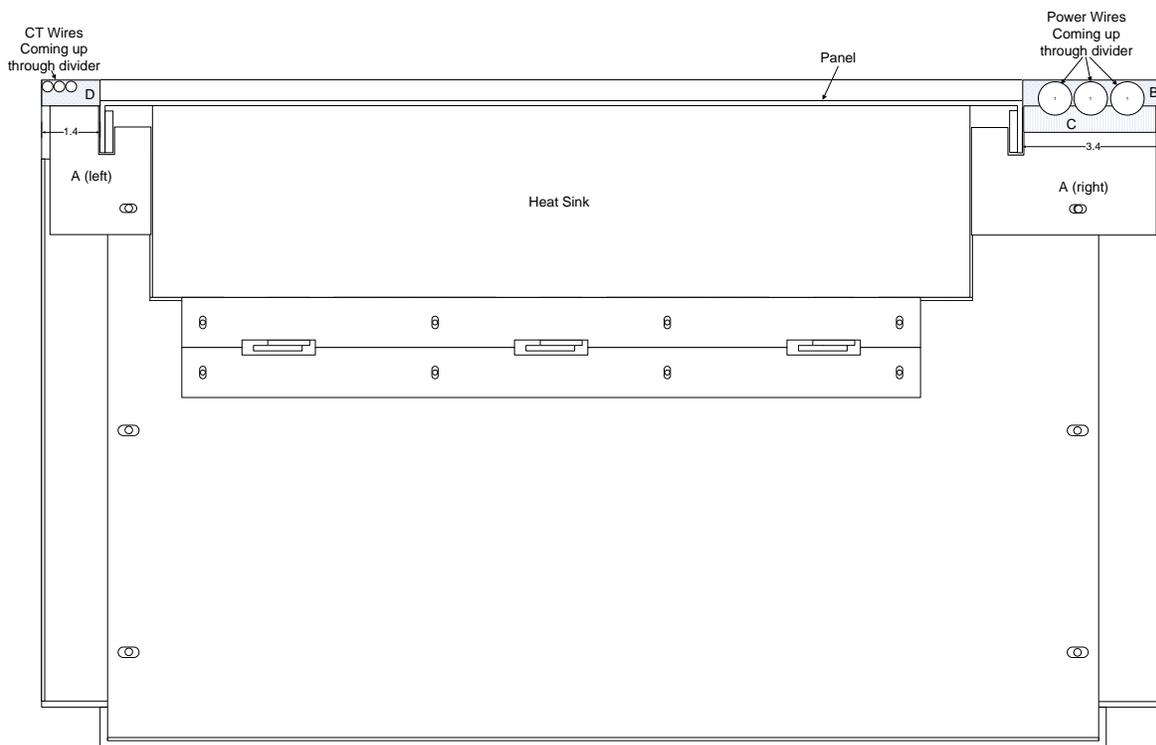
**Figure 3.7: 300 Amp AHF TYPE 1 Cabinet Bottom Wire Entry**



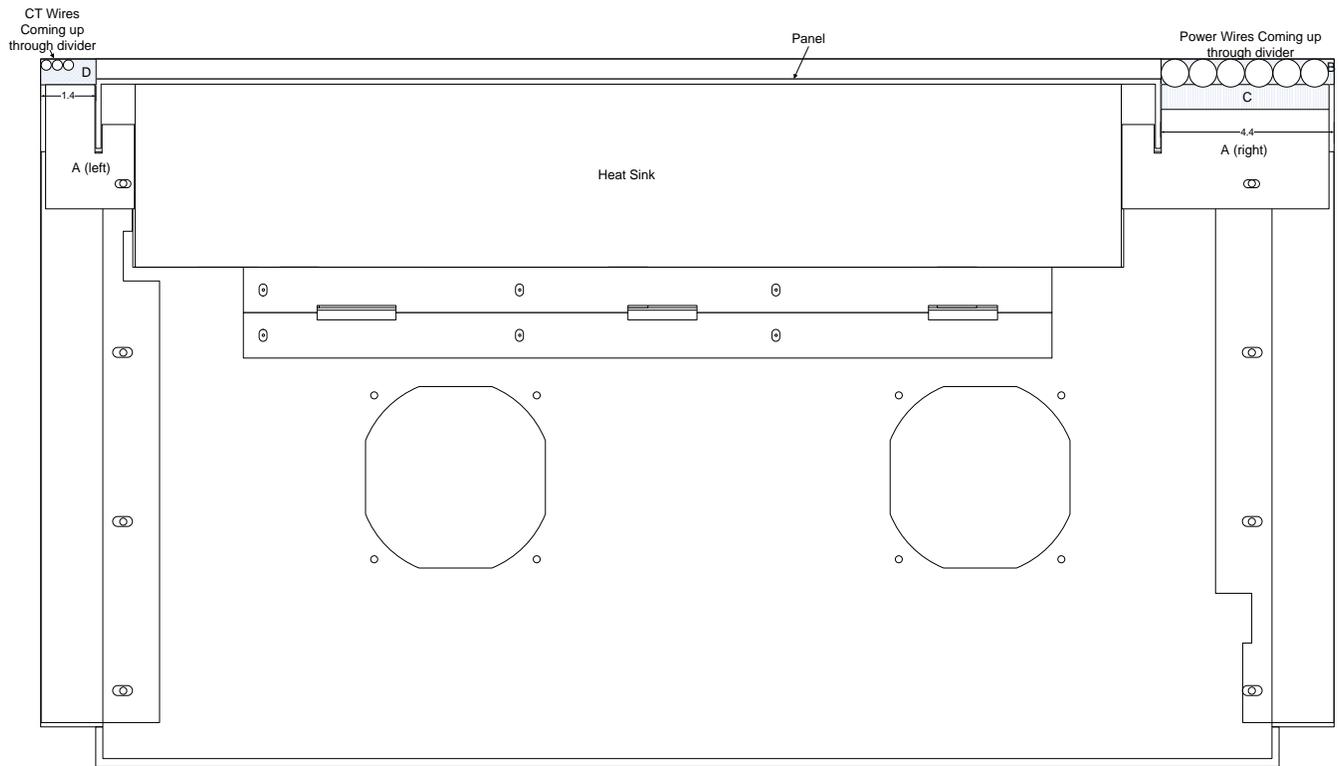
**Figure 3.8: TYPE 1 Enclosure Wire Routing**



**Figure 3.9: 50 or 100 Amp AHF TYPE 1 Wire Passage Through Divider Panel**



**Figure 3.10: 150 or 200 Amp AHF TYPE 1 Wire Passage Through Divider Panel**



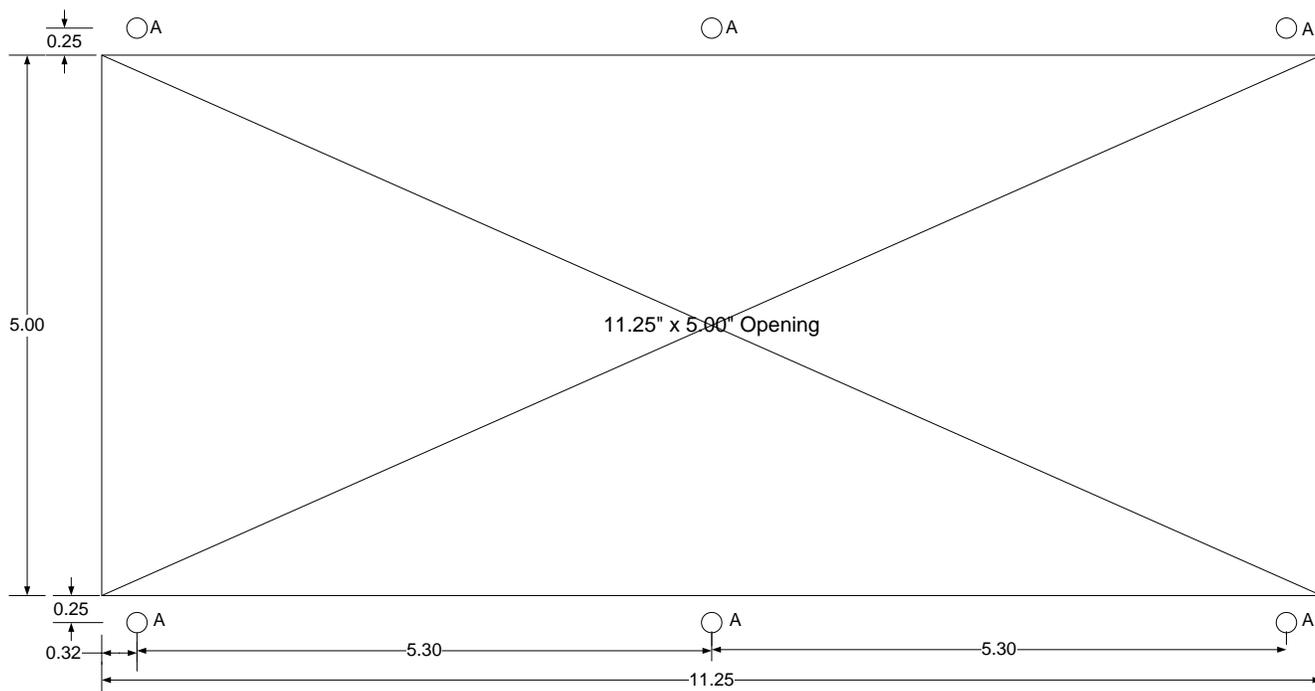
**Figure 3.11: 300 Amp AHF TYPE 1 Wire Passage Through Divider Panel**

### 3.3. INSTALLING AND WIRING AN AHF PANEL

AHF panels must be installed inside an industrial enclosure such as an MCC cabinet before they can be used. A panel is mounted inside an enclosure using the 6 holes in the panel. Machine screws holding AHF components to the panel may protrude up to 0.23" beyond the back surface of the panel. Because of this, at least ¼" thick spacers may need to be added between the rear surface of the panel and the mounting surface of the enclosure to avoid any of these protruding screws from preventing the panel from being tightened down. When installed, no ungrounded bare metal (e.g. power fuses and fuse blocks, aluminum bus-work connecting the large cylindrical Electrolytic capacitors together, etc.) on the AHF panel should come within 1" of any enclosure metal. Refer to the panel layout for your particular panel in Section 10 for panel dimensions and locations of ungrounded bare metal to avoid.

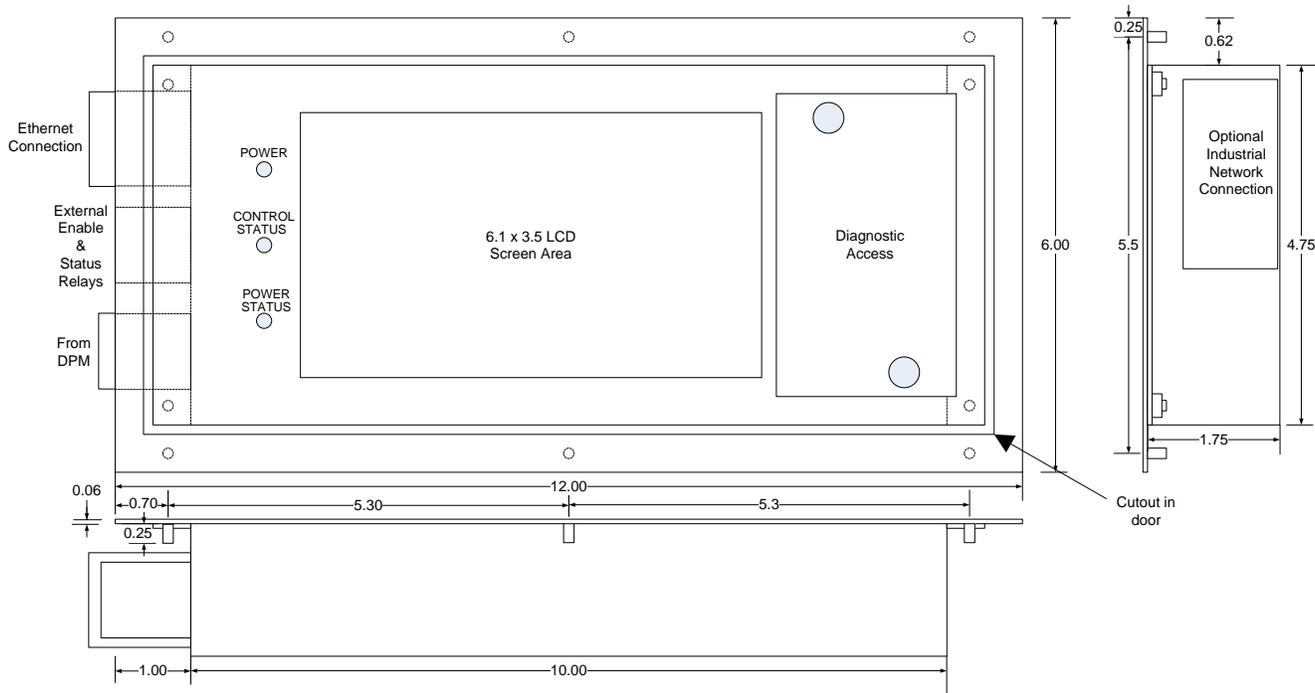
An HMI (Human Machine Interface) containing a resistive touch screen LCD display and signal interfaces (e.g. Ethernet connection, an external disable input, status relay outputs, and an optional industrial signal interface such as Ethernet/IP) is provided in a protective metal enclosure with each AHF panel. The front door of the enclosure should have the rectangular cutout and 6 holes shown in Figure 3.12 to accommodate this HMI, which is mounted from the exterior. The HMI protective "box" protrudes 1.67" beyond the inside surface of the door. Because of this, the placement of the panel should be such that no part of this protruding portion of the HMI box comes within 1" of any ungrounded metal on the AHF panel. Figure 3.13 shows the dimensions and location of the box within the front panel. A 300-amp panel has the additional requirement that the box should not come within 1.5" of the 3 drum inductors when the door of the enclosure is closed.

Table 3.2, Figure 3.14 (if panel is a 50, 100, 150, or 200 amp AHF) or Figure 3.15 (if panel is a 300 amp AHF), and the panel layout drawing for your panel found in Section 10 can be used to determine where the HMI is allowed to be located vertically on your enclosure's door. If the dimension "A", the distance between the back surface of the AHF panel and the inside surface of the enclosure door is less than the distance indicated in Table 3.2 where there is no restriction on the vertical location of the front panel, the front panel must be located in the vertical areas indicated in the table and referenced figures. An alternative would be to make a frame that protrudes out the front of your enclosure that houses the display so that the display back doesn't protrude into the cabinet.



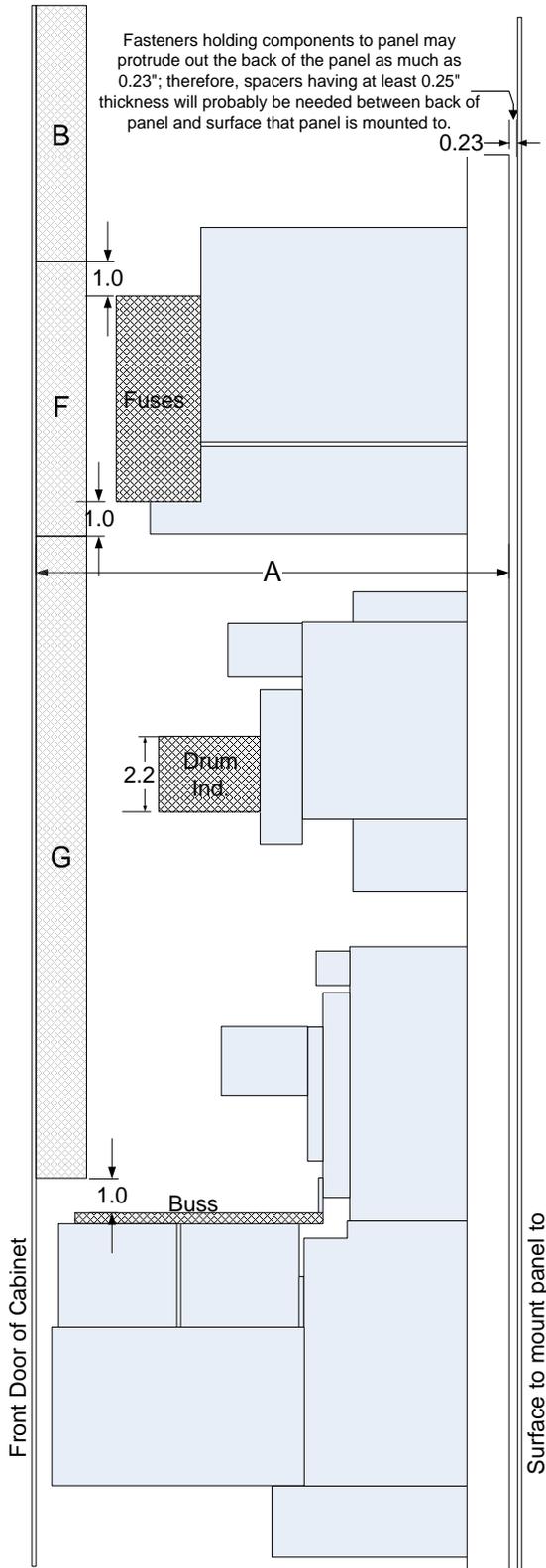
HOLE "A" (6 PLACES) - #3/16 DRILL 0.188 DIA

**Figure 3.12: HMI Enclosure Cutout Pattern**

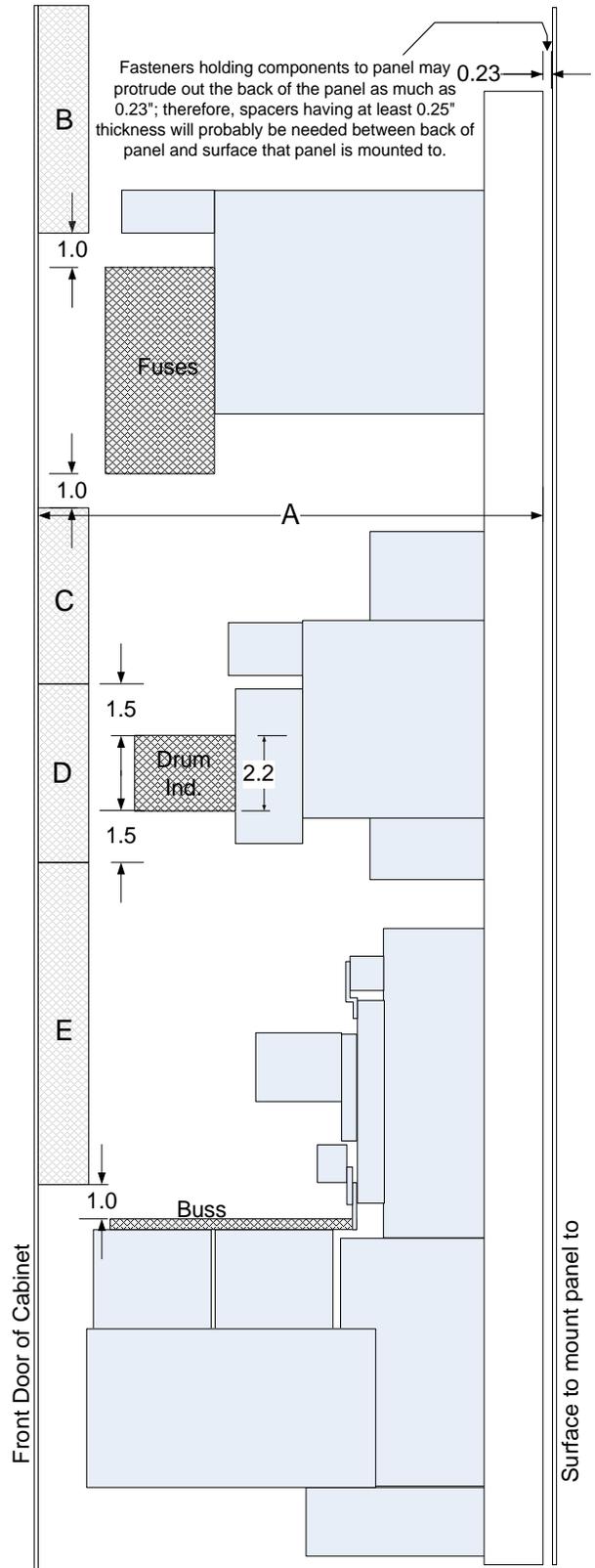


**Figure 3.13: HMI Dimensions**

<b>Table 3.2: Cabinet Depth Design Guidelines for Panels</b>		
Refer to Figure 3.14 for 50-200 amp panels or Figure 3.15 for 300 amp panels for definition of dim. A and areas B through G; and refer to panel layout drawing for your size panel in section 10 to determine location and vertical size of areas.		
<b>AHF Size (Amps)</b>	<b>Distance from back surface of panel to inside surface of door (dim. A)</b>	<b>Vertical location of HMI 10" x 4.75" box that protrudes into the cabinet enclosure</b>
300	14"	Minimum allowed distance for this panel
	≥ 14" and < 15.38"	Box must be located within area B, C, or E
	≥ 15.38" and < 15.75"	Box must be located in area B, C, D, or E
	≥ 15.75"	No restrictions on position of front panel
200	13.7"	Minimum allowed distance for this panel
	≥ 13.7 and < 14.37"	Box must be located in area B or G
	≥ 14.37" and < 15.59"	Box must be located in area B, F or G
	≥ 15.59"	No restrictions on position of front panel
150	13.0"	Minimum allowed distance for this panel
	≥ 13.0 and < 14.37"	Box must be located in area B or G
	≥ 14.37" and < 14.7"	Box must be located in area B, F or G
	≥ 14.7"	No restrictions on position of front panel
100	13.0"	Minimum allowed distance for this panel
	≥ 13.0 and < 14.37"	Box must be located in area B or G
	≥ 14.37" and < 14.98"	Box must be located in area B, F or G
	≥ 14.98"	No restrictions on position of front panel
50	13.0"	Minimum allowed distance for this panel
	≥ 13.0 and < 13.87"	Anywhere except area F
	≥ 13.87"	No restrictions on position of front panel

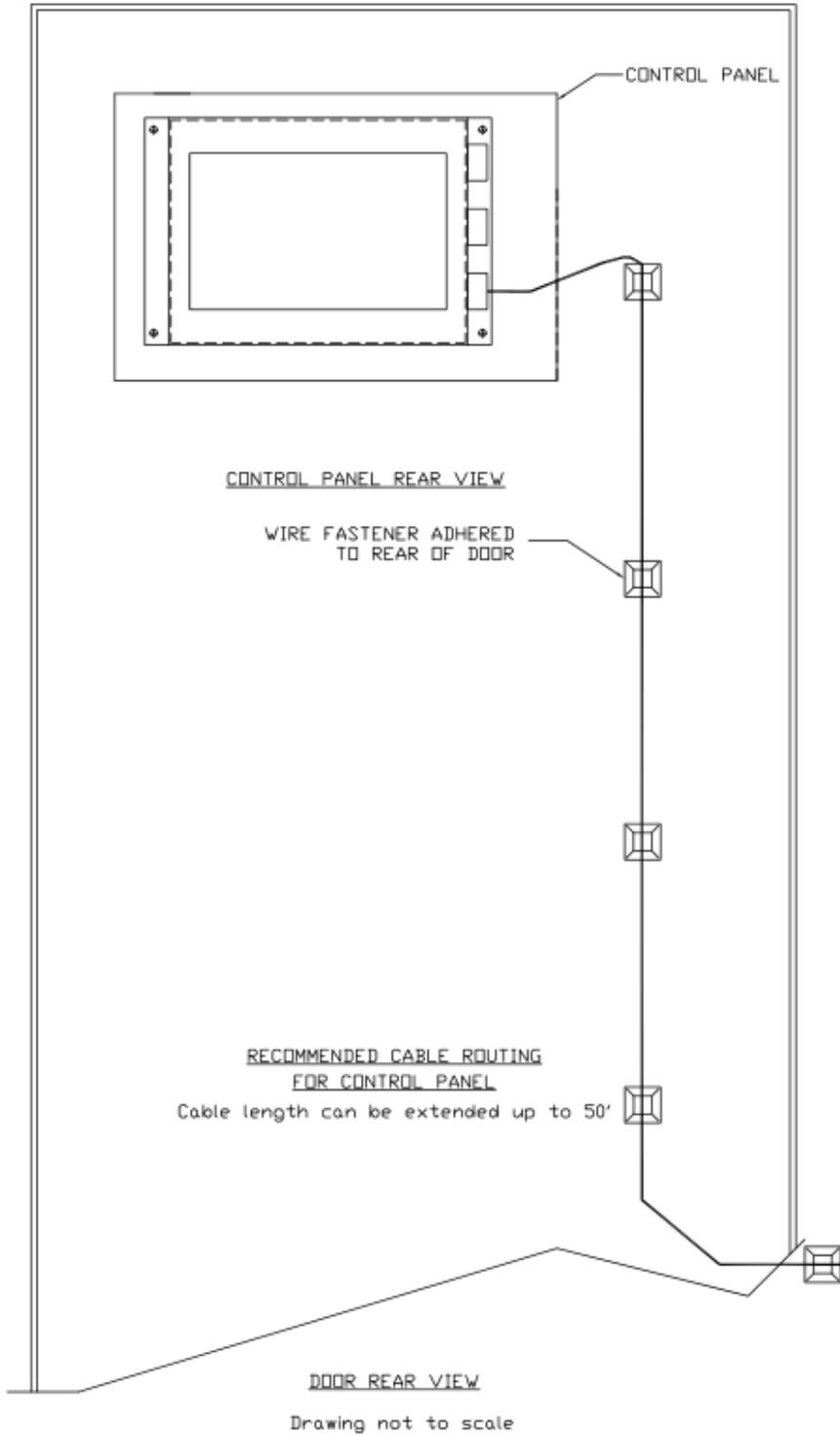


**Figure 3.14: 50-200 Amp Panel to Cabinet Front Door Dimensions**



**Figure 3.15: 300 Amp Panel to Cabinet Front Door Dimensions**

The grey CAT-5 (or better) cable coming from the bottom connector of the HMI provides 24V DC power to the HMI and signal interface to the AHF control circuitry. Although this is the same type of cable used for Ethernet, this is NOT and Ethernet connection. Instead, it needs to be routed to connector P7 of the PC-C board (see **Error! Reference source not found.**) located in the bottom part of the AHF panel. The RJ-45 type P7 connector is marked with a grey dot to indicate that this grey cable is to be connected to it. A possible routing path for this cable down the inside of the enclosure door is shown in Figure 3.16.



**Figure 3.16: Possible Routing Path for HMI to PC-C Signal & Power Cat 5 Cable**

Panels do not come with disconnect switches like the Type 1 enclosed systems. A disconnect switch will need to be added in line with the power wires to the AHF, following electrical code requirements. The output of the disconnect switch is then wired to the 3 power fuses of the AHF. Unless wiring between the fuses and the added disconnect switch or between the disconnect switch and the place where the power is tapped from are long, electrical codes will normally allow you to rely on the UL listed fuses in the AHF to over-current protect your wiring and switch; however, check your applicable electrical codes to confirm this.

Either input or exhaust fans will need to be added to the enclosure to ensure the air exchange rate shown in the specification table for your size AHF, located in Section 10, is met. If input fans are used, they should be located near the bottom of the enclosure with exhaust vents located near the top of the enclosure. If exhaust fans are used, they should be located near the top of the enclosure with intake vents located near the bottom of the enclosure. Air brought into the enclosure should be appropriately filtered so that large dirt build-up does not occur in the AHF panel that would impair the airflow through vital components. The airflow specified in the specification table should be achieved at the pressure created by the vents and filtering in the enclosure. Power for these fans will have to be derived from either the incoming power to the enclosure or some other external source, as the AHF panel does not provide a power source.

Table 3.3 provides power wiring information for all of the AHF panels. Power wiring is needed between the output of the user-provided disconnect switch to the bottom terminals of the power fuse blocks on the panel. Care should be taken so this power wiring is routed so that the integrity of components on the AHF panel are not compromised. Welding wire is recommended (but not required) because of its flexibility.

AHF Size (Amps)	Fused Current Level	Wire Range (Use 75C or equiv. Copper wire only)	Torque (in-lbs) at Power Fuse Blocks	
			Wire Connection	Fuse Bolt
50	70	#8-2/0	120	72
100	125	#4 – 350kcmil	275	132
150	200	#2 – 350kcmil	275	132
200	250	1/0 – 600kcmil	600	228
300	400	3/0 – 600kcmil	600	228

**Table 3.3: AHF Panel Power Wiring Information**

### 3.4. CONNECTING POWER WIRES AND CT WIRES TO THE AHF

There are several different possible implementations of a HPS TruWave AHF. Many are described in the sub-sections that follow. The basic interface to the AHF consists of 3 power wires, a chassis ground wire, and a set of 2 or 3 current transformers (CTs) to each AHF. The 3 power wires conduct the corrective current produced by the AHF to the loads (and line). To determine what corrective current is needed, the CTs are mounted to monitor the currents coming from the utility (or line), or the currents going to the loads that are drawing the harmonic currents. As mentioned earlier, the “line” current consists of the current to the loads plus the current to the AHF, whereas the “load” current consists of only the current to the loads.

Up to several AHFs may be paralleled to achieve higher current correction than a single system is capable of. Although more than 10 could theoretically be paralleled together, paralleling more than a few usually becomes physically difficult to realize. Instead, it is normally better to break up the loads into more manageable groups, and assign 1 or small groups of paralleled AHFs to each group of loads.

If multiple AHFs are used in parallel, the CTs MUST monitor the “load” currents. If a single AHF is used, either the “line” or the “load” currents may be monitored with the CTs. The AHF must be configured to match where the CTs are located (“line” or “load” side) via the LCD front panel.

Split core CTs purchased from HPS come with 12 feet of twisted pair wire leads. These wires may need to be lengthened to meet your needs. Total wire length that can be used depends on the following factors:

- Burden capacity of the CTs in volt-amperes (VA).
- Gauge of wire used (AWG) including the wire supplied with the CT, wire used to extend that length, wire used to daisy-chain between AHFs that are paralleled, etc.

A CT is capable of driving a particular maximum load in volt-amperes (VA), depending on the CT’s design. If the load draws more power than this value, the output of the CT will be distorted. AN AHF or multiple AHFs (if units are paralleled) monitoring the CT outputs, present a negligible load for the CTs compared to the wire leads. If the CT is producing its maximum rms output of 5 amps, the leads present a load of  $I^2 \cdot R$  to the CT, where I is 5 amps and R is the wiring resistance. Heavier wire has lower resistance, resulting in a longer wire length being able to be used. Table 3.4 can be used to determine how long the wires of a CT may be extended. In this table, VA indicates the volt-amp capability of the CT, VA\_loss indicates the losses due to the leads that come with the CT at 5 amps rms current, and Wire Gage is that of the wire the CT leads are being extended with. These calculations have a constant K. If a higher CT ratio is chosen so that the CT output current is less than 5 amps when the line being monitored is carrying its maximum possible current (normally equal to the circuit breaker rating protecting the line), K is calculated to be  $(i/5)^2$ , where i is the current produced by the CT when the line is operating at maximum possible current. As an example, if a 1200/5 CT is used on a line protected by a 1000 amp breaker, a 1200/5 CT will produce 4.167 amps of current at 1000 amps of line current. K is calculated to be  $(4.167/5)^2$  or 0.695. It is recommended that despite what the calculation yields in length that the total wire length does not exceed 100 ft. Beyond 100 ft, the inductance of the wire can cause excessive distortion to the signal, which will adversely affect performance.

Table 3.4: Maximum lengths for CT leads	
Wire Gage (AWG)	Maximum Additional Wire Length (ft)
16	$(VA - (VA\_loss * K)) * (4.4 / K)$
14	$(VA - (VA\_loss * K)) * (7.1 / K)$
12	$(VA - (VA\_loss * K)) * (11.2 / K)$
10	$(VA - (VA\_loss * K)) * (17.8 / K)$

As an example, if a CT is rated for 5 VA, has 12 ft of 12 AWG leads, and has an output of 5 amps rms at the highest current that the line it is monitoring can possibly carry: VA=5, K=1, and VA\_loss = 1.1 (VA loss of 12 ft of twisted pair 12 AWG wire carrying 5 amps of current). Using 12 AWG wire to extend

the leads with twisted pair wire results in  $(5-1.1)*11.2 = 44$  ft. Using a higher CT ratio will result in a longer possible distance because K will be less than 1 in the equations in this table.

Table 3.5 shows a list of possible standard split core CTs available from HPS. Included in the table are the VA capacity of the CT, the gage of the 12 ft. of twisted pair wire leads the CTs come with, and the VA\_loss of those wire leads. These VA and VA\_loss values can be used with equations in Table 3.4 to calculate the length that the CT leads may be extended. If the CT chosen produces 5 amps at the maximum current the line can carry, the values listed in the wire AWG columns can be used to determine the maximum lengths that can be added.

Table 3.5: Lengths that leads on HPS supplied CTs may be extended							
CT Current Ratio	VA capacity of CT	Wire AWG of CT leads	VA_loss for 12 ft. supplied length @ 5 amps	Maximum extra length of wire that can be added to 12 ft. leads using indicated wire gage @ 5 amps			
				16 AWG	14 AWG	12 AWG	10 AWG*
200/5 – 400/5	2	12	1.1	4.0	6.4	10.1	16
500/5	3	12	1.1	8.4	13.5	21	34
600/5 – 800/5	5	12	1.1	17	28	44	69
1000/5 – 1200/5	5	16	2.8	9.7	15.5	25	39
1500/5 – 1600/5	15	16	2.8	54	87	88	88
2000/5	25	16	2.8	88	88	88	88
2400/5	35	16	2.8	88	88	88	88
3000/5 – 6000/5	45	16	2.8	88	88	88	88

\*If 10 AWG wire is to be used, you must transition back to 12 AWG or smaller for a short distance prior to terminating wires in the CT Interface board terminals in all AHFs, as those terminals are not large enough to reliably accept larger wire than 12 AWG.

In this table, no lengths are shown greater than 100 feet. Beyond 100 ft, wiring inductance, which distorts the signal seen by the AHF or paralleled AHFs, becomes a concern. From this table, we note the following:

- Higher current ratio CTs have higher VA capacities, so can drive higher loads (i.e. longer wire lengths). Also, using higher current ratio CTs will result in lower VA loads caused by the leads, since the CT will produce less than 5 amps at the maximum current seen. For example, if a 1200/5 CT is used instead of a 1000/5 CT on a line that can carry no more than 1000 amps, The diA tradeoff of using higher current ratios CTs will be reduced resolution of the current produced by the CT (e.g. a 2000/5 CT produces only half of the signal that a 1000/5 CT produces). However, the HPS TruWave AHF is designed with excellent current resolution. Even 50 amp AHFs have been shown to operate well with 2000/5 CTs. At all times, the “n” value in the n/5 ratio should be greater than the maximum rms current that can flow in the wires being monitored by the CTs.
- The 12’ leads supplied on 1000/5 and 1200/5 CTs are 16 AWG. If using these CTs and planning to extend these leads, you may need to consider either going to a higher CT ratio (thus increasing the VA capability of the CT), or cutting much of the supplied 12’ length off and replacing with heavier gage wire that is being used to extend the lead length.

After consulting the subsections that follow showing different possible implementations of a HPS TruWave AHF or AHFs, the following procedure should be used to connect power wires and CT wires to the AHF or AHFs:

- 1) It is highly recommended for safety reasons to turn off power feeding the circuit that powers the AHF and the lines to be monitored by the CTs. If split-core CTs are to be installed on live lines, the secondaries of the CTs MUST be terminated prior to installing the CTs on the live lines.

Termination should be either to the terminals inside the AHF or to a shorting block with shorting bars engaged. Shorting bars should not be removed until connections are made between the shorting block and the AHF.

- 2) Designate the 3 phases of your power circuit as phases A, B, and C. Phase rotation is not a concern, so the designation you make is arbitrary, and has nothing to do with physical wire or bus positions. Phase A will be the phase you decide to put CT A on, phase B will be the phase you decide to put CT B on, and phase C is the remaining phase (it will need to have CT C on it if 3 CTs are to be installed). If you are only using 2 CTs, they All CTs should be placed on either the “line” side or the “load” side, whichever positioning is required or optimal for your situation.
- 3) If the AHF is an enclosed unit, connect the power wiring to the switch inside the AHF via an external breaker or fused switch. In certain cases, the electrical code may allow direct wiring without going through a breaker or fused switch. If the AHF is a panel unit, connect the wiring through a switch (or breaker) to the power fuse blocks on the panel. The electrical code will usually allow the switch to rely on the fuses in the AHF for protection. Wire the power wiring from your designated phase A to the left-most terminal of the AHF’s switch or left-most fuse block, wire your designated phase B to the middle terminal or middle fuse block, and phase C to the right-most terminal of the switch or right-most fuse block. If multiple AHF units are paralleled, repeat for all units. If external over-current protection is required, each paralleled AHF will need its own external protection sized to protect the wiring to each unit.
- 4) Terminate the secondary leads of CT A to A+ and A- terminals, CT B to B+ and B- terminals, and CT C (If used) to C+ and C- of P1 of the CT Interface board inside the AHF enclosure. If using CTs supplied by HPS, the black lead is the “+” lead and the white lead is the “-“ lead. Use a tightening torque of 4 in. lb. Also, use the provided mounting points and wire ties to route the CT wires and provide strain relief. If you are only employing 2 CTs, the 2 CTs must be connected to the A+/A- and B+/B- terminals on this board with the C+/C- terminals not used.
- 5) If the AHF is a single unit with no other units in parallel with it, make sure the P2 connector with the 3 shorting jumpers is in place on the CT Interface Board. If additional units exist to be paralleled with this AHF, jumper from P2 from this AHF to P1 of the next AHF as described in the paralleled AHF example. Jumpering of P2 from one AHF to the P1 of the next AHF is continued until the last AHF to be paralleled. That last AHF must have the 3 shorting jumpers in place on its P2 connector.
- 6) Encircle the conductor(s) you designated as phase A of your power circuit that feed both the AHF and the loads to be corrected with the CT marked “A”. Make sure to orient the CT so that its arrow is in the direction pointing from the utility to the load. Repeat for phase B, and then for phase C, if the optional phase C CT is being used.

**WARNING:**

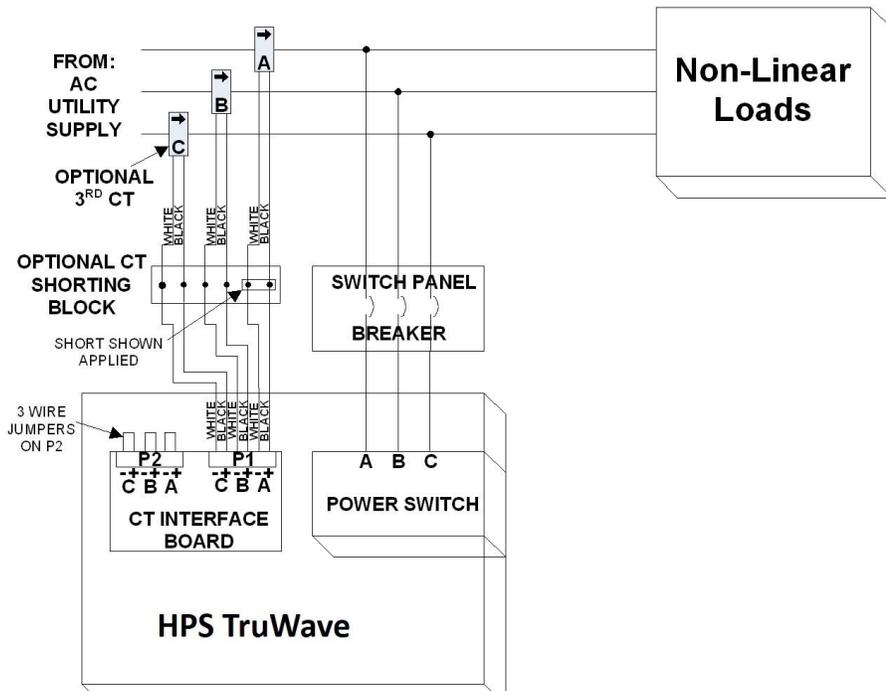
Once the circuitry that the CTs are monitoring is energized, DO NOT disconnect secondary wires of the CTs from P1 or remove P1 or P2 from the CT Interface Board from any AHFs monitoring those CTs. Power feeding the circuitry monitored by the CTs must be turned off before any P1 or P2 connections are removed. Circuitry should not be re-energized until either the CTs are removed or the secondary wires are properly terminated. (Exception: if CTs are first wired to a shorting block prior to the AHF or paralleled AHFs, and shorts are applied on the shorting block to all CTs, then the wiring to P1 or P2 of the CT Interface board(s) downstream may be disconnected without de-energizing the circuitry monitored by the CTs). CTs should never be installed on live circuitry if the secondary wires are not properly terminated. Open circuit terminals of a CT monitoring a live circuit may develop a lethal voltage across the secondary wires.

**FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN SERIOUS INJURY OR DEATH.**

Once all the power and signal connections have been made to the AHF or paralleled AHFs, the electrical service can be re-established to the node. The AHF should have its disconnect switch turned off when it is first installed and the power is re-established.

The following sub-sections show power wiring to a Type 1 enclosed AHF or paralleled AHFs, showing the power wires coming into the power switch of such units. Panel AHFs will include a user-supplied disconnect switch wired to the power fuses on the AHF panel.

### 3.4.1. SINGLE AHF MONITORING “LINE” SIDE CURRENT

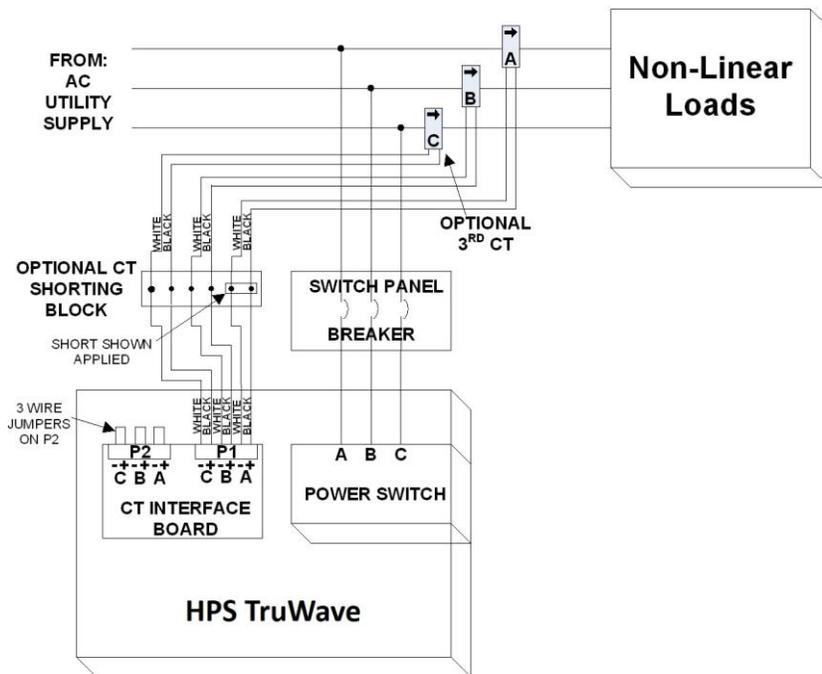


The most common implementation of a HPS TruWave AHF is a single system having 2 CTs, with some systems having a 3<sup>rd</sup> CT, monitoring the “line” side current as shown in Figure 3.17. A common setup consists of the input current to a distribution panel being monitored by the CTs, with breakers, feeding both the loads and the AHF, installed in the distribution panel. This example shows CTs wired to an optional shorting block; however, CTs could also be wired directly to the CT Interface board in the AHF. Since a single AHF is employed, P2 on the CT Interface board must contain jumpers as shown.

Figure 3.17: Single AHF with Line Side CTs

### 3.4.2. SINGLE AHF MONITORING “LOAD” SIDE CURRENT

Another common implementation is a single system having 2 CTs (with an optional 3<sup>rd</sup>), monitoring the

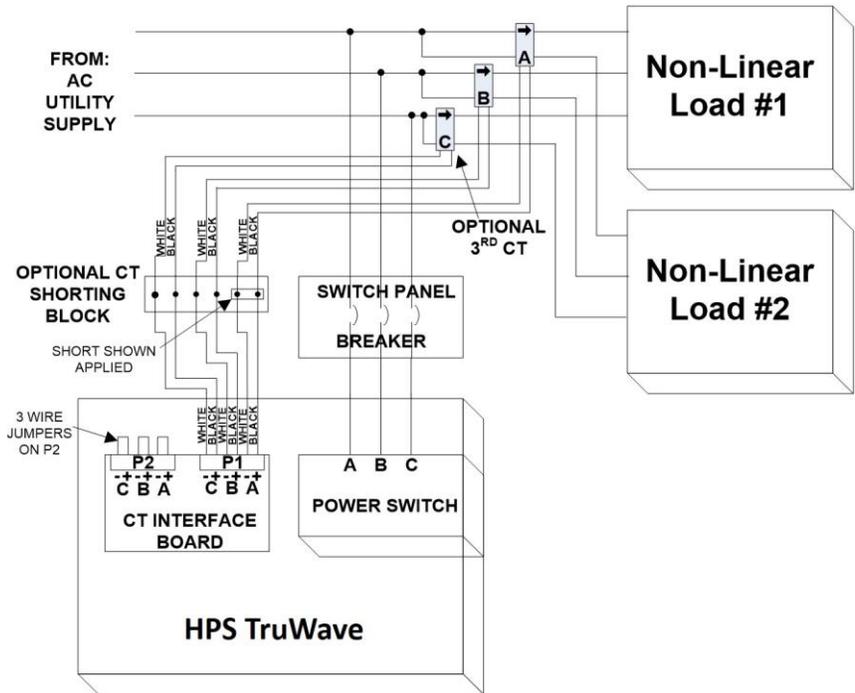


“load” side current as shown in Figure 3.18. A common setup consists of the AHF and a single load (or an entire MCC section downstream) being supplied via breakers in a distribution panel. The CTs are monitoring the current in the wires going to the load (or an entire MCC section downstream). If 2 loads exist with separate feed wires, the current going to both loads must be measured. This can be done by either routing the conductors to both loads through the set of CTs as shown in Figure 3.19, or by adding a 2<sup>nd</sup> set of CTs to monitor the current going to the 2<sup>nd</sup> load as shown in Figure 3.20. If a 2<sup>nd</sup> set of CTs is used, the current ratio of those CTs must be identical to the ratio of the first set of CTs. For example, if 1000:5 CTs are used for the first set of CTs, 1000:5 CTs must also be used for the 2<sup>nd</sup> set. The arrows on both sets of CTs must point towards the load they are

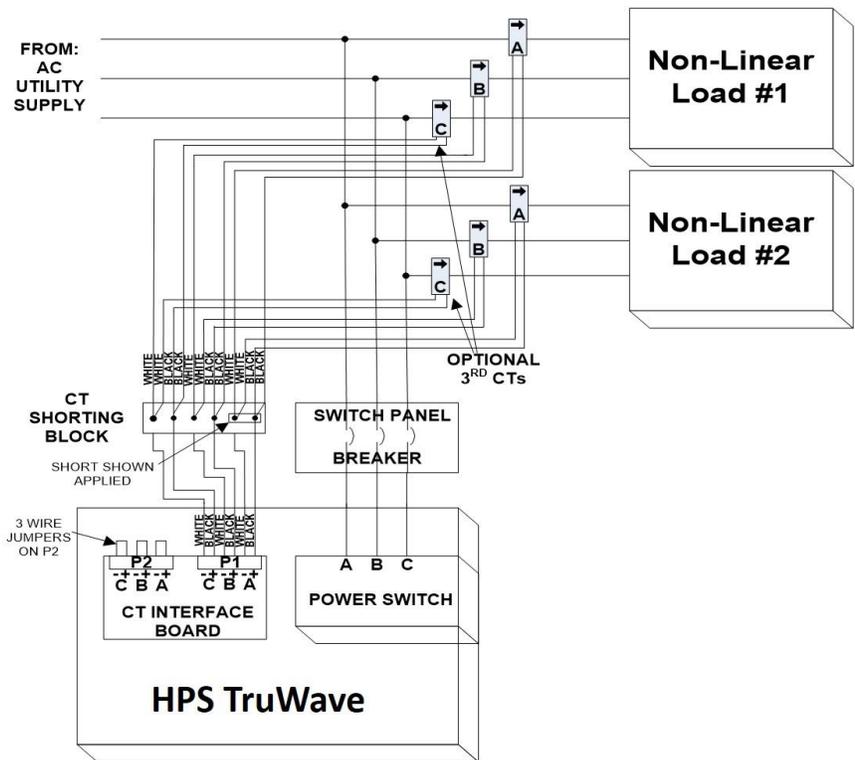
Figure 3.18: Single AHF with Load Side CTs monitoring one load

must also be used for the 2<sup>nd</sup> set. The arrows on both sets of CTs must point towards the load they are

monitoring. Make sure CT "A" of the 2<sup>nd</sup> set is on the same phase as CT "A" of the 1<sup>st</sup> set; and CT "B" of the 2<sup>nd</sup> set is on the same phase as CT "B" of the 1<sup>st</sup> set. If a CT "C" is present in the 1<sup>st</sup> set, there must be a CT "C" in the 2<sup>nd</sup> set measuring the same phase. A CT shorting block is now required, as both sets of CTs must be wired together into the block as shown. The connector on the CT Interface board in the AHF will not accommodate more than one wire reliably in each terminal of the P1 block. Either concept can also be used for more than 2 loads.



**Figure 3.19: Single AHF with 1 set of Load Side CTs monitoring 2 loads**



**Figure 3.20: Single AHF with 2 sets of Load Side CTs monitoring 2 loads**

### 3.4.3. PARALLELED AHFS TO CORRECT HIGHER CURRENTS

AHFs may be paralleled to increase the amount of harmonic current to be corrected. When AHFs are paralleled, the CTs must measure the “load” side current, and not the “line” side current. Figure 3.21 shows the wiring needed to parallel 2 AHFs. As can be seen, the CTs are measuring the “load” side current. The output wires of the CTs are wired to an optional CT shorting block. The shorting block is then wired to connector P1 on the CT Interface board in AHF#1 in an identical manner to when only a single AHF is used. The CT shorting block is optional; therefore the CT output wires could have been wired directly to the CT Interface board in AHF#1. The 3 jumper wires on P2 of this same board are removed. Six wires are needed to connect the 6 terminals on P2 of the AHF#1 CT Interface board with the same 6 terminals on P1 of the AHF#2 CT Interface board as shown. The A+ and A- connecting wires should be of different color (e.g. black and white as shown) and twisted together to minimize inductance and noise sensitivity. Likewise, the B+ and B- pair of wires and the C+ and C- pair of wires. Even if only 2 CTs (A and B) are used in your setup, you should wire the C+ and C- wires between AHFs in case at a later date a 3<sup>rd</sup> “C” CT is added. When done, you should have three pairs of black and white twisted wires going from P2 in AHF#1 to P1 in AHF#2. AHF#2 should have its P2 connector with the 3 jumper wires as shown.

Each AHF needs its own external breaker (if a breaker is required by code). The power wires going to each AHF are wired the same as if they were single AHFs, making sure the wire going to the left terminal inside the AHF is connected to the same phase that CT “A” is on, the wire going to the middle terminal is connected to the same phase that CT “B” is on, and the wire going to the right terminal is connected to the remaining phase. All power wires going to both AHFs must connect to the line (AC utility supply) side of where the CTs are located.

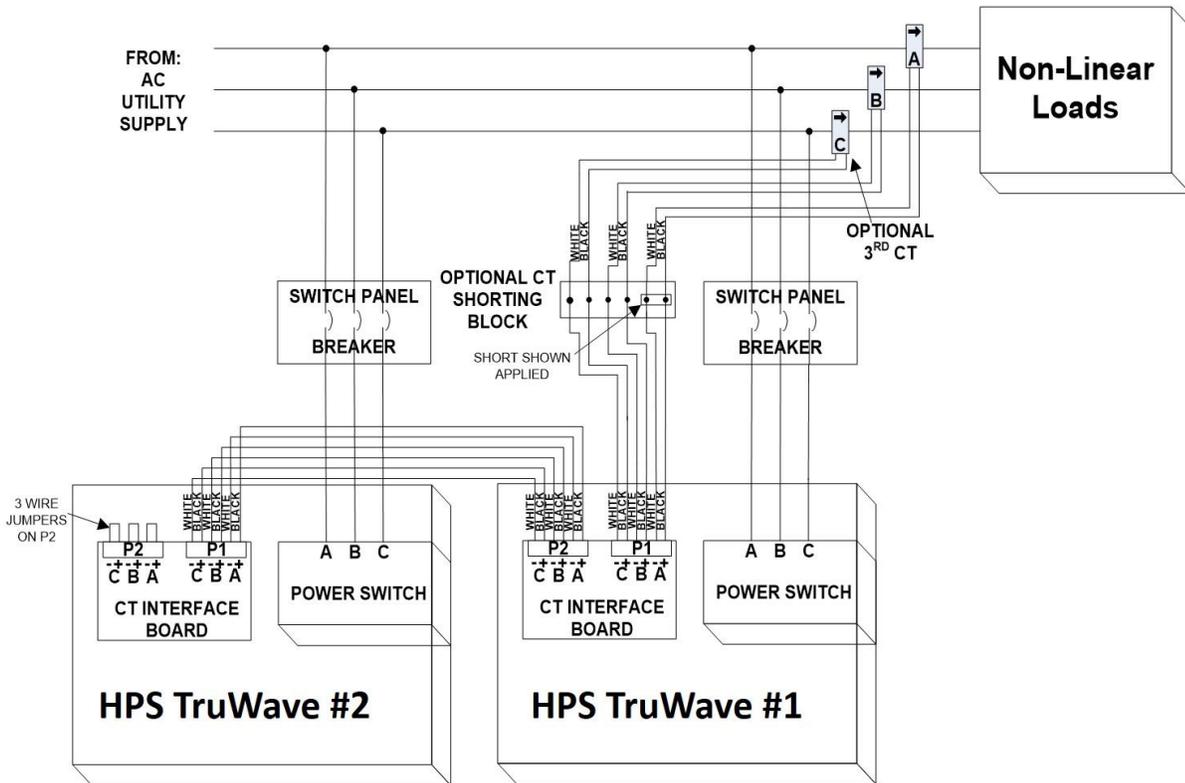


Figure 3.21: Paralleling 2 AHFs

To parallel a 3<sup>rd</sup> AHF, remove the 3 wire jumpers from P2 in AHF#2. Connect the same 6 terminals on P2 in AHF#2 to P1 in AHF#3 in the same manner that you connected P2 in AHF#1 to P1 in AHF#2. P2 in AHF#3 will now have the 3 wire jumpers shorting + to – terminals of A, B, and C. Power is connected to AHF#3 identical to how it was connected to the first two AHFs.

You could continue paralleling AHFs until the wire resistance of all of the CT runs (from CT to shorting block, from shorting block to AHF#1, from AHF#1 to AHF#2, etc.) presents too much of a load for the CTs to adequately drive. The CT Interface boards are a negligible load on the CTs compared to the wire resistance, so can be ignored. In reality room space, space for breakers in the distribution panel, etc. will probably limit the number of paralleled AHFs to some practical number.

AHFs set up to operate in parallel operate independently, and without knowledge about each other. This allows AHFs to continue operating when others in the paralleled arrangement are turned off. Since they operate without knowledge about each other, each paralleled unit must be programmed to correct the portion of the load harmonics that it is responsible for. For example, if two 300 amp systems are paralleled, each must be programmed to correct ½ of the harmonic currents in the load. Programming each AHF is done via the “%LOAD TO BE CORRECTED” parameter accessible via its front panel. See section 5.6.3 for details on setting this parameter to a value from 1 to 100%. The values put in for all of the AHFs paralleled together must sum to a value of 100. If they sum to less than 100% or more than 100% harmonics the paralleled AHFs will not correct harmonics properly.

The following equation should be used to calculate the %LOAD for each AHF that is paralleled:

$$\%LOAD = 100 * D/D\_total$$

where: D = the amp rating of that AHF and D\_total = total amp rating of all AHFs paralleled.

The calculated %LOAD value is rounded off to the nearest integer. After calculating the %LOAD values for all AHFs to be paralleled, add the numbers together. If the sum is not 100%, add or subtract 1 from units (starting with the larger units) until the %LOADs sum to 100.

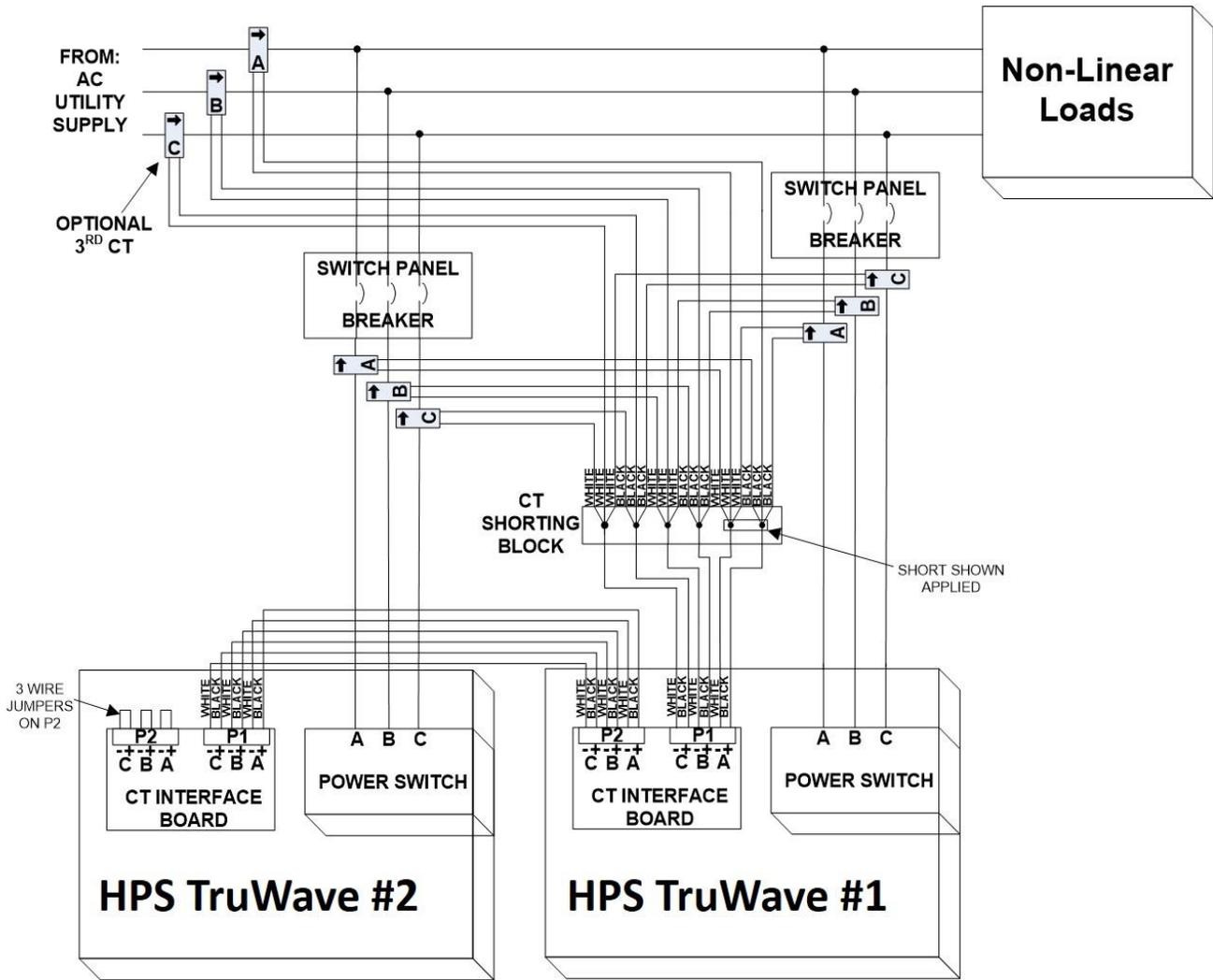
Example: two 300 amp and one 200 amp AHFs are to be paralleled:

- 1)  $D\_total = 2*300 + 200 = 800$
- 2)  $\%LOAD (1^{st} 300) = 100 * 300/800 = 37.5$  which rounds to 38.
- 3)  $\%LOAD (2^{nd} 300) = 100 * 300/800 = 37.5$  which rounds to 38.
- 4)  $\%LOAD (200) = 100 * 200/800 = 25$ .
- 5)  $38+38+25 = 101$ ; Therefore, subtract 1 from %LOAD from 1<sup>st</sup> 300, reducing it from 38 to 37.
- 6)  $37+38+25 = 100$ .
- 7) Program %LOAD of 37, 38, and 25 into the two 300's and one 200 amp AHFs, respectively.

It should be noted that the Line current THD displayed on the LCD displays of all paralleled units assumes that all units are programmed with the correct %LOAD value and all are fully operational. If not, actual line current THD will be higher. If all are correctly programmed and fully operational, actual current THD will be slightly better than what is displayed.

#### **3.4.4. USING “LINE” SIDE CTS TO PRODUCE “LOAD” SIDE CURRENTS**

If you really need to measure “Load” side currents such as is the case when paralleling AHFs, but that point is either inaccessible or there are many loads requiring many sets of CTs to monitor all of them, you can instead monitor both the line current and the current from the AHFs as in the paralleled system shown in Figure 3.22. A single AHF system would never need to do this, as it is capable of operating with either line or load side CTs.

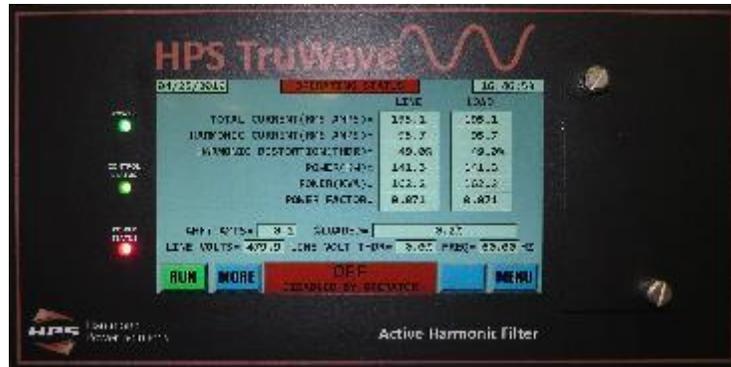


**Figure 3.22 Using “Line” side CTs to produce “Load” side currents**

This CT arrangement is possible because the load current is equal to the sum of the line current and the AHF currents. All of the CTs must have the same current ratio (e.g. 1000/5, etc.). The arrows on the line CTs must point towards the loads and the arrows on the AHF currents must point away from the AHFs as shown in the figure. CT “A” on the wire to each AHF must be on the wire going to the left terminal on the power switches of both AHFs and CT “A” on the line must be on the same phase coming from the utility. CT “B” on the wire to each AHF must be on the wire going to the middle terminal on the power switches of both AHFs and CT “B” on the line must be on the same phase coming from the utility. If “C” CTs are used, they must match up similarly. A CT shorting block is required to connect the output wires from all of the “A” CTs, all of the “B” CTs, and (if used) all of the “C” CTs as shown in the figure. If you can run the same phase power wires of each AHF together at some point, you could use one set of CTs to measure all of the AHF currents, thus cutting down on the number of CTs required. This arrangement will work for more than 2 paralleled AHFs as well.

### 3.5. HMI (HUMAN MACHINE INTERFACE)

The HMI (Human Machine Interface) is shown below. It is housed in a dust-proof, water-resistant metal enclosure that is usually mounted on the front of the enclosure housing the AHF. It consists of a 7" 800x480 pixel resistive touch screen color display, 3 status LEDs, and additional interface features described in this section. See section 5 for detailed information on the touch screen and section 5.12 for detailed information on the 3 status LEDs.



The HMI also has the following control related functions that can be externally wired to. These functions are located in the HMI enclosure. All wiring to this enclosure that is to leave the cabinet, should be routed either up or down the left side interior of the enclosure in order to keep it separated from the power wiring (refer to Figure 3.8 to see wiring path). The HMI enclosure is equipped with 3 dust-tight, water-resistant access points to these signals on the one side of the HMI enclosure. If the HMI is exposed to water or gases hazardous to electronics (e.g. hydrogen-sulfide), the dust-tight, water-resistant features of the HMI enclosure should be maintained.

#### 3.5.1. HMI POWER & COMMUNICATIONS CONNECTION

The bottom access point has a grey Cat-5 or better cable that connects the HMI to the internal controls of the AHF. This is the only required connection to the HMI. It provides the 24-volt DC supply that powers the HMI and the communications link to the AHF controls. It connects to the RJ-45 P7 connector (color coded with a grey dot) of the PC-C AHF Control board. The standard length of this cable is 7'; however, the customer can mount the HMI remotely by either extending this cable up to 50' with a RJ-45 connector coupler or replacing the 7' cable with a different cable. It is recommended that a grey colored cable is used to keep with the color coding of cables used in the system. Although it uses the same type of cable as Ethernet, this cable is NOT and an Ethernet connection.

#### 3.5.2. ETHERNET CONNECTION

The top access point houses an RJ-45 Ethernet connector. A Cat-5 or better cable supplied by the customer can be used to connect this point to the customer's computer network or stand-alone computer. Through this Ethernet connection, AHF operating parameters can be monitored and/or altered. See section ETHERNET COMMUNICATIONS

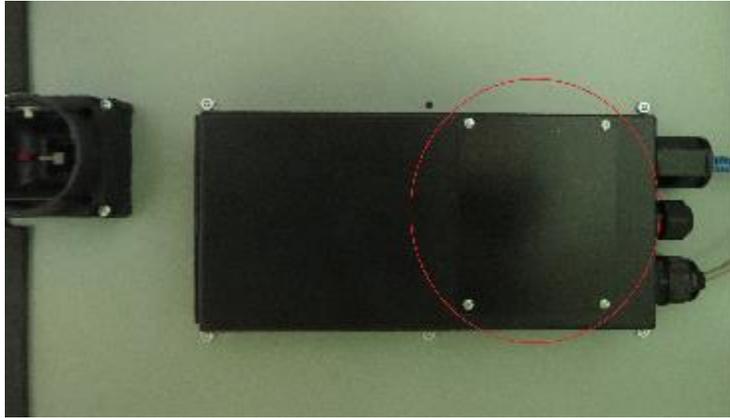
for details. Note: to remove a cable from this connection, a small flat blade screwdriver will be needed to push the tab of the cable connector down to release the cable from the HMI connector.

Refer to section 5.9 for details on setting up this Ethernet network connection.

#### 3.5.3. CONTROL STATUS RELAY CONTACTS & EXTERNAL ENABLE

The HMI has three status relays whose contacts can be accessed via the P9 terminal block inside the HMI enclosure. If desired, these signals can be wired to external circuitry supplied by the end user for the purpose of monitoring status of the system.

To access the relay connector, remove the 4 screw cover from the back of the front panel. See picture below. The cover is circled in red.



Removing the cover, exposes a green 9 pin terminal block (P9) that is used to connect to the status relays. This relay terminal block is circled in red in the following picture



- The first status relay uses pins 1 (common), 2 (normally open contact), and 3 (normally closed contact) of the connector.
- The second status relay uses pins 4 (common), 5 (normally open contact), and 6 (normally closed contact).
- The third status relay uses pins 7 (common), 8 (normally open contact), and 9 (normally closed contact).

If the unit is fully operational and correcting harmonics, the first status relay will be energized (pins 1 and 2 of the connector will be shorted, pins 1 and 3 will be open). If a diagnostic or warning condition exists, the second status relay will be energized (pins 4 and 5 of the connector will be shorted, pins 4 and 6 will be open). If the unit is operating at maximum capacity, the third status relay will be energized (pins 7 and 8 of the connector will be shorted, pins 7 and 9 will be open). The maximum rating of each contact is 0.5 amps @ 125 VAC or 1.0 amps @ 24 VDC.

The green 2 pin terminal block (P11), shown in the previous picture above the green 9 pin block are the connections to be made if the customer desires to control the ON/OFF operation of the AHF from an external dry contact. The system can be set up via the “EXTERNAL ENABLE INPUT” parameter on the “CUSTOMER PARAMETERS” display (see section 5.6.1) to enable the system via this input if the input is shorted, open, or ignored. The default from the factory is that this input is ignored (not used).

Wiring to either of these terminal blocks should enter the HMI enclosure through the middle access point. Unscrew the external black plastic cap of this access point, remove the foam insulation used to block the feed through hole, feed your wires through the hole, and tighten the plastic cap to seal the connection. Although not required, it is recommended to use one cable having multiple wires for these connections as opposed to several individual wires, especially if the dust-tight, water-resistant feature of the HMI enclosure needs to be maintained.

### **3.5.4. INDUSTRIAL NETWORK CONNECTION**

A factory option exists to add an industrial network connection (Ethernet/IP, Modbus/TCP, etc.) to the HMI. If this option is present, the side of the HMI enclosure opposite the side with the 3 access points previously mentioned will have connectors in place of the usual side cover plate. The usual industrial network connections provided are standard RJ-45 connectors. The addition of these to the HMI enclosure will result in the HMI enclosure no longer being completely dust tight or water-resistant, so if maintaining this feature is necessary for your application, consult with the factory for alternative industrial network connections that can be used.

Normally, there will be 2 connectors associated with your industrial network add-on. In such a case either can be connected to. The presence of 2 connectors allows serial daisy-chaining the HMI with other equipment in your network if you do not have a spare Ethernet switch input to connect to.

Refer to section 7 for detailed information about using your industrial network interface.

### **3.5.5. BATTERY REPLACEMENT & HMI INPUT CONNECTOR**

The HMI uses a CR2032 type coin-size battery to maintain its clock and some battery backed up memory functions. This battery should last more than 10 years. If it’s energy becomes depleted to the point that it needs to be replaced, it is accessible via the back cover of the HMI enclosure.

Also accessible via the back cover is the connection from the AHF controls that brings 24V power and the communications with the AHF controls to the HMI. This is the Cat-5 connection exposed when the back cover is removed. If this cable is to be replaced (e.g. by a longer cable), this connection must be removed and the cable pulled through the access point in the HMI enclosure. It is rather tricky to pull this cable through the access point, so call the factory for assistance before trying to do so.

### **3.5.6. USB AND ETHERNET ACCESS VIA THE HMI FRONT COVER**

There is a front cover to the right of the LCD display that is attached with 2 thumb screws. Unthread the top screw, then just loosen the bottom screw so that you can swing the front cover open, exposing the components as shown in the picture to the right. The USB connector can be used to plug in a flash drive. The HMI via the LCD display can be instructed to download various stored history data to the drive (see section 5.8 for additional details).



Also in this compartment is a Cat-5 cable plugged into a RJ45 connector. This is the Ethernet connection that gets routed to the top access point of the HMI enclosure. One can remove this cable from this connector and plug another Cat-5 cable into the RJ45 connector, and go to a computer or network with the added cable to look at data or parameters over the Ethernet connection. This allows access to the Ethernet

without having to open the enclosure door of the AHF to get to the Ethernet connection at the HMI enclosure.

There is also a pushbutton switch in this compartment. Pressing and releasing this switch will manually reset the HMI in the unlikely event that the HMI stops responding.

Lastly, there is a small shunt across 2 posts. This is used for diagnostics and should always remain in place unless otherwise instructed.

## 4. STARTING UP THE UNIT FOR THE FIRST TIME

Starting up the HPS TruWave AHF for the first time requires a simple procedure to be followed to verify that the unit has been installed correctly. Once all the power and CT (current transformer) sensor connections have been made, as described in the previous section, and the electrical service re-established, the AHF can be turned on and tested for proper installation. For more complete testing, a load should be present in the circuit that the AHF is correcting harmonics for.

For maximum accuracy, the load used during this test should predominately be 3-phase with a high linear power factor. Moderately to heavily loaded AC motor drives are the best loads to perform this test with as they will appear as only slightly inductive. Highly capacitive or inductive loads should be eliminated or minimized. Load must result in phase shifts between currents and corresponding line-to-neutral voltages between -10 degrees (not too capacitive) and +30 degrees (not too inductive). Loads (if they represent a sizeable portion of the overall load) that should be taken off line during the testing of the CTs are as follows:

- 1) Motors driven directly from the line (with or without soft-starters) – May appear too inductive, especially if motor is lightly loaded.
- 2) Equipment with EMC filters, unless being operated at moderate load – May appear too capacitive or inductive.
- 3) AC Motor drives operating at very light loads.
- 4) DC Motor drives (or other phase control input equipment) that is not at least moderately loaded – May appear too inductive.

These test results assume that the CTs are at least on different phases. Erroneously putting more than 1 CT on the same phase is not covered.

If CTs are installed on the “Line” side, it may still be possible to partially test the installation with insufficient load present using the procedure described in section 4.4; however, you should call the manufacturer for assistance before doing so. If CTs are installed on the “Load” side, you must have a load to check the system.

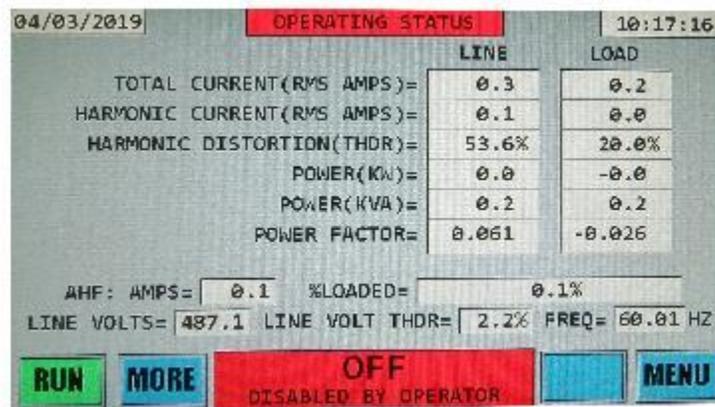
Throughout the following sections, displays of a 100 amp AHF are shown as examples. The displays you observe with your unit may differ somewhat.

### 4.1. TURNING ON THE UNIT TO CHECK FOR CORRECT CT PLACEMENT

To energize the unit, switch on the Disconnect switch to the AHF. If the power is connected correctly, the touch screen display will turn on. It is assumed that you are familiar with the Touch Screen Display. Please refer to section 5 for additional details on using the display. While the display is booting up, the following splash screen will be displayed. The system is shipped in the disabled state, so even though power is applied, the AHF will not start correcting harmonics – only the controls will be powered. To enable the system, you will be instructed later in this procedure to RUN (enable) the system. Once, running, the system can be STOPPED (disabled) in a similar manner. If the power switch on the unit is powered off, whatever state the system is in, enabled or disabled, when the system is powered off, is what the system will be in the next time power again is supplied to the unit. For this reason, it is important that if the system either does not successfully pass this test or you do not wish the system to operate yet, one should make sure the system is disabled (using the STOP function) prior to turning off the power switch.

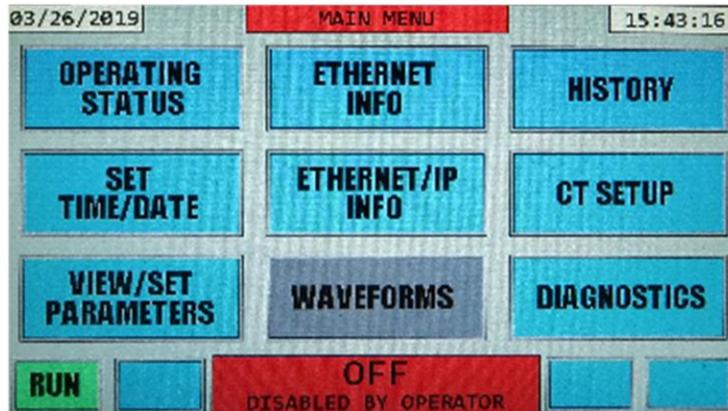


Do not press RUN when powering on the unit for the first time. After 5 seconds the “OPERATING STATUS” display page will appear. Pressing the STOP button when the splash screen is displayed will immediately send you to the “OPERATING STATUS” display instead of waiting the 5 seconds.

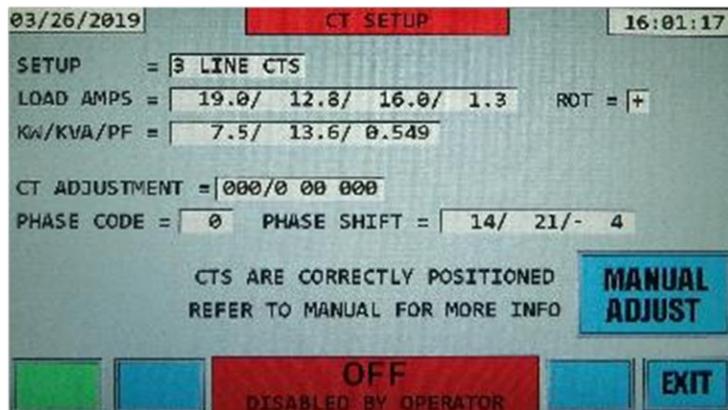


If a STOP button is shown instead of the RUN button on the bottom right of the display, press the STOP button displayed, followed by an acknowledgement of the STOP button in the display that follows to disable the AHF from operating. After pressing the STOP button in the two displays, you will be returned to the “OPERATING STATUS” display and the RUN button should now be displayed. In the middle of the display at the bottom, the message OFF – DISABLED BY OPERATOR status should be displayed. If not, go to troubleshooting portion of this manual to determine the problem based on the message displayed.

We will next want to go to the “CT SETUP” screen on the display to check for proper CT installation. First, press the “MENU” button located in the extreme bottom right of the display. The main menu page will be displayed:



Press the “CT SETUP” button from the menu to view the “CT SETUP” display:



Please note that the button on the lower left is blank and should be green. The button is blank and non-functional to prevent the unit from being enabled while in the CT SETUP display. If the unit was already enabled, the button on the bottom left would be red and say STOP.

The first line of this display, displays the “CT SETUP” title along with the present date and time.

The 2<sup>nd</sup> line indicates how many CTs the system is programmed for (2 or 3), and whether the system is programmed for LINE or LOAD side CTs. Make sure this matches your particular setup. This test cannot determine if you have erroneously put one or more of the CTs on the LOAD side but have declared they are on the LINE side or if you have erroneously put one or more of the CTs on the LINE side but have declared they are on the LOAD side. Not having this correct will result in erroneous operation of the unit.

The 3<sup>rd</sup> line shows how much current is presently being drawn by the load. The first 3 numbers, separated by “/” characters are the 3 phases A, B, and C. The 4<sup>th</sup> number indicates the neutral current. The neutral current is calculated by the AHF for systems that have 3 CTs. It is not possible to calculate the neutral current for 2 CT systems, so dashes will be displayed for such systems. The 3<sup>rd</sup> line also shows the phase rotation (“ROT=” + for ABC and – for CBA phase rotation). This rotation information is for informational purposes only. The AHF automatically adjusts for either rotation.

The 4th line shows the present real power in KW and apparent power in KVA, as well as the power factor of the load. Verify that the number of CTs indicated and the position (LINE or LOAD) agrees with the number of physical CTs and location of those CTs you have wired into your system. If not, go to section **Error! Reference source not found.**5 of this manual to correct these values. The power factor of the load (“PF”) should ideally be a positive number between about 0.7 and .999. If it is not, it may be due to mis-positioned CTs; however, don’t worry about that at this time. This example shows that the AHF is set up for 3 CTs located on the LINE side. Also, a power factor of 0.549 is indicated with a positive phase rotation. In this particular case, the low power factor of 0.549 is due to a very high amount of harmonic current present and not due to a highly capacitive or inductive load or due to incorrectly placed CTs, so does not present a problem.

The 5th line titled “CT ADJUSTMENT” indicates any “programmed” adjustment that the AHF has been set up for to compensate for CTs that are not placed correctly. The firmware can allow for mis-positioned CTs to be compensated for without actually moving the CTs to their correct positions.

The first number in the 6<sup>th</sup> line is the “Phase code”. This value will be “0” if your CTs are installed correctly. A non-zero code between -28 and 43 indicates the CTs are not on the correct phases and/or are in the wrong direction. Any other code indicates the system is unable to determine the status of the CTs. Following the “Phase code”, are 3 values”, these 3 values are the phase shift (in degrees) between phase A, B, and C voltages and currents. When the CTs are positioned on the correct phases and in the correct direction, these values should all be between -10 and +30 degrees. If not, either a CT is in the wrong position or the load is too capacitive or inductive to evaluate the CT positions. Also, in order to determine the phase shift between the voltage and current for each phase, there must be some minimal load current present. If there is insufficient load current on any phase, dashes will be displayed for all phases that are not reading enough current. If you think you have load current, but dashes are displayed, one possibility is that you are using shorting blocks to wire your CTs to and have inadvertently left a short in place across one or more of the CTs. Also, if 3 CTs are indicated in the 2<sup>nd</sup> line and the 3<sup>rd</sup> phase shift number is the only value displaying dashes, check to make sure your system does indeed have 3 CTs. If you are using 2 CTs and you have current showing on phase A but very little on phase B, or on phase B but very little on phase A, the phase not reading much current is not correctly wired or is being shorted by a shorting block.

Depending on the value of the “Phase code” in line 6, a status message will be displayed on the 7<sup>th</sup> line of this display. Table 4.1 contains the possible status messages, their explanation, and action you need to take.

<b>CT SETUP Message</b>	<b>Explanation and Action to Take</b>
LOAD CURRENT TOO LOW	Insufficient load current to determine if CTs are placed correctly. Continue with this present section.
LOAD TOO CAPACITIVE/INDUCTIVE	Load current is high enough; however, load is either too capacitive or inductive to correctly determine if CTs are placed correctly. Continue with this present section.
<b>CTS ARE CORRECTLY POSITIONED</b>	<b>CTs are on the correct phases and in the correct direction. CTs are correctly configured, go to section 4.2.4.</b>
<b>CTS ARE CORRECTLY ADJUSTED</b>	<b>CTs are not on the correct phases or in the correct direction; however, a programmed “CT ADJUSTMENT” has been entered that corrects the situation. CTs are correctly configured, go to section 4.2.4.</b>
ERRONEOUS PHASE CODE	Should not see this message. Stop and contact factory if you do see it.
2 CTS ON A&C. MUST BE ON A&B	When using 2 CTs, they must be located on phases A and B. Go to section 4.2 to correct.
2 CTS ON B&C. MUST BE ON A&B	When using 2 CTs, they must be located on phases A and B. Go to section 4.2 to correct.
FIX CTS OR ADJUST HERE	CTs are not on the correct phases and/or are in the wrong direction. Go to section 4.2 to correct.

**Table 4.1: CT SETUP Status Messages**

If you observe either of the first 2 messages in this table, you can NOT proceed to the next section (4.2) of this CT test until you remedy the situation.

If you see the “LOAD CURRENT TOO LOW” message, the CTs are not sensing enough current on one or more phases to determine the phase shift between the voltage and current. The 3 numbers in the 6<sup>th</sup> line will have dashes instead of the angular phase shift in degrees for all phases that are not sensing sufficient current. If your load is very small, you will have this situation. The line titled “LOAD AMPS” will

tell you the current being sensed by the CTs. If you know that the current should be much higher than any of these values, you may have a problem with your CTs. If such is the case check for the following:

- If you have wired your CTs into shorting blocks, you may have inadvertently left one or more CTs shorted.
- If you have 3 CTs indicated on the 2<sup>nd</sup> line of this display, but only have 2 physical CTs wired into your system, you will either need to add a 3<sup>rd</sup> physical CT or change the AHF setting to 2 CTs (see section 5.6.5 for details).
- If your CTs are NOT installed to properly read the LINE or LOAD current, you will need to correct this. WARNING: if the CTs are installed around a wire with current flowing in it, but the output wires of the CTs are not properly connected, do NOT touch the CT output wires until all power is shut off to the loads and no current is flowing in the wire being measured by the CT; otherwise, deadly voltage may be present on those output wires.

If you confirm that the reason for not reading much current is due to there not being much load operating, increase the load. If the load cannot yet be increased because it is not yet operational, you will not be able to continue with this test. Instead, if your CTS are located on the “Line” side, call the manufacturer for how to perform a less comprehensive “No load” test described in section 4.4 to perform a less comprehensive “No load” test. If your CTs are positioned on the “Load” side, you will need to apply load before proceeding.

If you see the “LOAD TOO CAPACITIVE/INDUCTIVE” message displayed, your load is either too capacitive or inductive for the AHF to accurately determine if the CTs are correctly positioned. Determine the loads that are presently running. If possible, remove any that might be highly capacitive or inductive (see beginning of section 4 to identify such loads). If removing such loads is not possible, consult with the manufacturer for additional assistance. Take a picture of the CT SETUP display while it is showing this message for the purpose of emailing the picture to the manufacturer for evaluation.

## 4.2. CORRECTING CTS THAT ARE INCORRECTLY INSTALLED

If the status message on the CT SETUP display is either “2 CTS ON A&C. MUST BE ON A&B”, “2 CTS ON B&C, MUST BE ON A&B”, or “FIX CTS OR ADJUST HERE” message, the CTs have been installed incorrectly on the wrong phases and/or in the wrong direction. If you have a system configured for 2 CTs, use Table 4.2 to determine how your CTs are incorrectly installed. If you have a system configured for 3 CTs, use Table 4.3 to determine how your CTs are incorrectly installed. The PHASE CODE value on the 6<sup>th</sup> line of the CT SETUP display will be a number ranging from -28 to 43. This number is referred to as your “Phase Code”. This number corresponds to how your CTs are actually positioned. Go down the “Phase Code” column in the applicable table until you find the number that matches the number observed on the CT SETUP display. There are 3 columns in the table labeled A, B, and C under the title “LINE”. On the line of the table having your “Phase Code” will be letters A, B, or C (C is only present in 3 CT systems) in these columns. These letters may or may not have a “-” minus sign after them. These letters refer to CTs “A”, “B”, and “C”. A “-” after the letter indicates the CT is installed backwards. For the AHF to work properly, you need to have an “A” in the “LINE A” column, a “B” in the “LINE B” column, and (for 3 CT systems only) a “C” in the “LINE C” column, with no “-” minus signs. This only occurs in the ***BOLDED, ITALIZED*** line in the chart when the Phase Code is 0.

For all other cases, either the CTs or the lines must be changed so that the CTs and the lines match each other. There are 3 different courses of action that can be taken to achieve this correction. Each is described in the 3 subsections that follow. Read all 3 options, and select the option that is best for your situation. These 3 subsections are followed by a 4<sup>th</sup> subsection with some examples. After you have corrected your CT situation and now observe the message “CTS ARE CORRECTLY POSITIONED” or “CTS ARE CORRECTLY ADJUSTED”, proceed to section 4.3.

#### 4.2.1. CORRECTING CT PLACEMENT BY PHYSICALLY MOVING THE CTS

The column titled “Corrective Action to move CTs to match Power Wires” in the tables indicates how to move the CTs to fix the problem. If your CTs are accessible and fairly easy to move safely to the correct position, then choose that route. If the CTs are not physically accessible or it is not practical to physically move the CTs, one of the other 2 options may make more sense.

If you have paralleled AHFs, choosing this method of correcting the CTs may only involve moving the 2 or 3 CTs. Selecting either of the remaining 2 options requires corrections done to all of the AHFs that are paralleled.

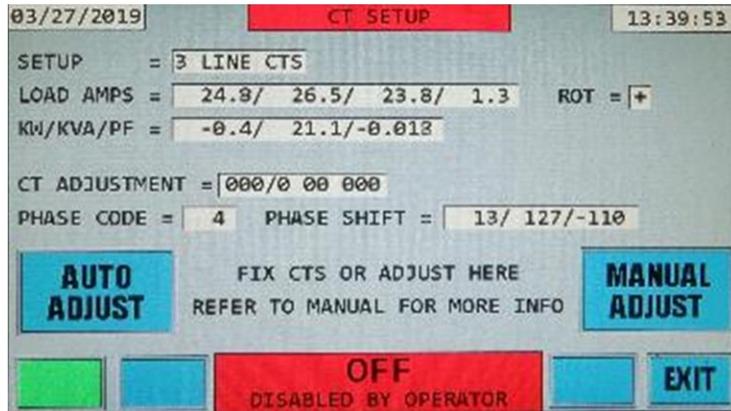
#### 4.2.2. CORRECTING CT PLACEMENT BY MOVING THE POWER WIRES TO THE AHF

Another column titled “Or Corrective Action to move Power Wires to match CTs” indicates how to move the power wires coming into the AHF to fix the problem. When moving the power wire connections in the AHF, wires 1, 2, and 3 in the charts refer to the wires connected to the left, center, and right power switch terminals (or fuseblocks). The letters A, B, and C in the charts refer to the left, center, and right power switch terminals (or fuseblocks). Prior to any wire movements, wire 1 is connected to A, wire 2 is connected to B, and wire 3 is connected to C. The wire movement instructions in the tables will result in 2 or 3 wires being moved to different terminals.

If the power wires coming into the AHF’s power switch terminals (or fuseblocks) are easier to change than physically moving the CTs, you may want to select this option. Prior to moving the power wires, remove voltage from those wires. Note that switching the power wire connections cannot fix a CT that is installed backwards. To fix a backwards CT, the CT must be removed from the wire and reinstalled in the opposite direction, or the output wires of the CT must be reversed, or the “AUTO ADJUST” function on the CT SETUP display described in the next subsection can be used. On HPS supplied CTs, reversing the output wires of the CT means swapping the black and white wires so the white wire becomes the positive (+) wire and the black wire becomes the negative (-) wire. **WARNING: DO NOT DISCONNECT CT OUTPUT WIRES WHILE CURRENT IS FLOWING IN THE WIRE MONITORED BY THE CT. DOING SO COULD RESULT IN LETHAL VOLTAGE AT THE CT OUTPUT WIRES. LINE VOLTAGE MUST BE REMOVED FROM THE CIRCUIT MONITORED BY THE CT PRIOR TO DISCONNECTING THE CT OUTPUT WIRES.** (Exception: if the CT output wires are brought to a shorting block, a short may be applied to that block to short both CT output wires together. Then the 2 wires for that CT connecting the shorting block to the AHF’s CT Interface board may be swapped at the AHF’s CT Interface board. Once the wires are re-secured, the short must be removed from the block.)

#### 4.2.3. CORRECTING CT PLACEMENT VIA THE CT SETUP DISPLAY

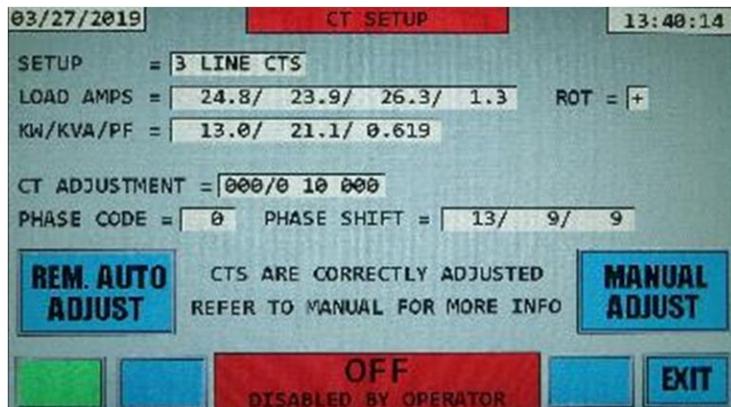
This 3<sup>rd</sup> method will normally be the easiest of the 3 methods to correct incorrectly placed CTs. If your setup uses 3 CTs, you can use this method to correct all cases. If the message “FIX CTS OR ADJUST HERE” is displayed on the 7<sup>th</sup> line of the CT SETUP display, you can fix the problem from this display screen. If your setup uses 2 CTs, you may instead observe the message “2 CTS ON A&C. MUST BE ON A&B” or “2 CTS ON B&C. MUST BE ON A&B”. When using 2 CTs, the CTs must be located on the 2 phases that connect to the left and center terminal of your power switch and/or fuseblock in the AHF. These 2 messages indicate that is not your case. You must first move the power wires as indicated using the method in section 4.2.2. If that corrects your CT problem, you are done. If that results in still having a problem (due to a CT being installed backwards), but now observe the message “FIX CTS OR ADJUST HERE”, you can finish fixing the problem using the method described in this section. See picture below for example of CTs which can be fixed with the AUTO ADJUST button.



Press the AUTO ADJUST button. Within a second or two, the PHASE CODE will change to 0 and the “FIX CTS OR ADJUST HERE” message will change to “CTS ARE CORRECTLY ADJUSTED”. You will also notice that the CT ADJUSTMENT value now has some 1’s in it in place of the 0’s. Also the AUTO ADJUST button will be replaced by a REMOVE ADJUST button. Pressing this button will remove the adjustment you made. If in the future you move your CTs or power wires to your AHF and now have the wrong adjustment, you will first have to remove the adjustment by pressing the REMOVE ADJUST button, and then if a different adjustment is needed, press the AUTO ADJUST button.

The only downfall with using this method of CT correction vs. the other methods is if for some reason you need to change the control board in your system, you will need to go through this procedure again as this information is stored in non-volatile memory on the control board.

See picture below for an example of what the display will look like after CT placement has been corrected with the AUTO ADJUST button.



To remove a CT adjustment, press the REM.AUTO ADJUST button.

MANUAL ADJUST is a feature you may be asked to use by the factory in certain cases.

See tables 4.2 and 4.3 below for explanations of the Phase Code and the corrective action you can take.

**Table 4.2: Incorrect CT Placement and Corrective Action Needed for a 2 CT System**

Phase Code	LINE			Corrective Action to move CTs to match Power Wires	Or Corrective Action to move Power Wires to match CTs (See Note 1)
	A	B	C		
-28	B		A	Move "B" CT to wire without a CT, then move "A" CT to wire that "B" CT was previously on.	Move wire 3 from C to A. Move wire 1 from A to B. Move wire 2 from B to C.
-24		B	A	Move "A" CT to wire without a CT.	Exchange wires 1 and 3, so 3 goes to A and 1 goes to C.
-22	B-		A	Move "B" CT (and flip direction) to wire without a CT, then move "A" CT to wire that "B" CT was previously on.	Move wire 3 from C to A. Move wire 1 from A to B. Move wire 2 from B to C.
-18		B-	A	Move "A" CT to wire without a CT, then flip direction of "B" CT.	Exchange wires 1 and 3, so 3 goes to A and 1 goes to C.
-16	B	A-		Swap wires that "A" and "B" CTs are on and flip direction of "A" CT.	Exchange wires 1 and 2, so 2 goes to A and 1 goes to B.
-14		A-	B-	Move "A" CT (and flip direction) to wire without a CT, then move "B" CT (and flip direction) to wire that "A" CT was previously on.	Move wire 2 from B to A. Move wire 3 from C to B. Move wire 1 from A to C.
-10	B-	A-		Swap wires that "A" and "B" CTs are on and flip direction of both CTs.	Exchange wires 1 and 2, so 2 goes to A and 1 goes to B.
-8		A-	B	Move "A" CT (and flip direction) to wire without a CT, then move "B" CT to wire that "A" CT was previously on.	Move wire 2 from B to A. Move wire 3 from C to B. Move wire 1 from A to C.
-2	A		B-	Move "B" CT (and flip direction) to wire without a CT.	Exchange wires 2 and 3, so 3 goes to B and 2 goes to C.
0	<b>A</b>	<b>B</b>		<b>CORRECT INSTALLATION</b>	<b>CORRECT INSTALLATION</b>
4	A		B	Move "B" CT to wire without a CT.	Exchange wires 2 and 3, so 3 goes to B and 2 goes to C.
6	A	B-		Flip direction of "B" CT.	No power wire changes
8	B		A-	Move "B" CT to wire without a CT, then move "A" CT (and flip direction) to wire that "B" CT was previously on.	Move wire 3 from C to A. Move wire 1 from A to B. Move wire 2 from B to C.
12		B	A-	Move "A" CT (and flip direction) to wire without a CT.	Exchange wires 1 and 3, so 3 goes to A and 1 goes to C.
14	B-		A-	Move "B" CT (and flip direction) to wire without a CT, then move "A" CT (and flip direction) to wire that "B" CT was previously on.	Move wire 3 from C to A. Move wire 1 from A to B. Move wire 2 from B to C.
18		B-	A-	Move "A" CT (and flip direction) to wire without a CT, then flip direction of "B" CT.	Exchange wires 1 and 3, so 3 goes to A and 1 goes to C.
20	B	A		Swap wires that "A" and "B" CTs are on.	Exchange wires 1 and 2, so 2 goes to A and 1 goes to B.
22		A	B-	Move "A" CT to wire without a CT, then move "B" CT (and flip direction) to wire that "A" CT was previously on.	Move wire 2 from B to A. Move wire 3 from C to B. Move wire 1 from A to C.
26	B-	A		Swap wires that "A" and "B" CTs are on and flip direction of "B" CT.	Exchange wires 1 and 2, so 2 goes to A and 1 goes to B.
28		A	B	Move "A" CT to wire without a CT, then move "B" CT to wire that "A" CT was previously on.	Move wire 2 from B to A. Move wire 3 from C to B. Move wire 1 from A to C.
34	A-		B-	Flip direction of "A" CT, then move "B" CT (and flip direction) to wire without a CT.	Exchange wires 2 and 3, so 3 goes to B and 2 goes to C.
36	A-	B		Flip direction of "A" CT.	No power wire changes
40	A-		B	Flip direction of "A" CT, then move "B" CT to wire without a CT.	Exchange wires 2 and 3, so 3 goes to B and 2 goes to C.
42	A-	B-		Flip direction of both "A" and "B" CTs.	No power wire changes

Note 1: If Power wires are being moved to correct the incorrect CT installation and either (or both) of the letters "A" and "B" in the LINE columns have a "-" sign after the letter, that CT is in the wrong direction. Besides moving the power wires as indicated, the direction of that CT will have to be fixed using one of the three methods described in section 4.2.2.

**Table 4.3: Incorrect CT Placement and Corrective Action for a 3 CT System (page 1 of 2)**

Phase Code	LINE			Corrective Action to move CTs to match Power Wires	Or Corrective Action to move Power Wires to match CTs (See Note 1)
	A	B	C		
-28	B	C	A	Move "B" CT to wire that "C" CT is on, then move "A" CT to wire that "B" CT was previously on, then move "C" CT to wire that "A" CT was previously on.	Move wire 3 from C to A. Move wire 1 from A to B. Move wire 2 from B to C.
-27	B	C-	A	Move "B" CT to wire that "C" CT is on, then move "A" CT to wire that "B" CT was previously on, then move "C" CT (and flip direction) to wire that "A" CT was previously on.	Move wire 3 from C to A. Move wire 1 from A to B. Move wire 2 from B to C.
-24	C-	B	A	Swap wires that "A" and "C" CTs are on, flipping direction of "C".	Exchange wires 1 and 3, so 3 goes to A and 1 goes to C.
-23	C	B	A	Swap wires that "A" and "B" CTs are on.	Exchange wires 1 and 3, so 3 goes to A and 1 goes to C.
-22	B-	C	A	Move "B" CT (and flip direction) to wire without a CT, then move "A" CT to wire that "B" CT was previously on, then move "C" CT to wire that "A" CT was previously on..	Move wire 3 from C to A. Move wire 1 from A to B. Move wire 2 from B to C.
-21	B-	C-	A	Move "B" CT (and flip direction) to wire without a CT, then move "A" CT to wire that "B" CT was previously on, then move "C" CT (and flip direction) to wire that "A" CT was previously on.	Move wire 3 from C to A. Move wire 1 from A to B. Move wire 2 from B to C.
-18	C-	B-	A	Swap wires that "A" and "C" CTs are on, flipping direction of "C" CT, then flip direction of "B" CT.	Exchange wires 1 and 3, so 3 goes to A and 1 goes to C.
-17	C	B-	A	Swap wires that "A" and "C" CTs are on, then flip direction of "B" CT.	Exchange wires 1 and 3, so 3 goes to A and 1 goes to C.
-16	B	A-	C	Swap wires that "A" and "B" CTs are on, flipping direction of "A".	Exchange wires 1 and 2, so 2 goes to A and 1 goes to B.
-15	B	A-	C-	Swap wires that "A" and "B" CTs are on, flipping direction of "A", then flip direction of "C" CT.	Exchange wires 1 and 2, so 2 goes to A and 1 goes to B.
-14	C-	A-	B-	Move "A" CT (and flip direction) to wire that "C" CT is on, then move "B" CT (and flip direction) to wire that "A" CT was previously on, then move "C" CT (and flip direction) to wire that "B" CT was previously on.	Move wire 2 from B to A. Move wire 3 from C to B. Move wire 1 from A to C.
-13	C	A-	B-	Move "A" CT (and flip direction) to wire that "C" CT is on, then move "B" CT (and flip direction) to wire that "A" CT was previously on, then move "C" CT to wire that "B" CT was previously on.	Move wire 2 from B to A. Move wire 3 from C to B. Move wire 1 from A to C.
-10	B-	A-	C	Swap wires that "A" and "B" CTs are on and flip direction of both CTs.	Exchange wires 1 and 2, so 2 goes to A and 1 goes to B.
-9	B-	A-	C-	Swap wires that "A" and "B" CTs are on and flip direction of both CTs, then flip direction of "C" CT.	Exchange wires 1 and 2, so 2 goes to A and 1 goes to B.
-8	C-	A-	B	Move "A" CT (and flip direction) to wire that "C" CT is on, then move "B" CT to wire that "A" CT was previously on, then move "C" CT (and flip direction) to wire that "B" CT was previously on.	Move wire 2 from B to A. Move wire 3 from C to B. Move wire 1 from A to C.
-7	C	A-	B	Move "A" CT (and flip direction) to wire that "C" CT is on, then move "B" CT to wire that "A" CT was previously on, then move "C" CT to wire that "B" CT was previously on.	Move wire 2 from B to A. Move wire 3 from C to B. Move wire 1 from A to C.
-2	A	C	B-	Swap wires that "B" and "C" CTs are on, flipping direction of "B".	Exchange wires 2 and 3, so 3 goes to B and 2 goes to C.
-1	A	C-	B-	Swap wires that "B" and "C" are on, flipping direction of both "B" and "C".	Exchange wires 2 and 3, so 3 goes to B and 2 goes to C.
0	A	B	C	<b>CORRECT INSTALLATION</b>	<b>CORRECT INSTALLATION</b>
1	A	B	C-	Flip direction of "C" CT.	No power wire changes
4	A	C	B	Swap wires that "B" and "C" CTs are on.	Exchange wires 2 and 3, so 3 goes to B and 2 goes to C
5	A	C-	B	Swap wires that "B" and "C" CTs are on, flipping direction of "C".	Exchange wires 2 and 3, so 3 goes to B and 2 goes to C
6	A	B-	C	Flip direction of "B" CT.	No power wire changes
7	A	B-	C-	Flip direction of both "B" and "C" CTs.	No power wire changes

Note 1: If Power wires are being moved to correct the incorrect CT installation and either (or both) of the letters "A" and "B" in the LINE columns have a "-" sign after the letter, that CT is in the wrong direction. Besides moving the power wires as indicated, the direction of that CT will have to be fixed using one of the three methods described in section 4.2.2.

**Possible CT Placement and Corrective Action for a 3 CT System (page 2 of 2)**

Phase Code	LINE			Corrective Action to move CTs to match Power Wires	Or Corrective Action to move Power Wires to match CTs (See Note 1)
	A	B	C		
8	B	C	A-	Move "B" CT to wire that "C" CT is on, then move "A" CT (and flip direction) to wire that "B" CT was previously on, then move "C" CT to wire that "A" CT was previously on.	Move wire 3 from C to A. Move wire 1 from A to B. Move wire 2 from B to C.
9	B	C-	A-	Move "B" CT to wire that "C" CT is on, then move "A" CT (and flip direction) to wire that "B" CT was previously on, then move "C" CT (and flip direction) to wire that "A" CT was previously on.	Move wire 3 from C to A. Move wire 1 from A to B. Move wire 2 from B to C.
12	C-	B	A-	Swap wires that "A" and "C" CTs are on, flipping direction of both "A" and "C" CTs.	Exchange wires 1 and 3, so 3 goes to A and 1 goes to C.
13	C	B	A-	Swap wires that "A" and "C" CTs are on, flipping direction of "A" .	Exchange wires 1 and 3, so 3 goes to A and 1 goes to C.
14	B-	C	A-	Move "B" CT (and flip direction) to wire that "C" CT is on, then move "A" CT (and flip direction) to wire that "B" CT was previously on, then move "C" CT to wire that "A" CT was previously on.	Move wire 3 from C to A. Move wire 1 from A to B. Move wire 2 from B to C.
15	B-	C-	A-	Move "B" CT (and flip direction) to wire that "C" CT is on, then move "A" CT (and flip direction) to wire that "B" CT was previously on, then move "C" CT (and flip direction) to wire that "A" CT was previously on.	Move wire 3 from C to A. Move wire 1 from A to B. Move wire 2 from B to C.
18	C-	B-	A-	Swap wires that "A" and "C" CTs are on, flipping direction of both "A" and "C" CTs, then flip direction of "B" CT.	Exchange wires 1 and 3, so 3 goes to A and 1 goes to C.
19	C	B-	A-	Swap wires that "A" and "C" CTs are on, flipping direction of "A" CT, then flip direction of "B" CT.	Exchange wires 1 and 3, so 3 goes to A and 1 goes to C.
20	B	A	C	Swap wires that "A" and "B" CTs are on.	Exchange wires 1 and 2, so 2 goes to A and 1 goes to B.
21	B	A	C-	Swap wires that "A" and "B" CTs are on, then flip direction of "C" CT.	Exchange wires 1 and 2, so 2 goes to A and 1 goes to B.
22	C-	A	B-	Move "A" CT to wire that "C" CT is on, then move "B" CT (and flip direction) to wire that "A" CT was previously on, then move "C" CT (and flip direction) to wire that "B" CT was previously on.	Move wire 2 from B to A. Move wire 3 from C to B. Move wire 1 from A to C.
23	C	A	B-	Move "A" CT to wire that "C" CT is on, then move "B" CT (and flip direction) to wire that "A" CT was previously on, then move "C" CT to wire that "B" CT was previously on.	Move wire 2 from B to A. Move wire 3 from C to B. Move wire 1 from A to C.
26	B-	A	C	Swap wires that "A" and "B" CTs are on, flipping direction of "B" .	Exchange wires 1 and 2, so 2 goes to A and 1 goes to B.
27	B-	A	C-	Swap wires that "A" and "B" CTs are on and flip direction of "B" CT, then flip direction of "C" CT.	Exchange wires 1 and 2, so 2 goes to A and 1 goes to B.
28	C-	A	B	Move "A" CT to wire that "C" CT is on, then move "B" CT to wire that "A" CT was previously on, then move "C" CT (and flip direction) to wire that "B" CT was previously on.	Move wire 2 from B to A. Move wire 3 from C to B. Move wire 1 from A to C.
29	C	A	B	Move "A" CT to wire that "C" CT is on, then move "B" CT to wire that "A" CT was previously on, then move "C" CT to wire that "B" CT was previously on.	Move wire 2 from B to A. Move wire 3 from C to B. Move wire 1 from A to C.
34	A-	C	B-	Flip direction of "A" CT, then swap wires that "B" and "C" CTs are on, flipping direction of "B" .	Exchange wires 2 and 3, so 3 goes to B and 2 goes to C.
35	A-	C-	B-	Flip direction of "A" CT, then swap wires that "B" and "C" CTs are on, flipping direction of both "B" and "C" .	Exchange wires 2 and 3, so 3 goes to B and 2 goes to C.
36	A-	B	C	Flip direction of "A" CT.	No power wire changes
37	A-	B	C-	Flip direction of both "A" and "C" CTs.	No power wire changes
40	A-	C	B	Flip direction of "A" CT, then swap wires that "B" and "C" CTs are on.	Exchange wires 2 and 3, so 3 goes to B and 2 goes to C.
41	A-	C-	B	Flip direction of "A" CT, then swap wires that "B" and "C" CTs are on, flipping direction of "C" .	Exchange wires 2 and 3, so 3 goes to B and 2 goes to C.
42	A-	B-	C	Flip direction of both "A" and "B" CTs.	No power wire changes
43	A-	B-	C-	Flip direction of all 3 CTs.	No power wire changes

Note 1: If Power wires are being moved to correct the incorrect CT installation and either (or both) of the letters "A" and "B" in the LINE columns have a "-" sign after the letter, that CT is in the wrong direction. Besides moving the power wires as indicated, the direction of that CT will have to be fixed using one of the three methods described in section 4.2.2.

#### 4.2.4. EXAMPLES OF CORRECTING CT PROBLEMS

Following are a few examples of CTs that are not correctly positioned that must be fixed:

##### Example #1:

A Phase Code of 4 is observed on the CT SETUP display for a system with 2 CTs. "2 CTS ON A&C. MUST BE ON A&B" message will also be displayed on the CT SETUP display. Since this system has 2 CTs, Table 4.2 is used to determine what the problem is and how to correct the problem. We first go down the Phase Code column until we locate the Phase Code value of 4. We then look at the 3 LINE columns A, B, and C and find that CT "A" is correctly in column A, but CT "B" is in column C instead of column B. We have 2 options to correct the situation. We could move CT "B" from where it is to the wire that does not have a CT presently on it as instructed in the "Corrective Action to move CTs to match Power Wires" column or we could remove power from the power wires coming into the AHF, then swap power wires 2 & 3 coming into the AHF's power switch (or power fuseblock) as instructed in the "Or Corrective Action to move Power Wires to match CTs" column. If the CTs are accessible, we could select to move the CT. However, if the CTs are not accessible or it is very difficult to move the CT (possibly power to the entire MCC must be shut down or there is not enough room around the other wire for the CT, we may instead opt for swapping the power wires coming into the AHF. If so, assign the numbers 1, 2, and 3, to the wires coming into the left (A), center (B), and right (C) terminals, respectively, of either the AHF's input power switch or the AHF's input power fuse block. Swapping wires 2 and 3 at either the power switch or the fuse block so that wire 2 now connects to the right (C) terminal and wire 3 now connects to the middle (B) terminal will correct the problem.

##### Example #2:

A Phase Code of 40 is observed on the CT SETUP display for a system with 3 CTs. "FIX CTS OR ADJUST HERE" message will also be displayed on the CT SETUP display. Since this system has 3 CTs, Table 4.3 is used to determine what the problem is and how to correct the problem. We first go down the Phase Code column until we locate the Phase Code value of 40. This table occupies 2 pages, and we find the value of 40 on the 2<sup>nd</sup> page. A-, C, and B are listed in the 3 LINE columns A, B, and C. This indicates that CT "A" is correctly installed on the correct line, but the "-" sign indicates it is installed backwards. CT "B" and CT "C" are installed on the opposite lines, but since no "-" sign exists, they are in the correct direction. If the CTs are easily accessible and can safely be removed and installed on each other's line, we could opt for this solution that is given in the "Corrective Action to move CTs to match Power Wires" column. We would also need to remove CT "A" from its line, and reinstall it in the opposite direction. However, if the CTs cannot be easily or safely moved, we could opt for the solution given in the "Or Corrective Action to move Power Wires to match CTs" column. This solution requires the same swapping of wires that was done in Example 1, after power is removed, so that wire 2 is moved to the right (C) power terminal of the power switch of fuseblock and wire 3 is moved to the middle (B) terminal. We will also have to correct for CT "A" being installed backwards by swapping the white and black wires from CT "A" at the CT Interface board in the AHF. **WARNING: DO NOT DISCONNECT CT OUTPUT WIRES WHILE CURRENT IS FLOWING IN THE WIRE MONITORED BY THE CT. DOING SO COULD RESULT IN LETHAL VOLTAGE AT THE CT OUTPUT WIRES. LINE VOLTAGE MUST BE REMOVED FROM THE CIRCUIT MONITORED BY THE CT PRIOR TO DISCONNECTING THE CT OUTPUT WIRES.** (Exception: if the CT output wires are brought to a shorting block, a short may be applied to that block to short both CT output wires together. Then the 2 wires for that CT connecting the shorting block to the AHF's CT Interface board may be swapped at the AHF's CT Interface board. Once the wires are re-secured, the short must be removed from the block.

The problem described in this example could also be corrected using the "AUTO ADJUST" feature of the CT SETUP display. Once the "AUTO ADJUST" button is displayed on the LCD display, press it to perform the adjustment. In this example, this corrective procedure is much easier to implement than either of the other two corrective options.

### 4.3. ENABLING AHF AFTER CTS HAVE BEEN VERIFIED

If the message “CTS ARE CORRECTLY POSITIONED” or “CTS ARE CORRECTLY ADJUSTED” is shown on the CT SETUP display, it is now time to enable the AHF to start correcting harmonics. Exit the CT SETUP display by pressing the EXIT button in the bottom right corner of the display. The OPERATING STATUS display will open.

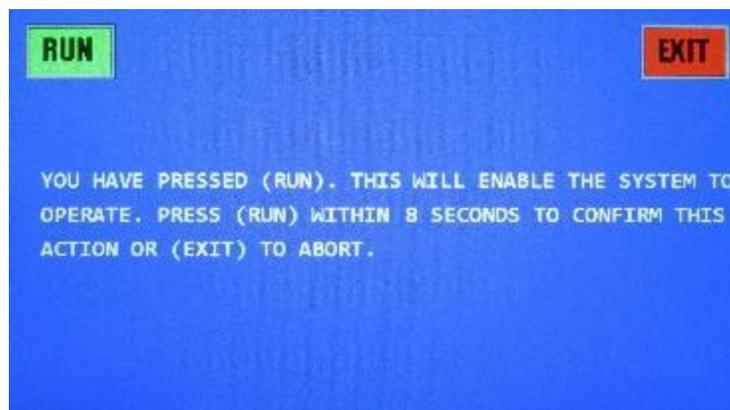
	LINE	LOAD
TOTAL CURRENT(RMS AMPS)=	94.0	94.0
HARMONIC CURRENT(RMS AMPS)=	61.1	61.1
HARMONIC DISTORTION(THDR)=	65.0%	65.0%
POWER(KW)=	59.4	59.4
POWER(KVA)=	79.2	79.2
POWER FACTOR=	0.750	0.750

AHF: AMPS= 0.1 %LOADED= 0.1%

LINE VOLTS= 486.1 LINE VOLT THDR= 1.5% FREQ= 60.01 HZ

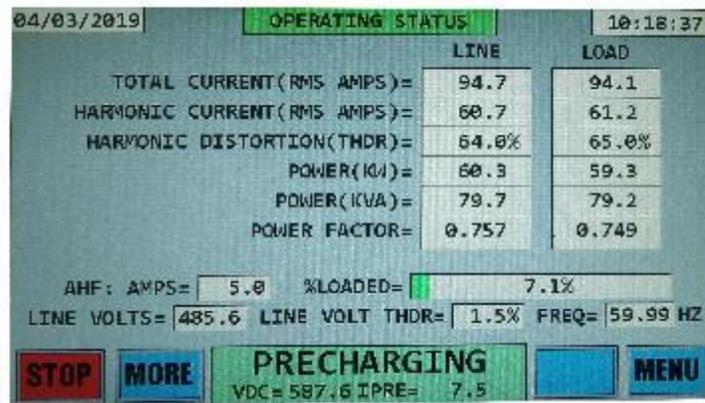
**OFF**  
DISABLED BY OPERATOR

To enable the system, press the “RUN” button in the bottom left corner of the OPERATING STATUS LCD display page. This will result in the following display:



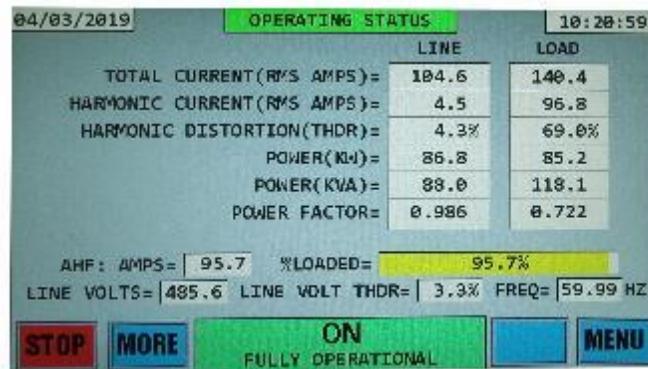
This screen allows the operator to confirm the “RUN” command, or exit without enabling the system in case the “RUN” button was pressed accidentally. The operator has 10 seconds to make a decision. Pressing the “EXIT” button will bring up the previous display page without enabling the system. If the “RUN” button is not pressed within 10 seconds, the effect will be the same as pressing the “EXIT” button. If the “RUN” button is pressed within 10 seconds, the AHF system will be enabled and begin to operate.

The AHF will begin charging the internal DC bus. This is indicated by a “PRECHARGING” message on the display. The precharging voltage and current are displayed at the bottom of the screen. This can be seen in the sample screen that follows.



Note that once the AHF is told to RUN, the place where the RUN button was previously located, there is now a STOP button. Since the AHF is already “running”, there is no need to command it to run; however, now there may be a need to “stop” or disable the AHF from running; hence a STOP button is provided to allow that action.

When the DC voltage bus has been completely pre-charged and the control determines it is OK to proceed, the AHF begins correcting the harmonics and power factor of the line and the display will indicate that the unit is operating. This is indicated by the “ON” status as shown in the following screen:



If the system is working correctly, the LOAD THDR% (total harmonic current distortion of the current fed to the loads) will still be relatively high (69.0% in this example); however, the LINE THDR% (total harmonic current distortion of the current drawn from the line) will be low (4.3% in this example). Most common loads will have about 30-40% harmonic distortion. The example in the picture above is an extreme case of a load with about 69% harmonic distortion. Even in such an extreme case, you should be able to achieve less than 5% THDR% on the LINE, and with most common loads, be able to achieve a harmonic distortion even lower than that. Also, if once the AHF starts operating, the LOAD THDR% drops (it should actually increase slightly), you may also have an installation problem. Press the STOP button, confirm the STOP operation and view the LOAD THDR%. LOAD THDR% should be slightly lower when the AHF is off compared to when it is on. If you do not observe this, keep the system off and call the manufacturer for assistance.

If substantially lower THDR% is not observed in the LINE THDR% displayed compared with the LOAD THDR% and the AHF is loaded to at least 5-10%, you probably have an installation problem. Disable the AHF by pressing the STOP button. When the next display asks you to confirm the STOP command, press the STOP button on that display as well. If the unit detects that it is not correcting harmonics satisfactorily, it may shut itself down. It will then attempt to reset (indicated by the splash screen being displayed). It could perform this cycle a few times before “giving up”. If it reaches this point, the OPERATING STATUS display will indicate a status of OFF and the reason for the problem underneath this OFF status.

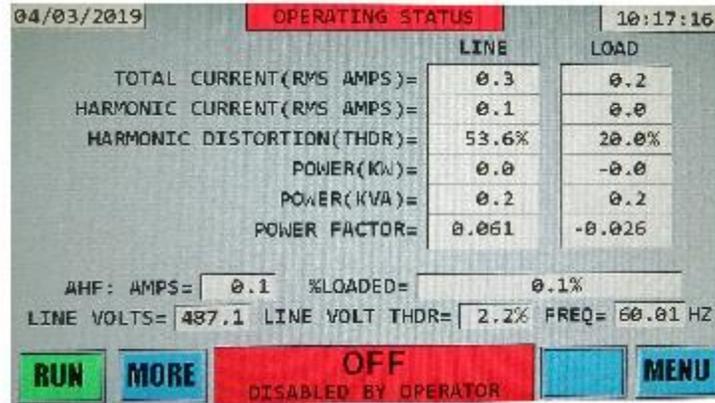
Even if your CTs are placed on the correct lines and in the correct direction, if you have them placed on the LOAD side, but have told the AHF they are on the LINE side, or vice-versa, the system will not operate correctly. Recheck your CT locations. If your CTs are on the line side, make sure the AHF is set up for CTs on the line side. If your CTs are on the load side, make sure the AHF is set up for CTs on the load side. If all CTs and settings seem to be correct, consult the factory for additional assistance. On the previous simulated display, "FULLY OPERATIONAL" was displayed under the ON status. "REDUCED LINEAR PF MODE" is also an acceptable message that might be displayed.

If you run into problems enabling the system, contact the factory. The factory may instruct you to use a laptop with Ethernet connection to obtain additional information not available via the LCD display. If you have access to such equipment, please have it ready when you call for assistance.

#### 4.4. CHECKING CTS WITH NO LOAD AVAILABLE

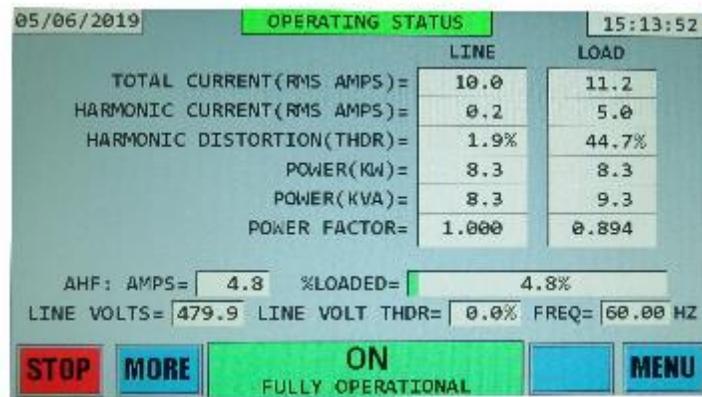
If you are powering up the AHF for the first time and you do not have sufficient load present to perform the CT test outlined in the previous sections, you may still at least partially verify the unit is installed correctly by following the procedure outlined in this section. However, you will need assistance with this procedure by the manufacturer.

Make sure you are displaying the OPERATING STATUS display. If not, press the MENU button on the bottom right of the display and select OPERATING STATUS from the main menu display. It will look similar to:



Very little current should be displayed. It should be noted that the THDR% values displayed may seem quite large; however, they are at extremely low current and, therefore, are of little importance.

Similar to what you would have done in section 4.2.4 if an adequate load was present, press the RUN button on this display. When the next "confirming" display appears, press RUN on that display as well to confirm the command. The OPERATING STATUS display will reappear; however, the OFF indication at the bottom of the OPERATING STATUS display will now display PRECHARGING and the precharging voltage and current will be displayed underneath. The RUN button will also be replaced with a STOP button. Once the AHF's internal capacitance is fully charged, the system will start full operation and the display will look similar to the sample display that follows:



At this point, 1 of 3 possible situations will arise.

- If your CTs are correctly positioned, the load current should remain nominally around 0; however, the LINE RMS and AHF RMS currents should go to some small values. The AHF % LOADED should all remain below 5% (4.8% are shown in this example) if there truly is no load. If a small load is present, this could inch up a bit.
- If you do not observe low AHF % LOADED values, you have an installation problem.
- The system may shut down. This will be noted by the status changing to OFF along with a message underneath indicating the reason. This will be followed by a system reset, indicated by the “HPS” splash screen being displayed. It will do this about 4 times. At first, the reset will occur immediately after the system goes OFF; however, each successive time, there will be a longer delay between when the system shuts down and when it resets. After about 4 shut downs, the system will stop resetting and retrying, requiring a power cycling of the system to reset the fault. If this set of events is observed, the CTs are sufficiently out of place as to cause the system to operate erratically. It is, therefore, shutting down to prevent erroneous harmonic current correction.

If either the 2<sup>nd</sup> or 3<sup>rd</sup> situation is observed, press the STOP button on this display, followed by pressing the STOP button on the confirming display that follows to disable the AHF from operating. Check to make sure your CTs are indeed wired as instructed in section 3. If you can't find a problem, you will need to wait until you have a load to troubleshoot the installation. Even if this test has positive results, the AHF should be disabled, turned off, and retested at a later date using the CT SETUP display when a sizable load is present.

## 5. FRONT PANEL TOUCH SCREEN DISPLAY

The AHF is equipped with a 7" diagonal 800x480 Full Color resistive touch screen display. Being a resistive touch screen, moderate pressure is required when pressing buttons. In addition, gloves may be worn or a stylus may be used to activate buttons on the display. If a stylus is used, make sure it does not have a sharp point that could poke a hole in the protective overlay. The display is equipped with a backlight that comes on when the unit is powered up or when the screen is touched. If the screen is not touched for 5 minutes, the backlight will go off in order to preserve the life of the light.

There are several different screens of information that can be displayed. All displays have a title line at the top that displays the date, the title of the display ("OPERATING STATUS" in this example), and the time displayed as a 24-hour clock. The date and time are internally kept by the unit by a running clock that keeps time whether the system is powered or not. The clock does not automatically adjust for time zone changes or daylight savings time, and although the clock is crystal controlled, it may gain or lose time after a while. If you desire to have the time always representative of the actual local time, you will need to periodically adjust it for these changes.



All displays also have a status area at the center bottom of the screen. This section contains the present status of the unit. In large letters will appear the operational status of the unit. Underneath this status message, appearing in a smaller font, is additional operational information (see the troubleshooting section for more information on these messages).



The colors red, light green, medium green, and yellow are also used in places on the display to help annunciate system status. Red is used to indicate a condition exists that is keeping the system from operating. Medium green indicates the system is operating. Light green indicates system is in the process of starting to operate (e.g. is precharging) or is in a normal IDLE mode due to there not being enough load to warrant full operation. Yellow indicates the system is operating, but warns that a condition exists that may result in limited performance (e.g. system is running at maximum capacity, or near temperature limits). The title block and status area will always be colored to reflect this status.

On either side of the status area at the bottom of the display are buttons that can be pressed to make changes to either the display or the system. Buttons may also appear elsewhere on the display. Buttons appear as colored (blue, green, or red) rectangles surrounded by a grey border. Within the colored rectangle is text or symbols indicating the function that pressing the button will achieve. If a box appears on the screen without a grey border, has an internal dark grey color, or is blank (contains no text or symbols), it is not a functioning button.

Examples of buttons are:



Buttons will normally appear as blue in color with the grey border with text. The 2 exceptions are the RUN and STOP buttons. These 2 buttons will cause the AHF to change operation status. The STOP button is red in color because pressing it will disable the AHF from operating. The RUN button is green in color because pressing it will allow the AHF to start operating. All other buttons do not directly affect the run operation of the AHF, so appear as a neutral blue color. A red STOP button will appear in the bottom left corner of every display if the system is presently enabled to operate. To disable the system from operating, the operator would press this red STOP button. A green RUN button will appear in this spot of every display if the system is presently disabled from operating, but is allowed to be enabled. To

enable the system to operate, the operator would press this green RUN button. See section 5.11 for additional information about the RUN and STOP button operation.

## 5.1. POWER-UP SPLASH DISPLAY

When the system first powers up, the following splash display is shown for up to 5 seconds:



In this case, the unit is powering up DISABLED, indicating it will not operate until the RUN button is pressed. The system will power up (DISABLED or ENABLED) in the same state that it was in when it was last powered down. When this splash screen appears, pressing the RUN button will allow the system to start operating, while pressing the STOP button will keep the system from operating. If neither the STOP nor RUN buttons are pressed within the first 5 seconds, the system will stay in the state it powered up in (in this case DISABLED). Once the STOP or RUN button is pressed, or the 5 seconds expires, the “OPERATING STATUS” display will replace the splash display.

## 5.2. “OPERATING STATUS” HOME DISPLAY

The default display that appears on the screen following the splash display is the “OPERATING STATUS” home display. The “OPERATING STATUS” display gives the operator a quick overview of the system status with the most important data needed to determine the AHF effectiveness at correcting harmonics and power factor. The values on this display are averages of the three phases. If more detailed information is needed, including the values for each individual phase, the MORE button at the bottom of the OPERATING STATUS display opens the OPERATING STATUS MORE display which is covered in section 5.3.

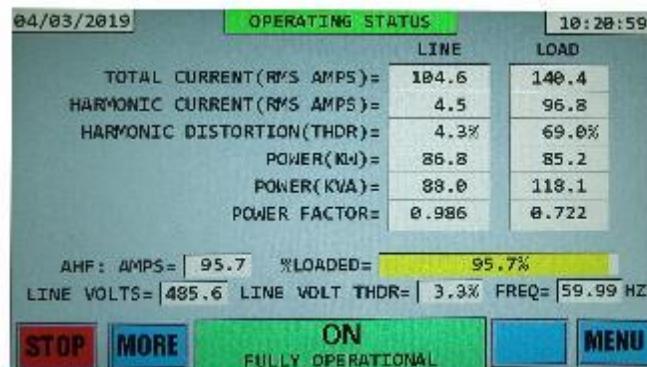
1. The informational section – This display’s information consists of the average values of phases A, B, C of the Line and Load: Current in RMS Amps, Harmonic Current in RMS Amps, Harmonic Distortion (THDR or THDF) in percent, Real Power in KW, Apparent Power in KVA, and the Power Factor. In addition it shows the AHF Current in RMS Amps, the Line Voltage in Volts, the Line Voltage Harmonic Distortion (THDR or THDF), and the Frequency in Hz.
2. The “Status” section – Located at the bottom of the screen. The middle section contains the present status of the unit. In large letters will appear the operational status of the unit. Underneath this status, appearing in a smaller font, is additional operational information (see the troubleshooting section for more information on these messages. The color of this middle section will change to reflect the system status. Possible common operational status indications and associated colors are listed:
  - OFF (RED) – System is not running. The line below will indicate why. In the example screen that follows, the system is OFF because it is presently “DISABLED BY OPERATOR”, indicating that you need to press the RUN button if you desire to have the system run.

- PRECHARGING (**LIGHT GREEN**) – This will be displayed for up to several seconds when transitioning from OFF to ON. The AHF contains a large bank of capacitance that must be “pre-charged” prior to starting operation. While in this interim state, the line underneath will contain the voltage across this capacitance and the charging current. While “PRECHARGING”, the voltage can be observed to be increasing steadily until it reaches its goal of a bit over 800 volts. The charging current will remain in a range from a couple of amps to a bit less than 10 amps.
- ON (**DARK GREEN**) – System is running. Normal lines underneath this indication are “FULLY OPERATIONAL” or “REDUCED LINEAR PF MODE”. Other information displayed might indicate attention is needed. See the troubleshooting section for more information.
- ON: MAX LOAD (**YELLOW**) – System is running, but is at maximum output. The load is requiring more harmonic and/or linear current correction than the unit is rated for. The system will self-limit itself to provide its maximum capability, with the remainder having to come from the utility. The system is designed to operate continuously under these conditions, so this condition is not usually a concern. There are a couple of instances where this may be a concern. First, if there is an installation or some other problem, the AHF could possibly run at max load and not performing properly. If the line harmonic currents are not substantially lower than the load harmonic currents, there could be a problem that should be investigated. Another time it could be a concern is if the unit is so undersized for the load it is meant to correct that the remaining amount of harmonic and/or linear current correction that still needs to come from the utility is above that which can be tolerated. In such a case the only recourse is to either replace the AHF with a larger AHF or add a 2<sup>nd</sup> AHF in parallel with the 1<sup>st</sup> unit.
- IDLE (**LIGHT GREEN**) – System is idling. If the “UNIT DISABLED IF LOAD POWER BELOW THIS %” setting in the “Set Parameters” is set to a value other than zero, and the load power is below this set value, the AHF will go to an “idle” state and display this status. While in this state, the AHF will keep its internal DC link capacitors charged. When the load power increases, the AHF can quickly start operating again. Normally, the message “LOAD TOO LOW” will appear under the IDLE status indicator.
- “IDLE” (**LIGHT GREEN**) - this is displayed if the “UNIT DISABLED IF LOAD POWER BELOW THIS %” parameter is set to something other than zero and the load power is below the set value. No additional message below will be displayed.

To the left of the Status information will appear a “RUN” button if the system is currently disabled, thus giving the operator the opportunity to enable the system; or a “STOP” button if the system is currently enabled, thus giving the operator the opportunity to disable the system.

To the right of the Status information is a “MENU” button. Pressing the “MENU” button will display the main menu, where the operator can select a different display.

An example of an “OPERATING STATUS” home display for a 100 amp AHF that is running follows:



There are 2 columns in the “informational section”, one for the LINE information and one for the LOAD information. All values on this screen except for frequency and power are averages of the three phases.

The line current is the current measured coming from the utility. When the AHF is operating, this current represents the corrected current. Since the AHF supplies the harmonic currents to the load when the AHF is operating, these harmonic currents no longer come from the line (utility), so the harmonic content of these line currents will be greatly reduced. When the AHF is not operating, these “line currents” will essentially be equal to the “load currents”.

The first row in the first column displays the rms current of the average of all 3 phases. The 2<sup>nd</sup> row in the first column displays the rms harmonic current of the average of the 3 phases. The 3<sup>rd</sup> row in the first column displays the “total harmonic distortion” in the average of the 3 phases. Either THDR (equal to HARM. RMS/LINE RMS) or THDF (equal to HARM. RMS/Fundamental RMS) will be displayed depending on the THDR/THDF setting in the “Set Parameters” function.

The load current is the current measured going to the loads (motor drives, etc.). The load will draw harmonic currents whether the AHF is on or off, so the “load currents” will have harmonics present when the load is operating. Like the “line current” column, the “load current” column contains a row for rms of the current going to the load, a row for the rms of the harmonic current going to the load, and a row for the THDR or THDF total harmonic distortion of the current going to the load.

The next 3 rows are related to the line and load power, KW (kilowatts of power), KVA (kilo-volt-amps), and PF (power factor). PF is simply the ratio of KW divided by KVA. The ideal optimum power factor is 1.0. Such an ideal power factor would result if there are no harmonic currents or voltages, there are no reactive (out-of-phase) fundamental currents, and all of the phase rms currents and voltages were identical. Normally, with the AHF operating, one would see here that the KVA of the load is higher than that of the line. Since the voltages of the line and load are identical, the difference is due to the load having a higher rms current due to the existence of much higher harmonic currents going to the load than what is coming from the line, and due to some higher out-of-phase current drawn by the load than is drawn from the line. Since the AHF is supplying these undesirable “extra” currents that the load draws, they do not need to come from the line, so total line current is lower than that of the load. Reducing the current coming from the line by eliminating these undesirable “extra” currents also results in a vastly improved power factor from the line.

Although the line KVA is lower than the load KVA, you will notice that the Line KW is a little higher than the Load KW. The difference of 1.6 KW shown between the Line and Load power represents the losses of the AHF in providing the harmonic currents and reactive current drawn by the load. This 100 amp AHF was very heavily loaded to more than 95%. As the load on the AHF goes up, the losses will also increase.

The next 2 columns contain “AHF current” information. The first of these columns displays the rms of the average of the 3 phases of current supplied by the AHF. This is the current supplied by the AHF (both harmonics and out-of-phase linear current) to cancel those drawn by the load, so that the current does not have to come from the line (or utility).

The “% LOADED” bar indicates the percent loading on the AHF. A fully loaded AHF would have values around 100% in this line. Since this example is for a 100 amp AHF, the “% LOADED” values are identical to the “AHF RMS” values (note: 100 amps = 100% loaded). For an AHF rated for 300 amps, the “% LOADED” values would be 1/3 of the “AHF RMS” values, since 300 amps = 100% loaded for a 300 amp AHF. The color of the % LOADED bar changes depending on the percent loading value. If the percent loading is less than 96% the bar is green, if greater than 96% loaded, the bar is yellow. This indicates that the unit is heavily loaded, and gives a warning to the operator.

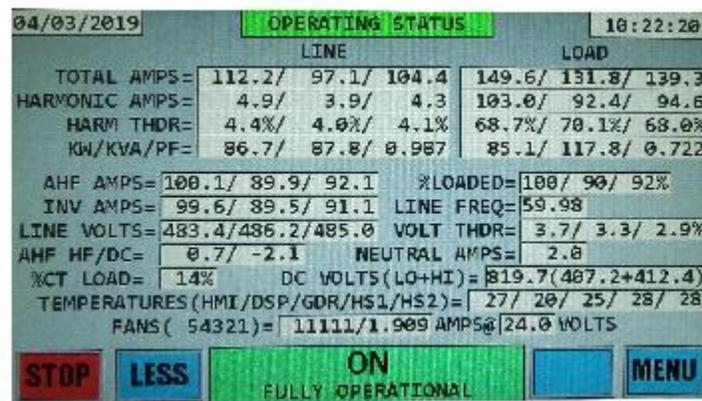
Note that there is some added “hysteresis” in the color of the % LOADED bar. If the unit becomes 96% loaded or higher, and then becomes less than 96% loaded, the bar color will not change back to green until the unit is 93% loaded or less. This prevents the bar from rapidly flashing between green and yellow if the % loaded value rapidly changes between 95% and 96% for example.

One will notice in this example display that the “LOAD” currents contain sizable harmonic currents, and that the “LINE” currents contain greatly reduced harmonic currents. This 100 amp AHF is supplying about 96% of its capability in providing this correction. For most situations, you should observe the line THDR being less than 5% (in many cases much less) when the AHF is 15% loaded or higher. Some exceptions would be if the line voltages are highly distorted, the THDR of the load is higher than normal, or if there is high impedance upstream (on the line side). The higher the AHF is loaded, the lower the resulting line THDR will be, up until the point that the AHF is 100% loaded.

The last 2 columns contain voltage and frequency information. The “LINE VOLTS” column contains the line-to-line voltages of the average of all 3 phases. Both the line side and load side are at the exact same voltage, so, unlike with the currents, there is not a need to list the line and load side separately. The 2<sup>nd</sup> column displays the “total harmonic distortion” in the average of the 3 voltage phases. Either THDR (equal to HARM. RMS/LINE RMS) or THDF (equal to HARM. RMS/Fundamental RMS) will be displayed depending on the THDR/THDF setting in the “Set Parameters” function. The 3<sup>rd</sup> column is the line frequency in Hz.

### 5.3. “OPERATING STATUS” MORE DISPLAY

Pressing the “MORE” button on the “Operating Status” display, opens the “Operating Status” “More” display. The “MORE” button will change to a “LESS” button to allow the operator to go back to the “Operating Status” “Less” display. See the following picture for an example of the “Operating Status” “More” display.



The “Operating Status” “More” display shows some of the same information as in the “Operating Status” “Less” display but for all 3 phases individually instead of the average of the phases. This gives more detail to better understand the status of the system. The first 5 rows provide the same information as the “Operating Status” “Less” display but for all 3 phases. The following explains the next 6 rows of status data, much of which is not available on the “Less” display.

INV AMPS are the inverter currents that are very similar to the AHF AMPS currents except they include the switching currents. These are currents related to the inverter switching frequency that are internally filtered so do not appear in the AHF AMPS. At higher AHF current levels, switching currents make up a small percentage of the overall current, so INV AMPS and AHF AMPS will be about the same. At lower AHF current levels, the switching currents make up a much higher percentage of the overall current, so INV AMPS currents will be several amps higher than the AHF AMPS.

AHF HF/DC shows the amount of high frequency and DC current produced by the AHF. The value prior to the “/” is an average of the 3 phases of the amount of switching current in the AHF AMPS. This should be less than 1% of the AHF current rating as the switching currents should be internally filtered. The value following the “/” shows the average amount of DC current in the 3 phases produced by the AHF. This value will average over time to be zero, but will vary between low positive and negative numbers.

The NEUTRAL AMPS current will only display a reading if 3 external CTs are being used in cases where a neutral current is possible. In such a case, the neutral current will be displayed here in amps rms. 0.0 amps, as shown in this example, indicate only 2 CTs are used; therefore, neutral current cannot be calculated.

%CT LOAD represents the percentage that the highest externally located line or load CT is loaded to. In this case, the line CTs are scaled to 2000/5, so that 2000 amps produces 5 amps in the output of the CT. These CTs are capable of monitoring up to 2000 amps rms of current. The highest line current in this case is presently 119.1 amps in phase C. 119.1 amps is 6% of the 2000 amp capability of the CTs; therefore, the CTs are loaded to 6% of their capability. This value should not reach more than about 80%, otherwise, some distortion could occur in some instances. If this reaches 80%, a higher ratio CT may need to be considered.

DC VOLTS (LO+HI). This is the voltage across the inverter DC link bank of capacitors. The nominal DC link voltage for this 3-phase, 480 VAC AHF is 820 volts. The capacitance consists of 2 banks of capacitors with the two banks wired in series. There is a lower and upper bank, signified by the LO and HI labels. The total DC voltage of 820 volts will nominally be split equally between the 2 banks.

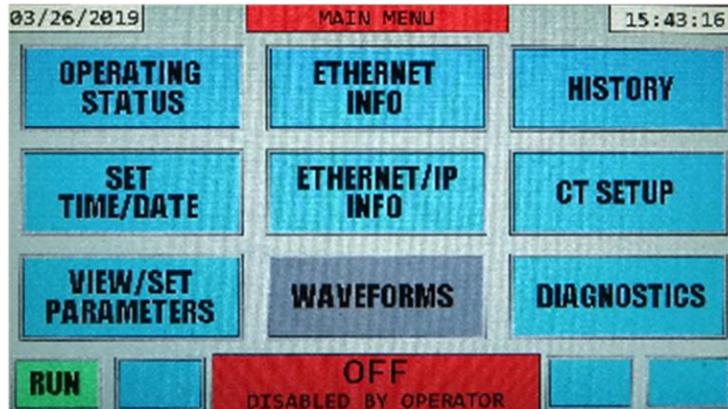
TEMPERATURES are internal temperatures in degrees Centigrade. The first value is the temperature internal to the HMI enclosure. The second value (20 in the example) is a temperature on the DSP control board. For units shipped by HPS as Type 1 systems, this temperature should be fairly close to the room temperature, as it should reflect the air temperature coming into the enclosure. For units shipped as panels and installed into cabinets by a 3<sup>rd</sup> party, the value of this temperature could be a bit higher, depending on the airflow amount and arrangement in the cabinet. The 3<sup>rd</sup> value is the temperature of the gate drive board. The 4<sup>th</sup> and 5<sup>th</sup> temperatures are that of the heatsink that contains the system's inverter. The 4<sup>th</sup> temperature is monitoring the left side of the heatsink, while the 5<sup>th</sup> temperature is monitoring the right side of the heatsink. These temperatures are normally around 15-25 degrees higher than the room temperature when the AHF is at full load. At the 98% load this example AHF is operating at, the heatsink temperatures are about 15 C higher than the ambient. If all fans are not operational or input filters are dirty, higher temperatures will result. At some point, a high temperature warning will occur (indication under the ON status in place of the FULLY OPERATIONAL) and accompanied by the title and status areas displayed in yellow. If temperatures continue to climb, the unit will shut down.

"FANS" is an indication of the operation of the internal 24 Volt DC powered cooling fans. Fans are turned on or off as needed. There are 5 possible outputs for fans (1 through 5). The numbers inside the square prior to the "/" indicates fan outputs that are presently commanded on in the system. The 50 and 100 amp AHFs have 3 fans, so only the outputs associated with the numbers 3, 2, and 1 drive fans (outputs 4 & 5 can be ignored), as in this 100 Amp AHF example. The 150 and 200 amp AHFs have 3 or 4 fans, so if 3 fans, outputs 4 & 5 are ignored and if 4 fans, output 5 is ignored. The 300 amp AHF has 4 or 6 fans, so output 5 is ignored if 4 fans and all outputs are used if 6 fans (fans 5 and 6 are driven together by output 5, so count as one fan). Units shipped as Type 1 systems by HPS, have the higher number of fans previously listed. Units shipped as panels by HPS will only have the lower number of fans indicated. The integrator will use additional fans powered by external means that are not monitored by the AHF. The numbers in the square will consist of 1's or 0's. Each 1 or 0 corresponds to the fan number, and indicates if that fan is being commanded on (1) or off (0). In the example display, there are five 1's indicating all 5 fan outputs are being commanded on. Since there are only 3 fans in this system the 1's corresponding to fan outputs 4 and 5 are ignored. All 3 fans corresponding to outputs 3, 2, and 1 have a "1" displayed, indicating all 3 of those fans are being commanded on. The value after the "/" indicates the current drawn by the fans. If this value drops from its value when the system is new, it indicates that one or more fans may not be operating correctly. A Fan test described in the Troubleshooting section of this manual can be performed to see which fan(s) is not drawing the correct current. The voltage after "AMPS@" is the voltage of the 24V DC power supply primary supply powering all of the controls and the fans.

## 5.4. "MENU" DISPLAY

Pressing the "MENU" button on a display will bring up the MENU display, which allows you to change to a different display.

This display offers 9 choices for screens to be displayed. They are blue rectangles with grey borders, indicating that they are buttons that can be pressed. To select the desired screen, press within the blue rectangle.



The Waveforms button is dark grey to indicate that this feature is not yet functional. This is true for any grey button. Note: your system may not have Ethernet/IP or Modbus TCP capability. In that case the button which says ETHERNET/IP INFO in the picture above will say INDUSTRIAL NETWORK and be grey and inactive. See section 7 for information about the industrial network option for the AHF.

## 5.5 "SET TIME/DATE" DISPLAY

This display allows you to set the time and/or date of the internal clock kept by the HMI module. As noted earlier, the HMI does not account for time zone or daylight savings changes. Also, over periods of time, the time may drift a bit from the actual time.



This display has the 2 buttons "SET TIME" and "SET DATE", along with a keypad. Press the "SET" function desired, and use the keypad to enter the correct time or date. When done changing the time and/or date, press the EXIT button to exit back to the main menu.

For example, if SET TIME is pressed the display will change to the following display. The SET TIME button changes to a white color to indicate that is the selection made. If you meant to set the date instead, you could press the blue SET DATE button to change to that display without making changes to the time.



To the right is a keypad for you to use to enter in a time. To change the time, use the keypad to enter 2 digits for the hours in military time format (hours 00-11 = AM, 12-23 = PM). After these 2 digits are entered a “.” will be displayed. After the “.” enter the minutes (00-59). After the minutes are entered, a 2<sup>nd</sup> “.” will be displayed. Now you can either enter the seconds (00-59) or press the ENTER key on the keypad, to select 00 seconds. It is important to note that leading zeros must be typed, as all entries require 2 digits to be entered. The backspace “BS” button can be used to erase the last key entered.

Pressing ENTER once a legitimate time is entered ends the SET TIME session, changes the time to the value entered, and reverts back to the original SET TIME/DATE display.

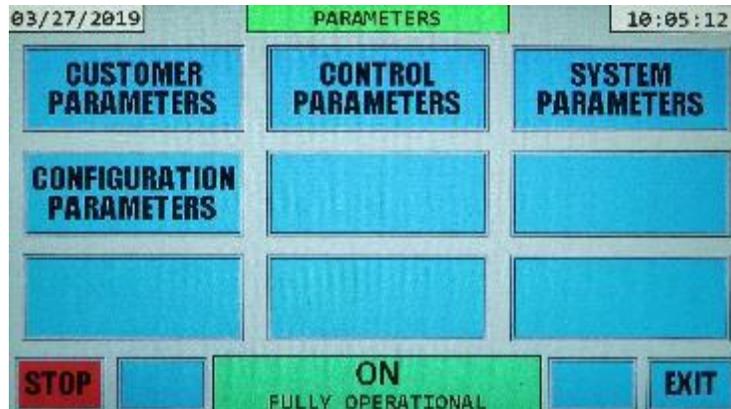
Pressing the EXIT button prior to pressing the ENTER button exits the “SET TIME/DATE” display and reverts back to the main menu display, without making any changes to the time.

Pressing the SET DATE button, results in a similar “set time” display.

Again, use the keypad to enter in a date. To change the date, use the keypad to enter 2 digits for the month (01-12). After these 2 digits are entered a “/” will be displayed. After the “/” enter the day of the month (01-31). After the day is entered, a 2<sup>nd</sup> “/” will be displayed. Now enter the year (00-99). It is important to note that leading zeros must be typed, as all entries require 2 digits to be entered. The backspace “BS” button can be used to erase the last key entered. Pressing the ENTER key once a legitimate date is entered will change the date to what was entered and exit back to the original SET TIME/DATE display. The EXIT button exits the “SET TIME/DATE” display without making any changes to the date.

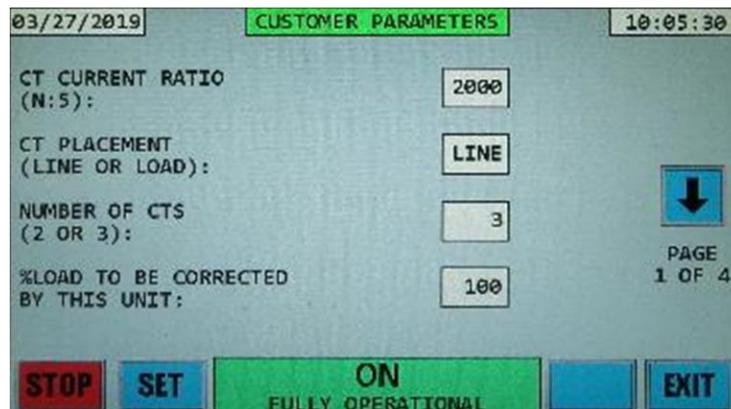
## 5.6 “VIEW/SET PARAMETERS” DISPLAY

The PARAMETERS display is similar to the MENU display and contains multiple buttons which open various parameter sub-displays. The buttons without text are empty spaces for future parameter displays. An example of a PARAMETERS display follows:



### 5.6.1 “CUSTOMER PARAMETERS” DISPLAY

If the CUSTOMER PARAMETERS button was pressed on the PARAMETERS display, a display similar to the following picture will appear:



The message, “Reading Parameters Please Wait” will appear briefly as the parameters are read from memory.

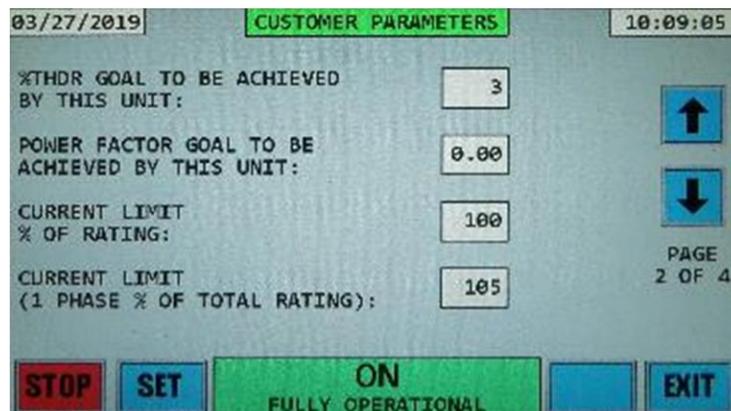
In this display the operator is able to view and change customer parameters to customize the AHF for their specific application.

As in the OPERATING STATUS display, there is a Title line as the first line, the Status section at the bottom, and an Information section in between. In the information section are multiple AHF parameters that can be changed along with their present value. Note: If an Industrial Network option exists in the system, an additional parameter will exist on page 4. Use the arrow buttons to navigate the 4 pages.

- CT CURRENT RATIO (N:5) – The value of this parameter tells the system the current ratio of the external CTs being used on either the line or the load. The example shown indicates that 2000/5 ratio CTs are being used in this system.
- CT PLACEMENT – This value is either LINE or LOAD. The value entered here must agree with where the external CTs are placed – on the line side or the load side. See section 3.4 for further information.

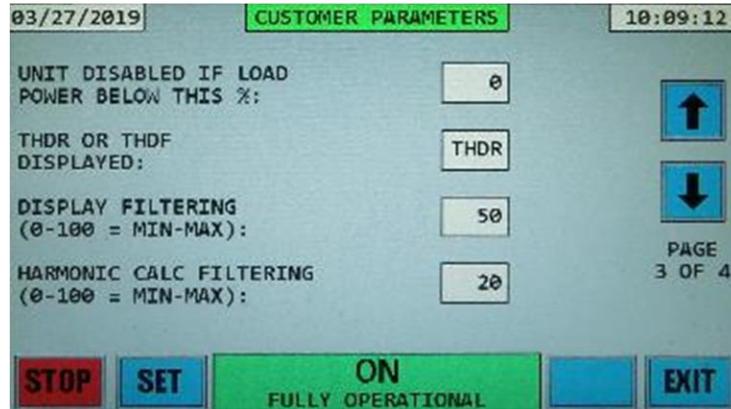
- **NUMBER OF CTS** – This value is either 2 or 3 and relates to the number of phases monitored by external CTs. Most installations only need 2 CTs; however, if loads exist that draw sufficient current through the neutral power wire, 3 should be used. The value of 3 should be entered here **ONLY** if all 3 phases are being monitored with the external CTs.
- **%LOAD TO BE CORRECTED BY THIS UNIT** – This parameter only has meaning if the external CTs are on the load side. It is totally ignored if the external CTs are on the line side. If AHFs are operated in parallel (see section 3.4.3 for additional information), the external CTs must be installed on the load side. This parameter is then used to indicate what percentage of the load distortion current is to be corrected by this unit. The percentages of all units paralleled should add up to 100%. For example if three 300 amp AHFs are paralleled, two should have this value set to 33% and the 3<sup>rd</sup> should be set to 34%. The AHFs then work independently to correct their portion of the distortion. If paralleled units are different sizes, such as using a 200 amp system in parallel with a 300 amp system. The percentage selected for each unit should be proportionally divided so that the 200 amp system provides 40% ( $200/(200+300)$ ) and the 300 amp system provides 60% ( $300/(200+300)$ ). If only one AHF is used and the CTs are on the load side, this %LOAD value should be set to 100%; otherwise, all of the load distortion will not be corrected.

The  button on the right side of the screen indicates additional parameters exist. Press this  button to scroll through additional parameters on the next page. See the following picture for an example of the next page.



- **%THDR GOAL TO BE ACHIEVED BY THIS UNIT** – This parameter allows the operator to select the THDR percentage desired to be achieved on the line currents. For example if a THD of 5% is all that is required, putting a value of 5 for this parameter will ensure that the AHF does not spend extra energy trying to lower the harmonics to below 5%.
- **POWER FACTOR GOAL TO BE ACHIEVED BY THIS UNIT** – This parameter allows the operator to select the minimum power factor desired to be achieved from the line. For example if a power factor of 0.95 is all that is required, putting a value of 0.95 for this parameter will ensure that the AHF does not spend extra energy trying to increase the power factor to above 0.95.
- **CURRENT LIMIT % OF RATING** – This parameter allows the operator to select a maximum amount of correcting current delivered by the AHF required for the particular application. For example, a value of 100 for a 100 amp AHF would cause the system to deliver up to 100 amps of correcting current, while a value of 80 would cause that same 100 amp AHF to deliver only up to 80 amps. Normally this value will be set to 100; however, if the unit needs to be derated for some specific reason, this value can be set to a lower number.
- **CURRENT LIMIT (1 PHASE % OF TOTAL RATING)** – Often, the amount of correction needed for one phase exceeds what is needed on the other phases. This determines how much extra is allowed on a single phase prior to current limiting. Note that the average of all 3 phases still is limited to the value set in the previous parameter. Normally this value is set to 105 indicating that 105% of the unit's rated current is allowed one or two phases prior to current limiting.

The  button on the right side of the screen indicates additional parameters exist. Press this  button to scroll through additional parameters on the next page. See the following picture for an example of the next page.



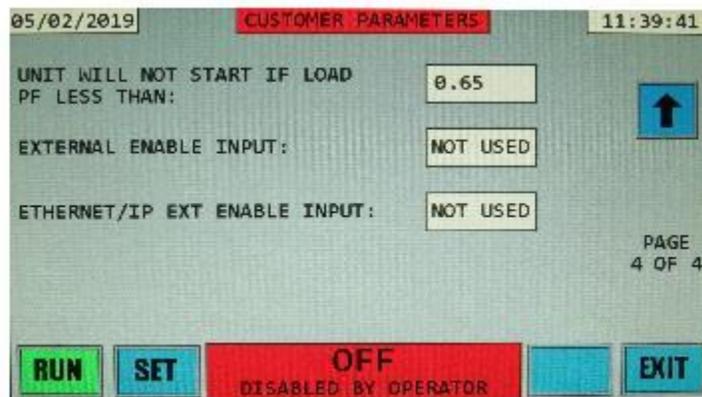
- UNIT DISABLED IF LOAD POWER BELOW THIS %** - If the load power drops below this value, the AHF will stop operating and go into an IDLE state. While in the IDLE state, the AHF will keep its internal DC link capacitors charged and ready to go, but will not operate its inverter. As soon as the load power increases above this threshold value + 3% (3% added for hysteresis), the AHF's inverter will begin operating again to correct the distortion in the load current. The percentage entered is equivalent to  $P * D * 0.000831$  KW of load, where P is the percentage and D the current rating of the AHF. As an example, if this percentage is set to 2%, a 300 amp AHF will stop and enter the IDLE state when the load power drops below  $2 * 300 * .00831 = 4.99$  KW. This 300 amp AHF would start operating when the load power increases above  $(2+3) * 300 * .00831 = 12.465$  KW. This is a power saving feature for installations that don't run 24 hrs/day, 7 days per week. Even with its very high efficiency, a fully operating 300 amp AHF with no load has losses of around 1200 watts. When in the IDLE mode, the inverter and cooling fans turn off, reducing losses to below 100 watts. At the same time, the internal DC capacitors remain fully charged, so that when the load is again present, the inverter can start very quickly – no waiting for capacitors to charge. A value of 0 entered for this parameter, as shown on the sample display results in this function being disabled – in other words, the AHF will operate continuously despite what the load power drops to. A value between 0 and 50% may be entered for this parameter.
- THDR OR THDF DISPLAYED** – The setting of this parameter determines whether THDR or THDF is calculated for all “total harmonic distortion” values displayed on any screens. THDR is calculated as the rms value of all harmonic components divided by the rms value of the total current (or voltage if doing voltage distortion). THDF is calculated as the rms value of all harmonic components divided by the rms value of the fundamental current (or voltage if doing voltage distortion). THDR can be in the range of 0 to 100%, 0 indicating no harmonics present and 100% indicating all of the current or voltage is composed of harmonics. THDF can range from 0% to higher than 100%. A value higher than 100% is possible if the rms of the harmonics is greater than that of the fundamental, which can occur with current drawn by loads that draw high harmonic currents. The fundamental component is the current (or voltage) that is at the same frequency as the utility supply (60 or 50 Hz).
- DISPLAY FILTERING** – This setting affects the display of rms currents, rms voltages, power, etc. that occur throughout all screens and sent over the Ethernet interface(s). A higher value means that the displayed value is more heavily filtered. Loads may constantly change, resulting in constantly changing rms values. This would result in the displayed values jumping all over the place. These jumping values may be hard to read; therefore some filtering is needed to “smooth them out” so they can be better comprehended by an observer. This parameter accomplishes this task. A value of 50 is the default, as it provides the optimum filtering in most cases. It should be

noted that the amount of filtering is not a linear function of this number. For example, a very high number such as 99 has extremely high filtering, many times more than a value of 90 has. It should be noted that changing the DISPLAY value has NO affect on the actual operation of the AHF – this value simply affects the displayed values and values sent over the Ethernet interface(s). The AHF will continue to perform the same fast correction independent of these values.

- HARMONIC CALC FILTERING – This setting is similar to DISPLAY FILTERING, but affects just the harmonic and harmonic distortion values. Here, a value of 20 is the default, as it provides the optimum filtering in most cases.

It should be noted that changing the HARMONIC CALC FILTERING value has NO affect on the actual operation of the AHF – this value simply affects the displayed values and values sent over the serial or Ethernet interface. The AHF will continue to perform the same fast correction independent of these values.

The  button on the right side of the screen indicates additional parameters exist. Press this  button to scroll through additional parameters on the next page. See the following picture for an example of the next page.



- UNIT WILL NOT START IF LOAD PF LESS THAN – This parameter prevents the unit from starting operation if the linear load power factor is below the displayed level. Linear load PF is different from load PF as the harmonic currents are filtered out prior to calculating linear load PF whereas they are not when calculating load PF. This means we are only looking at the fundamental 60 or 50 Hz power factor which in cases where a substantial amount of harmonic currents are present results in a much higher linear load PF than load PF. If CTs are not correctly positioned, the unit will calculate a linear PF that is very low or even negative. This parameter prevents the AHF from trying to operate in such cases. Operating in such cases will produce erroneous results that could result in increased harmonics in the line and/or eventual damage to the AHF. Once you have determined that your CTs are properly wired, and you indeed experience loads that have linear power factors less than 0.65, preventing the AHF from sometimes starting, this parameter can be lowered a bit to accommodate your special circumstance.
- EXTERNAL ENABLE INPUT – The AHF has the capability of being externally enabled by an externally driven dry contact. There is an input in the HMI module (see section 3.5.3 for details) that can be wired to provide this external on/off control if needed. This parameter has the following 3 possible values:

NOT USED – The default. Indicates that the “external enable input” is not being monitored.

SHORT=EN – Pins 1 and 2 on the terminal block must be shorted together (by an external dry contact) for the AHF to operate.

OPEN=EN – Pins 1 and 2 on the terminal block must have no connection across them for the AHF to operate. Shorting the two pins together will cause the AHF to stop operating.

Note that if this function is used, having the external enable present will NOT override an internal condition that is preventing the AHF from operating. It is simply an additional condition that is needed for the AHF to operate.

**Note: The following parameter only applies to Ethernet/IP or Modbus TCP Enabled systems. If your system does not have the optional Ethernet/IP or Modbus TCP module, this parameter will not appear on the 4<sup>th</sup> page.**

- ETHERNET/IP EXT ENABLE – The AHF has the capability of being externally enabled and disabled over the Ethernet/IP or other industrial network by an external control (e.g. a PLC). The external control sends a code word of 1 to enable the AHF and a code word of 0 to disable the AHF if this parameter is set to “USED”. If this parameter is set to “NOT USED”, the AHF will ignore the code word sent to it.

Note that if this function is used, receiving the enable code over the network will NOT override an internal condition that is preventing the AHF from operating. It is simply an additional condition that is needed for the AHF to operate.

### 5.6.2 “CONTROL PARAMETERS” DISPLAY

The CONTROL PARAMETERS display allows the operator to view and change AHF control parameters. These parameters are set at the factory, and should only be changed by consulting the factory as needed. Please contact the factory for more information regarding these parameters.

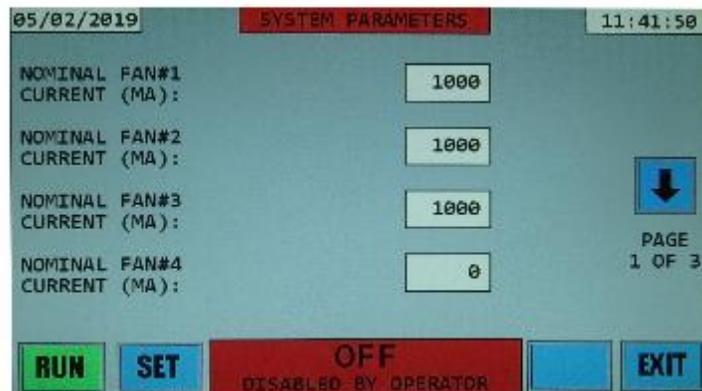
### 5.6.2 “SYSTEM PARAMETERS” DISPLAY

If the SYSTEM PARAMETERS button was pressed on the PARAMETERS display, the following example display will appear:

The message, “Reading Parameters Please Wait” will appear briefly as the parameters are read from memory.

In this display the operator is able to view and change system parameters related to AHF fans and temperature limits as well as other system parameters.

In the information section are 12 AHF parameters that can be changed along with their present value.



**NOMINAL FAN#n CURRENT (MA)** – The AHF has 6 Fan control outputs located on the DSP control board (PC-C). Fan#1 through Fan#6 control outputs connect to the board via 2-pin connectors P15, P13, P12, P11, P10, and P8, respectively. All systems have either 3 or 4 fans blowing air directly through the power heatsink fins. Each of these fans has a dedicated Fan control output on PC-C. In all systems,

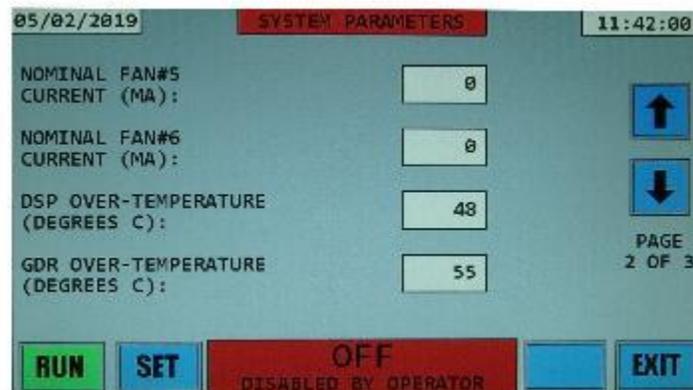
Fan#1 is the fan to the far right of the heatsink and Fan#3 or Fan#4 is the fan to the far left of the heatsink. 50 through 200 amp units use 3 fans to blow air through the heatsink while the 300 amp unit uses 4 fans. 50 and 100 amp units use 119mm square x 39mm thick fans, while all other units use larger 172x150x51mm fans. In addition, the Type 1 150 and 200 amp units use a 119mm square fan (Fan#4) in its divider plate and the Type 1 300 amp unit uses two 119mm square fans (both controlled by Fan#5 output) in its divider plate. 150 thru 300 amp systems provided on a panel do not have these additional square fans, as they do not utilize divider panels.

On this display page, the Nominal currents drawn by Fan#1 through Fan#4 control outputs are displayed. Fan#5 and Fan#6 control output nominal currents appear on the next display page. The values shown in the blocks are the “nominal” current drawn by the fan(s) connected to that control output. If a value of 0 is shown, there is no fan corresponding with that output. Since this display is that of a 100 amp system, there are only non-zero numbers shown for Fan#1 through Fan#3 as there are only 3 fans in a 100 amp system. It should be noted that if only one of the heatsink fans is operating it will draw an amount of current slightly higher than the value shown here. As the number of heatsink fans operating increases, each subsequent fan added draws less current because there is some interaction between the fans. By the time all heatsink fans are operating, the total current drawn will actually be a bit less than the total of the values shown for those 3 or 4 fans.

In a 300 amp Type 1 system, the 2 fans in the divider plate are powered from the same FAN#5 output; therefore, the current shown for FAN#5 is higher than the other FAN outputs.

If a fan needs to be replaced, it should be replaced with a fan that has similar airflow and back pressure capabilities. A similar replacement should draw a similar amount of current. If this is not the case, the values for the FAN#n CURRENT can be changed.

The  button on the right side of the screen indicates additional parameters exist. Press this  button to scroll through additional parameters on the next page. See the following picture for an example of the next page.

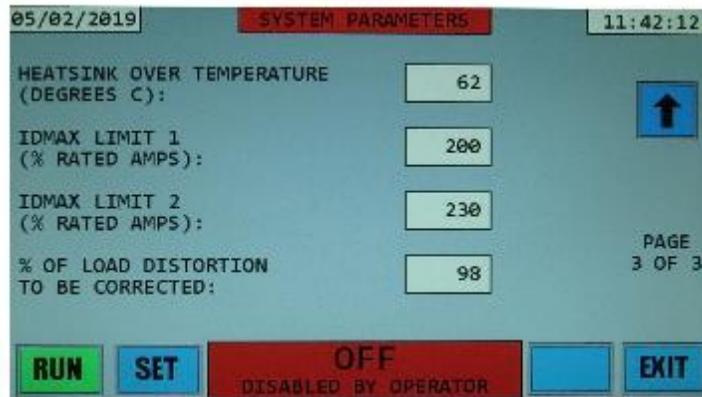


As mentioned earlier, the first 2 value on this 2<sup>nd</sup> page are the nominal currents for FAN#5 and FAN#6. FAN#5 will be zero for all units except for a Type 1 300 amp system. FAN#6 output is presently not used in any systems, so will always be zero.

**DSP OVER-TEMPERATURE (DEGREES C)** – If the temperature sensor on the DSP Control board (PC-C) reaches the value shown here, the unit will shut down.

**GDR OVER-TEMPERATURE (DEGREES C)** – If the temperature sensor on the Gate Drive board (PC-G or PC-GP) reaches the value shown here, the unit will shut down.

The  button on the right side of the screen indicates additional parameters exist. Press this  button to scroll through additional parameters on the next page. See the following picture for an example of the next page.



**HEATSINK OVER-TEMPERATURE (DEGREES C)** – If either of the two temperature sensors on the heatsink reaches the value shown here, the unit will shut down.

A warning will be issued if a temperature sensor reaches a value that is 5 degrees below the “over temperature” values displayed. A warning will result in the title and status areas being displayed with yellow (instead of the normal green) backgrounds. The unit will continue to run indefinitely while in a temperature warning state; however, if the temperature continues to rise to the over-temperature level, the unit will shut down and require a power off/power on cycle to reset the over-temperature condition and allow the unit to run again.

**IDMAX LIMIT n (% RATED AMPS)** – These values determine the maximum peak current that the software will limit the output of the unit to. They are listed as percentages of the rms rated values of the system (e.g. a 100 amp system is rated at 100 amps; therefore 200% of rated would result in the peak current limited to 200 amps). LIMIT 1 is the peak current that the software will limit the system to using normal means by the control. LIMIT 2 is a higher limit that if reached will result in the control taking much more aggressive action to keep the current from rising further. Under some circumstances such as disturbances in the utility or very fast and large load changes, the software may be incapable of limiting the output current to within either of these levels. In such a case there exists a hardware current limit that is approximately 310% of the rated rms current of the system. If the output current of the system reaches this hardware current limit, the unit will not be able to ride through the disturbance and will have to shut down to protect itself. Within a short period of time, the unit will start up again.

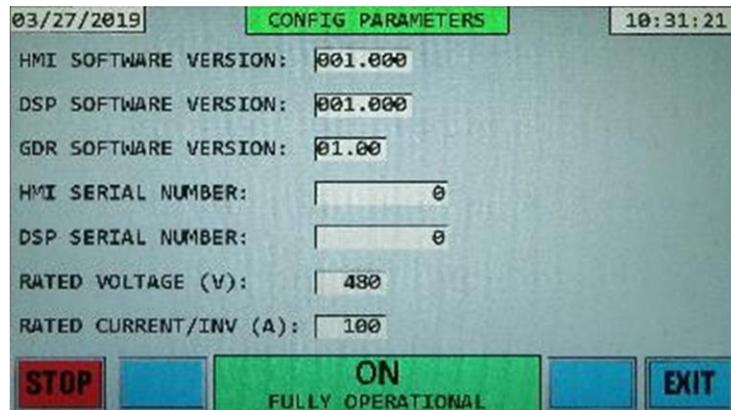
The higher these IDMAX LIMITs are set, the higher the distortion that the unit can correct. On the negative, the higher these limits are set, the higher the likelihood that the unit will have hardware current shutdowns. The limit of 200% allows comfortable current headroom to provide excellent distortion correction while also allowing comfortable current headroom to the hardware current trip level, thus minimizing hardware current trip shutdowns.

**% OF LOAD DISTORTION TO BE CORRECTED** – This value indicates the percentage of load distortion current to be corrected. Ideally, one might want to correct all of the distortion current; however, in practicality, trying to correct all of it results in some “overcorrecting”. This “overcorrecting” results in extra current produced that doesn’t really accomplish any additional improvement in the line current drawn from the utility. To correct for this, we limit the system to attempt to correct for “almost all” of the distortion current. A value of 97% is found to usually achieve optimum results. For a site that has a load drawing a fairly common value of around 40% THDR current, correcting 97% essentially means that the line current would have a little over 1% higher THDR content than if ideally correcting 100%. This 1% increase would still result in being able to achieve 3% THDR on the line while reducing the amount of current produced by the unit.

If needed, any of these “SYSTEM PARAMETERS” can be altered; however, the factory should be contacted before doing so. The password needed to alter parameters will then be provided by the factory. Cases where parameters might need to be altered include changing a fan that has a different current draw, operating in an environment that may see ambient temperatures exceeding 40C, etc.

### 5.6.3 “CONFIGURATION PARAMETERS” DISPLAY

If the CONFIGURATION PARAMETERS button was pressed on the PARAMETERS display, the following example display will appear:



In this display the operator is able to view configuration parameters such as: AHF Software versions, AHF Serial Numbers, as well as the system Rated Voltage and Rated Current.

In the information section are 7 AHF parameters with their present value.

- HMI Software Version – The software version of the HMI “AAA.BBB” where AAA is the major revision and BBB is the minor revision.
- DSP Software Version – The software version of the DSP “AAA.BBB” where AAA is the major revision and BBB is the minor revision.
- GDR Software Version – The software version of the Gate-Drive “AA.BB” where AA is the major revision and BB is the minor revision.
- HMI Serial number – The serial number of the HMI board
- DSP Serial number – The serial number of the DSP board
- Rated Voltage – The Vac nominal voltage of the system
- Rated Current – The AHF current capacity.

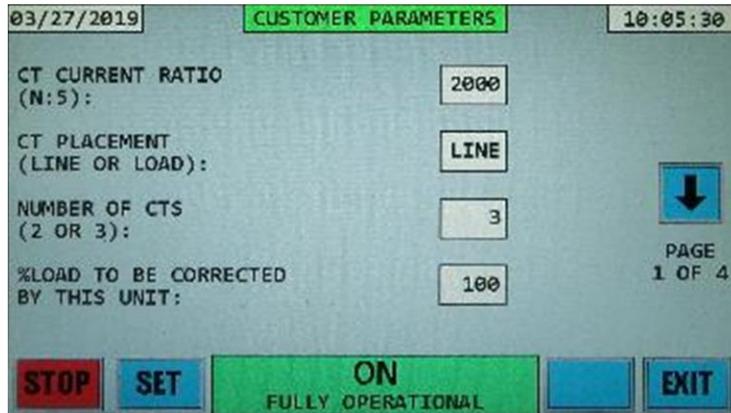
### 5.6.4 CHANGING THE SETTING OF A PARAMETER

The following applies to the displays CUSTOMER PARAMETERS, CONTROL PARAMETERS, and SYSTEM PARAMETERS.

To protect against someone unauthorized from changing a parameter, parameters are not allowed to be changed until the operator enters a password code. Once this password code is entered, all parameters are enabled to be altered. For the CUSTOMER PARAMETERS display, the code is “1076”.

For the CONTROL PARAMETERS and SYSTEM PARAMETERS displays, please contact the factory for the code. These parameters should only be modified after consulting with the factory.

For our example we will modify a parameter in the CUSTOMER PARAMETERS display. The screen should initially look similar to the following:



Perform the following steps to enter the code.

1. Press the SET button on the bottom left of the display. The following screen should open and have a keypad on the right side and "ENTER CODE TO ENABLE EDITING" message displayed in the information section of the display.

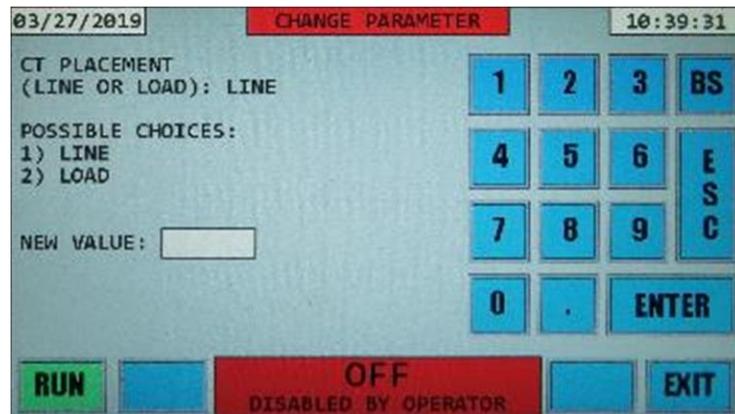


2. Using the keypad, enter the code "1076" and press Enter. Use the backspace button "BS" to delete an incorrectly entered character. The following screen should open.



3. Note that the parameter values are now inside blue rectangles surrounded by grey borders. This indicates that these are now buttons that can be to change the parameter desired. In the following example we will modify the CT PLACEMENT parameter from the value LINE to the value LOAD.

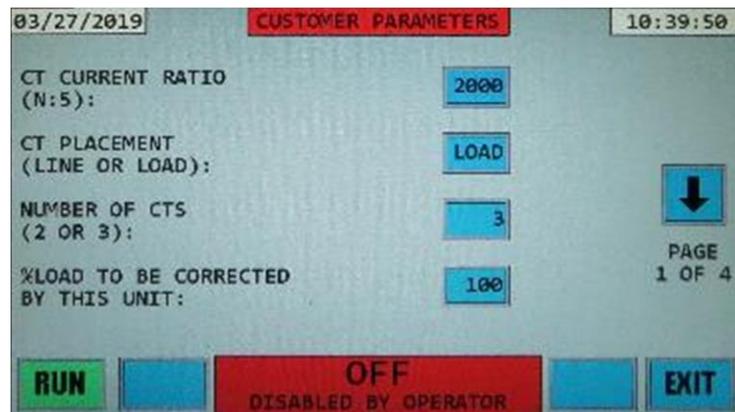
- Press the parameter button whose value you want to change. In our example, the button next to parameter CT PLACEMENT. The following screen will open.



- There is now a keypad on the right side of the display. At the top of the information section is the present parameter value, in our example "LINE". Below that are the possible choices for the parameter. In this example there are 2 choices Line or Load. Entering 1 will choose Line for the new value, entering 2 will choose Load for the new value. Entering any other number will result in the error message "BAD INPUT – TRY AGAIN" being displayed.

For some of the other parameters, a range of possible values will be displayed. For example 100-30000 for CT CURRENT RATIO. In this case a number smaller than 100 or larger than 30000 would result in an error message, "BAD INPUT – TRY AGAIN" being displayed.

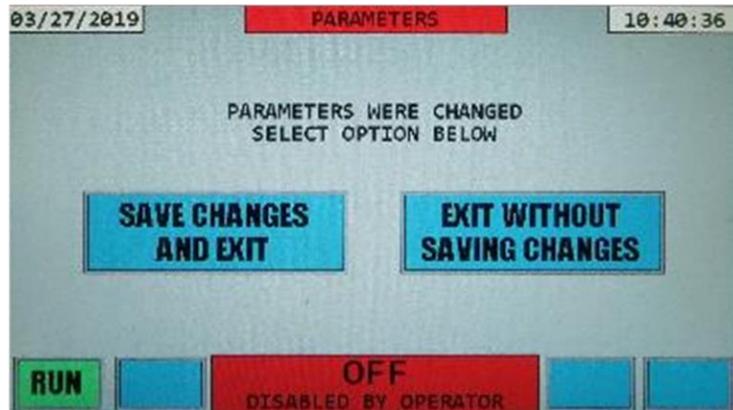
In our CT PLACEMENT example we will enter the number 2 with the keypad indicating that we want CTs to be placed on the load side. Then press Enter. The following screen will open.



Note that the blue box next to CT PLACEMENT now says LOAD.

- If desired, you can go on and change additional parameters. To change parameters on another page, press the arrow   buttons on the far right of the information section of the display.
- To save the new parameter(s) to the system memory, press the EXIT button. The following screen will appear asking if you want to SAVE CHANGES AND EXIT or EXIT WITHOUT SAVING CHANGES. Press SAVE CHANGES AND EXIT. The PARAMETERS display will open. The parameter CT PLACEMENT (and any other parameters changed during this session) is now set to the new value and saved in memory.

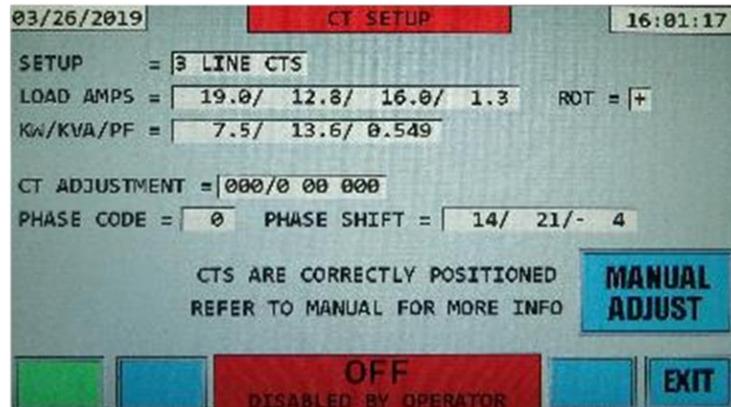
If you decided that you don't want to save the new parameter value(s), press EXIT WITHOUT SAVING CHANGES. The MENU display will open and the parameter value(s) will remain unchanged in system memory.



In the CUSTOMER PARAMETERS display, all parameters except the first 3 shown on the first page can be changed with the AHF running (enabled) or when the AHF is shut down (disabled). To change these 3 parameters, the AHF must be disabled. These 3 parameters involve the CTs, so if they are not the correct value and, therefore, need to be changed, the unit should not be running in the first place, as doing so would cause erroneous operation. The system must be disabled (not just OFF for some other reason) to change one of these 3 parameters. If the button in the bottom left of the display is the STOP button, the system is not disabled. This button should say RUN if the system is disabled.

## 5.7 "CT SETUP" DISPLAY

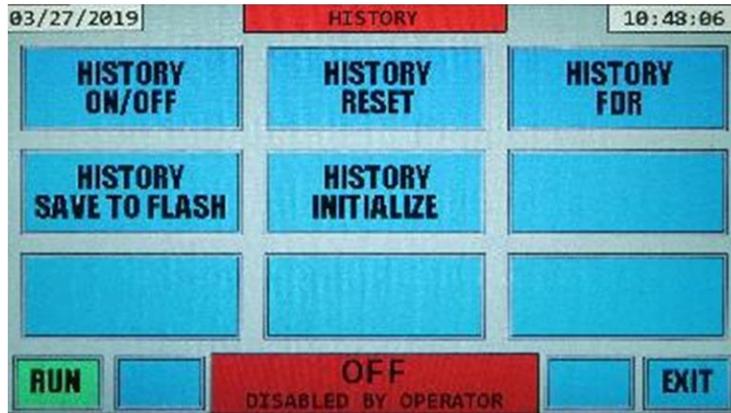
Pressing the "CT SETUP" button on the MAIN MENU display will result in the CT SETUP screen being displayed:



This display is very useful in determining if the external LINE or LOAD placed current transformers (CTs) are placed on the correct phases and in the correct direction. Section 4 of this manual covers how to use this display to check the placement of the CTs.

## 5.8 "HISTORY" DISPLAY

The HISTORY display is similar to the MENU display and contains multiple buttons which open various history sub-displays. The buttons without text are empty spaces for future history displays. An example of a HISTORY display follows. Press the EXIT button to revert back to the MAIN MENU display.



### 5.8.1 “HISTORY ON/OFF” DISPLAY

The HISTORY ON/OFF DISPLAY allows the operator to view the AHF shutdown event historical database.

This database contains the date and time the system starts operating (correcting harmonics, etc.) and stops operating. The reason for a unit to stop operating could be intentional (system is disabled) caused by an operator pressing the STOP button on the front panel LCD display, by an operator issuing an ACDIS command over the Ethernet communications connection, or by receiving an external disable signal (if that feature is activated). The reason for a unit to stop operating could be due to an unavoidable external condition such as loss of utility voltage (or dropping out of tolerance) either due to unit being powered off via the front power switch or a utility interruption. The reason for a shutdown could be due to a temporary condition that the unit was unable to deal with requiring the unit to shut down and restart, such as a hardware current trip. Also, the reason could be due to a problem such as over-temperature (dirty filter or inoperable fan) or internal problem detected. Each time the AHF’s power inverter shuts down, a snapshot of several operating parameters (voltages, currents, temperature, etc.) are saved along with the reason for the shutdown. The last 480 “on-off” events are stored in non-volatile flash memory on the DSP Control board inside the AHF (not in the HMI module), thus this information is preserved even when the unit is totally powered down. When more than 480 shutdown events occur, the oldest events are erased from memory to make room for the latest events.

Open the HISTORY ON/OFF display from the HISTORY display. An example of a HISTORY ON/OFF display follows.



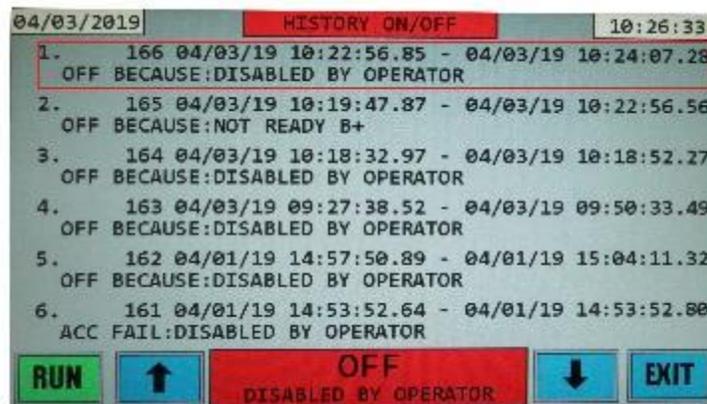
The display contains 2 lines of data for each shutdown event. The events are displayed from newest to oldest. Using the arrow buttons on the bottom of the display it’s possible to navigate the database to view even older events, up to 480 events. The first number in each row with a period after it, is the event number with number 1 being the latest event. The second number in each row is the internal database

count. In the example display shown in the picture, the first row contains event number 1 being the latest event, and the internal database count is 166, which means 166 shutdown events have been recorded so far, and the latest event is the 166<sup>th</sup> one in the database.

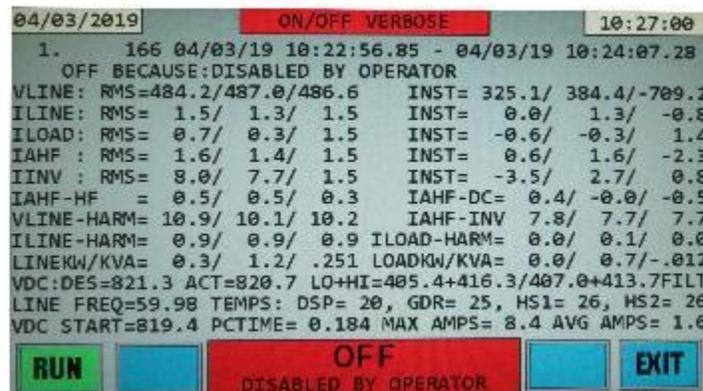
Following the internal database count is the date and time the unit began operating followed by a dash and the date and time the unit stopped operating. The message on the line below the date and time is the shutdown reason. In the example screenshot it says “OFF BECAUSE: DISABLED BY OPERATOR” which indicates that the unit shut down because the operator pressed the STOP button or entered ACDIS over the Ethernet network. The following section has additional features of the HISTORY ON/OFF DISPLAY. Press the EXIT button to revert back to the HISTORY menu display.

### 5.8.2 “HISTORY ON/OFF VERBOSE” DISPLAY

To see more detailed information about a specific shutdown event, press the touchscreen anywhere on the text for that event. This will open a new display called ON/OFF VERBOSE. See the screenshot below. Press anywhere within the 2 lines of text for that event (outlined with a red line for event 1 in the following example) to open the ON/OFF VERBOSE display for that event. The verbose information for any of the events displayed on the page can be displayed by pressing similarly within the 2 lines of text for that event.



The screenshot below shows the ON/OFF VERBOSE display which will open for event 1.



In the ON/OFF VERBOSE display, along with the ON/OFF shutdown reason line, there are 12 additional lines containing operational information at the time the unit shut down.

The first additional line, VLINE contains line-to-line voltage information for all 3 phases Vab, Vbc, and Vca. On the left side are the rms values of these voltages and on the right side are the instantaneous values of these voltages. Since the voltages are sinusoidal and vary between – and + values, the

instantaneous voltages will have both positive and negative values, whereas the rms values will always be positive.

The next 4 lines are currents for all 3 phases A, B, and C. ILINE are the currents from the utility, ILOAD are the currents drawn by the load, IAHF are the currents drawn by the AHF, and IINV are inverter output currents produced by the AHF, which will be fairly similar to the AHF currents. Similar to the line voltages, the left side of the ILINE, IAHF, ILOAD, and IINV main currents are rms values and the right side are instantaneous values. IAHF-HF indicates the amount of high frequency rms current the AHF was emitting to the line. This value should be less than 1% of the AHF current rating. If not, it could indicate a problem with the high frequency filtering in the unit. IAHF-DC is the amount of DC current the AHF was emitting into the line. These values will normally swing within +/- 3% of the AHF current rating. Higher values (either positive or negative) could indicate a possible problem with the inverter or the AHF current sensors, or an unusual load.

LINE\_FREQ is the frequency of the line voltage.

VDC:DES and ACT are the DC voltage that the system is trying to maintain (DES short for desired) and the ACTUAL DC voltage across the DC Link capacitors averaged over the last AC line period. LO+HI is the instantaneous voltage across the lower and upper halves of the DC Link capacitance. DC\_VOLT FILT voltages represent slightly filtered versions of the instantaneous DC link voltages, but not nearly as filtered as the VDC:ACT voltage.

TEMPS DSP and GDR are the temperatures on the control boards. DSP temperature will usually be close to the room ambient temperature as it is close to the air intake to the AHF. GDR will be elevated due to its proximity to the heatsink. HS1 and HS2 are temperatures on the left and right side of the heatsink. They normally will be close in value to each other, but several degrees higher than the DSP temperature unless the unit is not running or is very lightly loaded.

ILINE-HARM and ILOAD-HARM are the harmonic current content in rms amps of the currents drawn from the line and currents delivered to the load side.

LINEKW/KVA are the KW (power in kilowatts), KVA (kilovolt-amperes), and power factor of the power drawn from the line and power delivered to the load.

VLINE-HARM are the line-to-line voltage harmonic content in rms volts of the line voltages.

IAHF-IINV are the rms values of the difference between the AHF and INV currents. The INV currents are similar to the AHF currents except they contain high frequency currents produced by the switching of the inverter. It is necessary to keep these high frequency current components from reaching the line, so they are removed by internal power filtering components prior to the point where the AHF currents are measured. These values are normally about 10-15% of the current rating of the AHF. Values higher than this indicate a problem with either the AHF or INV current sensors.

VDC START is the voltage of the capacitors at the start of precharge. PCTIME is the time in seconds it took to charge the capacitors. MAX AMPS is the maximum capacitor precharge current which occurred during precharge.

To exit the ON/OFF VERBOSE display and go back to the HISTORY ON/OFF display, press the EXIT button on the bottom of the display.

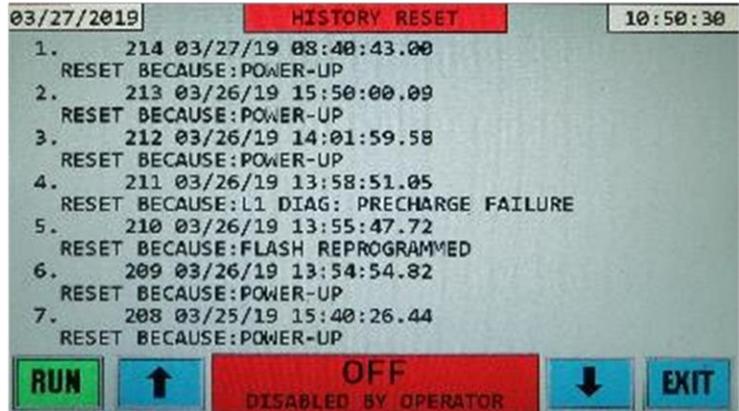
Now press the arrow buttons on the bottom of the display to view more shutdown events. Press EXIT to go back to the HISTORY MENU.

### **5.8.3 “HISTORY RESET” DISPLAY**

The HISTORY RESET DISPLAY allows the operator to view the AHF reset event historical database. This database contains information about each time the AHF microcontroller is reset. Information recorded includes date and time when the event occurred and the cause of the reset. A processor reset occurs every time power is applied to the unit; therefore, most resets that appear in this data base will be “POWER-UP” resets. However, the appearance of abnormal resets may be useful in diagnosing a

possible problem. The last 1,856 “Reset” events are stored in non-volatile flash memory on the DSP control board.

Open the HISTORY RESET display from the HISTORY display. An example of a HISTORY RESET display follows.



The display contains 2 lines of data for each reset event. The events are displayed from newest to oldest. Using the arrow buttons on the bottom of the display it's possible to navigate the database to view even older events, up to 1,856 events. The first number in each row with a period after it, is the event number with number 1 being the latest event. The second number in each row is the internal database count. In the example display shown in the screenshot, the first row contains event number 1 being the latest event, and the internal database count is 214, which means 214 reset events have been recorded so far, and the latest event is the 214<sup>th</sup> one in the database.

Following the internal database count is the date and time the unit reset. The message on the line below the date and time is the reset reason. In the example picture, event 1 says “RESET BECAUSE:POWER-UP” which indicates that the unit reset because the power was cycled on the unit. A few other reset reasons can be seen in the picture also. See the Troubleshooting section 9 for a list of possible reset causes.

#### 5.8.4 “HISTORY FDR” DISPLAY

The HISTORY FDR DISPLAY allows the operator to view and save to a USB flash drive, the AHF flight data recorder (FDR) event historical database. The flight data recorder captures 4½ 60Hz AC line periods (or 4 50Hz AC line periods) of 10 parameters of waveform data sampled at 20,000 times per second. Parameters captured are Line Voltages, CT Currents, AHF Currents, Inverter Currents, and Inverter Capacitor Voltage at the time of a system shutdown. With this data it's possible to plot the 10 waveforms and analyze the system behavior at the time of a shutdown. This is very useful for troubleshooting issues which caused the unit to stop operating correctly and resulted in a shutdown.

FDRs can be easily saved to a flash drive. The flash drive USB port is located under the protective cover to the right of the LCD screen on the front panel of the HMI. Refer to section 3.5.6 on opening the cover and locating the USB port. Note: if saving FDRs for more than one unit, use a separate flash drive for each unit. FDRs are saved with the history event number as the file name with a .FDR file extension. Different AHFs could have similar event numbers. If a file name already exists on the flash drive, that file will get overwritten.

The FDR data is saved to the USB flash drive in a simple ASCII text file format with the extension .FDR. It's possible to open this text file with a spreadsheet or any data plot program and plot the data for the purpose of analyzing system behavior. Each .FDR file is about 350kb in size, and the FDR database can save up to 100 FDRs, thus only about 35MB is needed to save all possible FDRs.

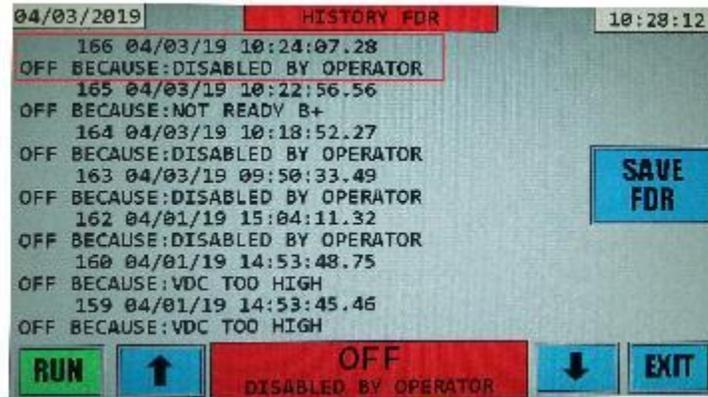
Open the HISTORY FDR display from the HISTORY display. An example of a HISTORY FDR display follows.



The database list on this display contains the same information as the HISTORY ON/OFF display. See section 5.8.1 for more details. The FDR event is saved every time the system stops operating, which is why this information is similar to the HISTORY ON/OFF display. The only difference is, only the shutdown time is shown, not the start time. Also each event number is the number in the internal database, thus in the screenshot above, event 166 is the latest event, and the 166<sup>th</sup> event recorded in the database. It corresponds exactly to event 1 in the HISTORY ON/OFF display. Use the arrows on the bottom of the display to scroll through all FDRs in the database.

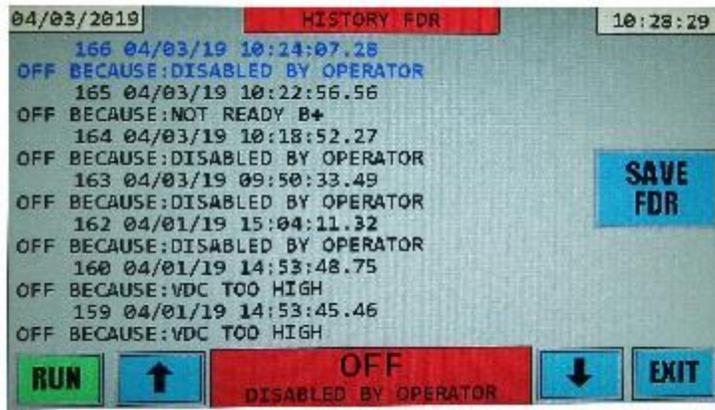
To save an FDR event(s) to the USB flash drive, you must first select which event(s) you want to save. It's also possible to save all of the FDR events in the database without having to select individual events.

In the following example, we will save the first three FDR events to the flash drive. In the screenshot below, events 166, 165, and 164 will be saved. To select an event, simply press the touchscreen anywhere on the 2 lines of text for the FDR desired to be saved. See the following screenshot.



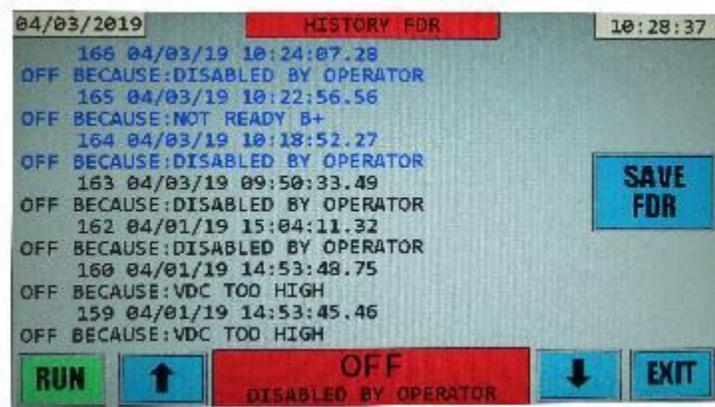
To save event 166 in the screenshot above, touch the screen anywhere within area outlined with the red box.

When event 166 is touched, the text of the event row becomes blue. See the following screenshot.



The text of event 166 became blue to indicate that this event is selected.

Repeat this for events 165 and 164. Now all 3 events have blue text. See following screenshot.



If you selected an FDR event that you wish to un-select, simply press on the text of the event (now blue) again and the text will change back to black to indicate that it's no longer selected.

After the events which you want to save have been selected, press the SAVE FDR button. The following screen will open, see picture below.



You have a choice to save either the selected FDRs (166,165,164) in our example, or to save all FDRs presently stored in memory. It takes approximately 20 seconds to save each FDR to the flash drive. To save the 3 selected FDRs would take about a minute. Up to 100 FDRs can exist (corresponding to the last 100 ON/OFF events; therefore, it could take up to 100x20 seconds = 33 minutes to save 100 FDRs.

Either press the SAVE SELECTED FDRS TO FLASH button to save the selected FDRs or press the SAVE ALL FDRS TO FLASH to save all FDRs to the flash drive. The flash drive is detected by the system and goes through USB enumeration. You will briefly see a message "USB ENUMERATION IN PROGRESS PLEASE WAIT". Now the system will begin saving the FDRs to the flash drive.

The message "FLIGHT DATA RECORDS BEING SAVED TO FLASH DRIVE PLEASE WAIT" will be displayed. There will be a progress bar indicating how many FDRs still need to be saved, and which FDR is currently being saved out of the total. The bar will fill in green as each FDR is saved. See photo below for example of what you should see.



**Note:** Do not remove the flash drive while the FDRs are being saved, as this may cause the file and or the flash drive to be corrupted. If once you start saving FDRs you decide you don't want to save all of the selected FDRs, simply press the EXIT button. After the current FDR being saved completes, no additional FDRs will be saved.

When all of the FDRs are done being saved to the flash drive, you will see a message similar to the following picture. In this example we saved 3 FDRs.



Press the EXIT button to exit to the HISTORY menu display.

Saving FDRs to the flash drive will result in a separate file saved to the root directory of the flash drive with a .FDR extension for each FDR. Each file will be named with the event number of the FDR. In our example we saved FDRs 166,165,164, so the files are named 00000166.FDR, 00000165.FDR, and 00000164.FDR.

Each .FDR file is an Ascii file and can be opened with a text editor or a spreadsheet program such as Microsoft Excel. The first line is a title line containing the event number, the date & time, and reason for the shutdown. The 2<sup>nd</sup> line contains the names of the 10 parameters saved:

Vab Vbc Ict\_a Ict\_b Ict\_c IAHF\_a IAHF\_b linv\_a linv\_c Vdc

This is followed by approximately 3000 lines of data. Each line has the value of the 10 parameters taken approximately every 50 usecs for a period of 4½ 60 Hz line periods (or 4 50 Hz line periods). All but the last line period of data occurred before the shutdown happened. The last line period of data occurred after the shutdown happened. The data is formatted in scientific notation form and is separated by spaces.

This data, when input to a spreadsheet or plot program, can be plotted to see the system behavior over the captured time period at the time of the system shut down. The manufacturer may ask you to send these files so that they can troubleshoot your unit if it is having problems.

### 5.8.5 “HISTORY SAVE TO FLASH” DISPLAY

The HISTORY SAVE TO FLASH DISPLAY allows the operator to save a large amount of diagnostic data in the form of an ASCII file to a USB flash drive. This data consists of system status information, system parameter settings, and the entire History On/Off and Reset database. This information is very useful when troubleshooting issues which caused the unit to stop operating correctly. When a problem occurs, the factory will often ask for this diagnostic file to assist with troubleshooting an issue.

Open the HISTORY SAVE TO FLASH display from the HISTORY display. An example of a HISTORY SAVE TO FLASH display follows.



First make sure that a USB flash drive is inserted into the USB port on the front panel. The flash drive USB port is located under the protective cover to the right of the LCD screen on the front panel of the HMI. Refer to section 3.5.6 on opening the cover and locating the USB port.

To save the diagnostic data, press the SAVE AHF DIAGNOSTIC DATA button. Note this may take a few minutes depending on the number of History On/Off and History Reset events in the database.

The flash drive is detected by the system and goes through USB enumeration. You will briefly see a message “USB ENUMERATION IN PROGRESS PLEASE WAIT”.

Then a message will come up with a status bar which fills in green as the data is saved to the flash drive. See photo below.



When the data is finished being saved to the flash drive the following message will be displayed SUCCESSFULLY SAVED “DSP SERIAL NUMBER.DIA” TO THE FLASH DRIVE PLEASE EXIT TO MENU. See photo below.



The file will be named with the same number as the DSP board serial number and have the extension .DIA for diagnostic.

In our example, our DSP board serial number is 0, so we would find the file 00000.DIA on the flash drive. You can open the file with a text editor such as notepad.

The file contains the same information which can be obtained by entering several commands over the Ethernet network. See section 6 for more details. The first data is a copy of the S command as described in section 6.2.7. This is followed by the OPT command as in section 6.2.5, KSET command in section 6.2.4 and other parameter commands as well as History On/Off and History Reset commands as in section 6.2.3.

It's also possible to obtain the same information by entering these commands over the Ethernet network, copying the results, and creating your own text file with the same data, however the HISTORY SAVE TO FLASH display allows you to simply press a button, and this information is automatically saved to a flash drive. This is especially useful when access to an Ethernet network is not available. In most cases you would simply send the .DIA file to the factory for analysis and troubleshooting

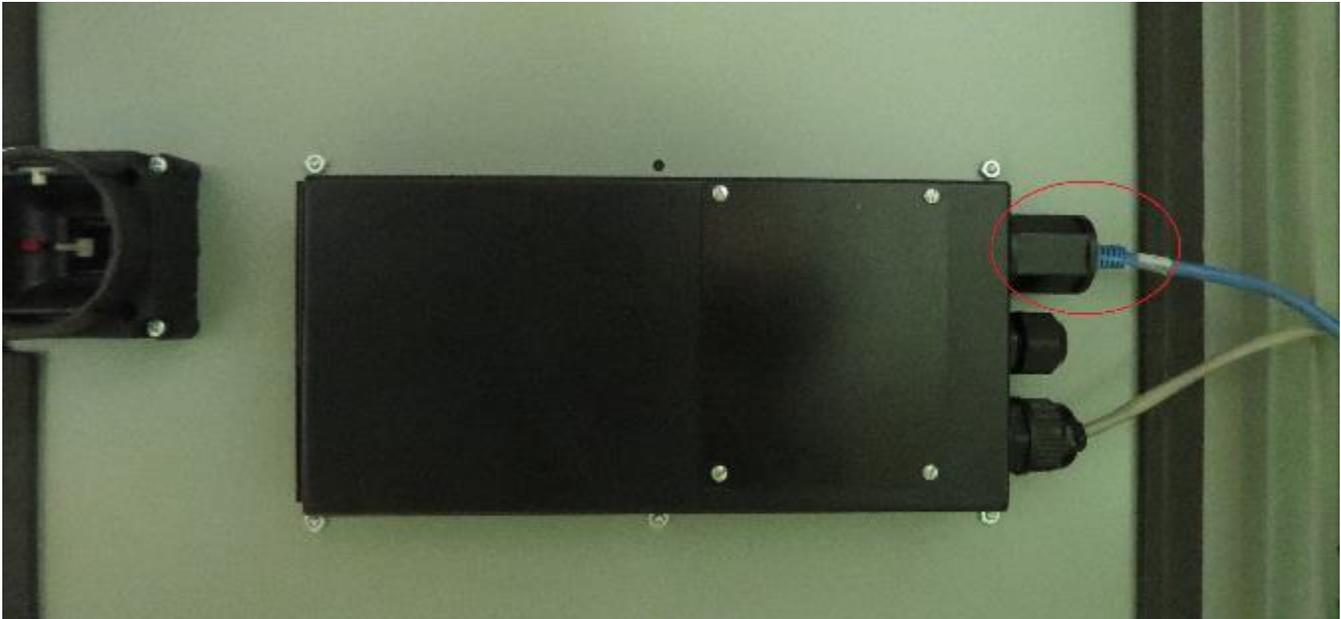
### 5.8.6 “HISTORY INITIALIZE” DISPLAY

This display allows the operator to initialize sections of system memory related to the History displays. The factory may instruct you to enter this display in certain cases to help with troubleshooting and fixing issues. Contact the factory for more information.

## 5.9 "ETHERNET INFO" DISPLAY

Prior to selecting the "ETHERNET INFO" display from the MENU, the Ethernet port should be connected to a switch, hub, etc. in your network via a straight through Ethernet patch cable, or connected directly to a computer using a crossover Ethernet cable or a straight through cable via Auto-MDIX. For more information on setting up your computer or laptop to talk to the AHF via a crossover cable or via Auto-MDIX, see section 5.9.3 of this manual.

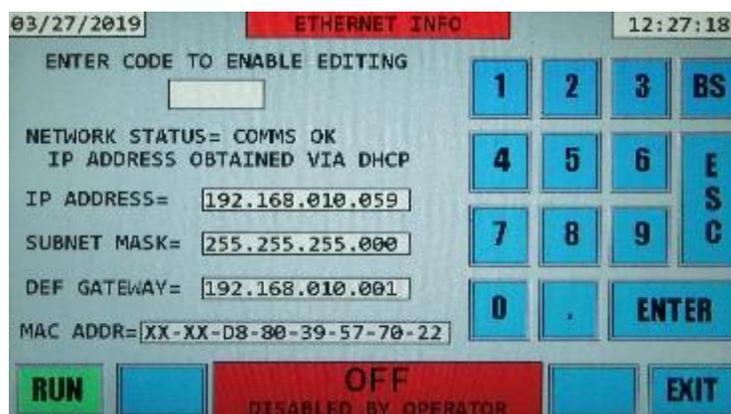
The Ethernet port is located on the back of the HMI front panel assembly on the right side when looking at the back of the front panel. It's the top weatherproof connector. See picture below. The Ethernet port is circled in red. There is a blue Ethernet Cat 5 cable connected to the port in the picture. Also see section 6 of this manual for additional information about Ethernet.



Your system is shipped with its Ethernet DHCP enabled. This will allow your network (or computer) to automatically assign an IP address to the AHF.

In addition to displaying the automatically determined IP address, the ETHERNET INFO display allows the operator to enter and set a static IP address, subnet mask, and default gateway address.

After opening the ETHERNET INFO display from the MENU display you should see something similar to the following picture:



At the top of the information section it says ENTER CODE TO ENABLE EDITING. This is used to enter the display for changing the IP address mode: Static IP Address or DHCP IP Address. This will be covered in section 5.9.1.

Next is the NETWORK STATUS line. This shows the status of the Ethernet Network. If an Ethernet cable is plugged in to the Ethernet port, the NETWORK STATUS should say COMMS OK. If there is no Ethernet cable connected, NETWORK STATUS will say COMMS ERR. Even if the Ethernet cable is connected, but the network is having problems, NETWORK STATUS may say COMMS ERR. If you see this message and the Ethernet Cable is connected, check the functionality of your network.

In our example, the next line says IP ADDRESS OBTAINED VIA DHCP. This line could also say IP ADDRESS IS STATIC. This depends on the IP address setting. Your system is shipped with its Ethernet DHCP enabled.

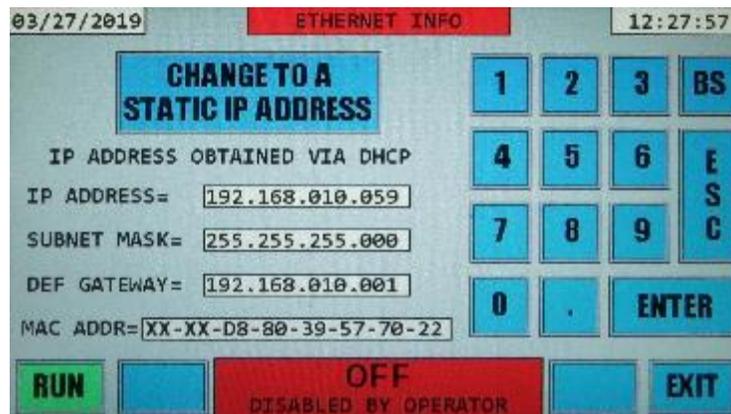
The next 3 lines are the present networking information of the unit. First is the IP Address of the system followed by the Subnet Mask and Default Gateway Address. The last line is the MAC Address of the unit. The IP Address will be needed to use the Ethernet Communications Interface in section 6.

### 5.9.1 CHANGING FROM DHCP TO STATIC IP ADDRESS

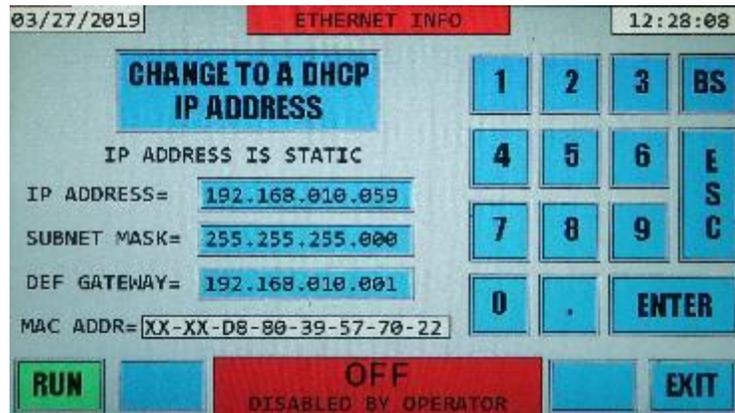
Your system is shipped with its Ethernet DHCP enabled. If you want to set a static IP address, perform the following steps.

1. Using the keypad on the ETHERNET INFO display, enter the code “1076” and press Enter. Use the backspace “BS” button to erase incorrectly entered characters.

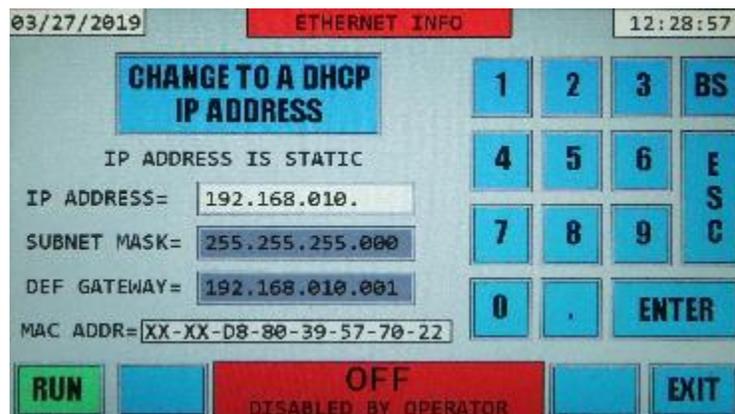
Now a blue button will be displayed at the top of the information section of the display. This button will say CHANGE TO A STATIC IP ADDRESS. See the following picture.



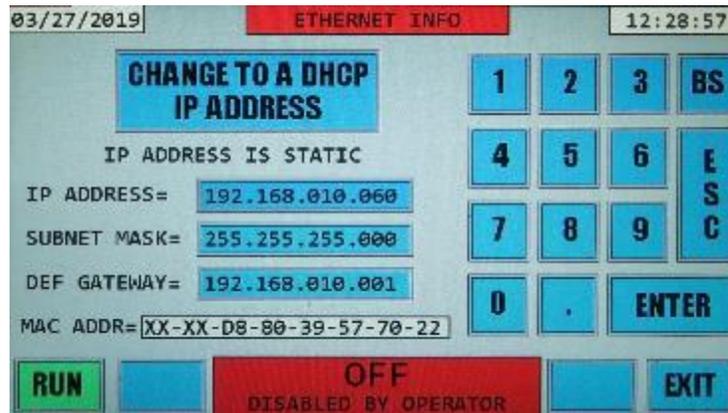
2. Press the CHANGE TO A STATIC IP ADDRESS button. This button will now say CHANGE TO A DHCP IP ADDRESS. The values next to IP ADDRESS, SUBNET MASK, and DEF GATEWAY now have blue rectangles around them which indicate that these are buttons. See the following picture.



3. If you want to simply set the current IP Address which was determined by DHCP to a static IP address (this is very common), simply press the EXIT button on the bottom right of the display and go to step 4. If instead you want to edit the IP address manually and enter new values, continue on to step 4.
4. To edit a network address value, press one of the blue buttons next to it. For example, we will change the IP Address from 192.168.010.059 to 192.168.010.060. Only enter an IP address which is appropriate for your network. If you are unsure, ask your network administrator. Press the blue button next to IP ADDRESS. The rectangular area next to IP ADDRESS now became white with the last 3 digits have been erased, and the rectangular areas next to SUBNET MASK and DEF GATEWAY have become gray. This indicates that IP ADDRESS is being edited. If you are changing the SUBNET MASK, the IP ADDRESS and DEF GATEWAY lines would become gray. The last 3 digits of IP ADDRESS have been erased because in cases where you used DHCP to get an IP address, you will only be changing the last 3 digits. If you need to change anything in the first 3 groups of numbers in the IP address, press the backspace "BS" button and more digits will be erased. If you do erase the other IP Address digits and begin to enter new ones, you don't need to type in the periods after each 3 digits, they will be automatically inserted. See the following picture:

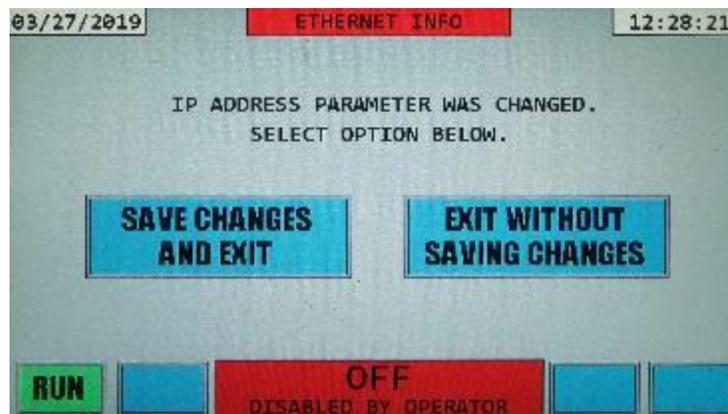


The period key is disabled in this screen. Now in our example we enter 060 with the keypad. After pressing Enter, the rectangular area around IP ADDRESS became blue again, and the IP Address inside this area is now 192.168.010.060 as shown in the following picture:



If needed, the subnet mask and default gateway can also be altered; however that is not necessary for this case. When done, press the EXIT button.

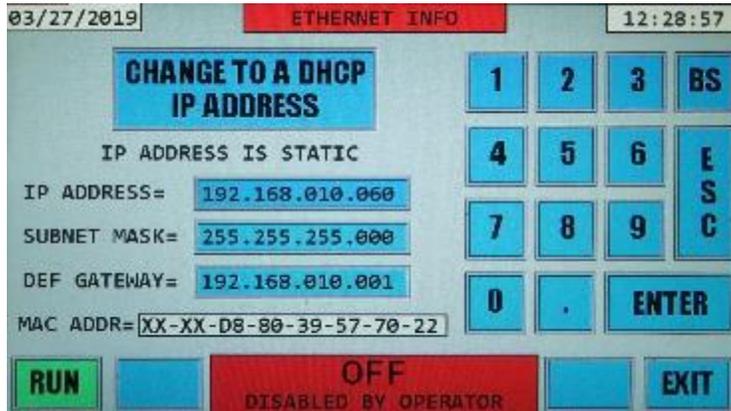
5. A new display opens with a message saying IP ADDRESS PARAMETER WAS CHANGED. SELECT OPTION BELOW. Now you have a choice, SAVE CHANGES AND EXIT if you want to save the changes made to system memory and set it static, or EXIT WITHOUT SAVING CHANGES if you don't want the changes to take effect, and want the IP Address to remain DHCP. After pressing one of these two buttons, the display exits to the MENU display. See picture that follows:



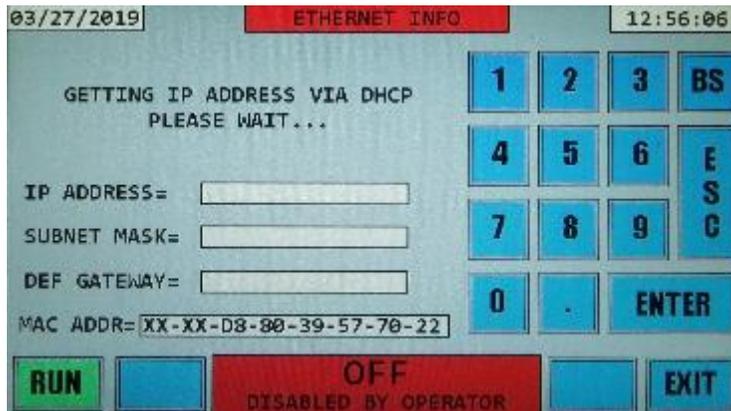
## 5.9.2 CHANGING FROM STATIC IP ADDRESS TO DHCP

If your IP Address is set to static and you want to enable DHCP, perform the following steps.

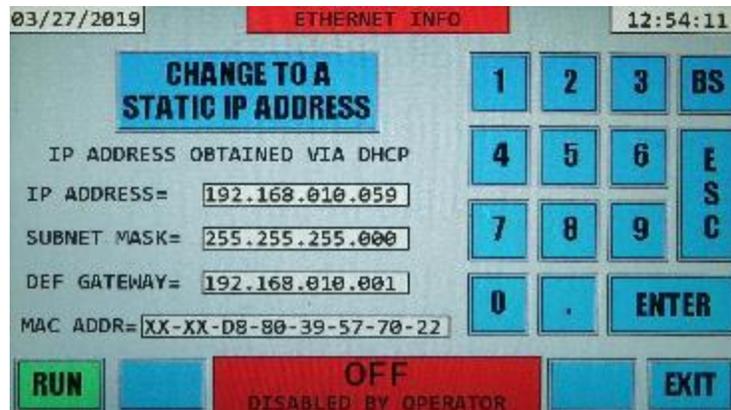
1. Using the keypad on the ETHERNET INFO display, enter the code "1076" and press Enter. Use the backspace "BS" button to erase incorrectly entered characters.
2. Now a blue button will be displayed at the top of the information section of the display. This button will say CHANGE TO A DHCP IP ADDRESS. See the following picture.



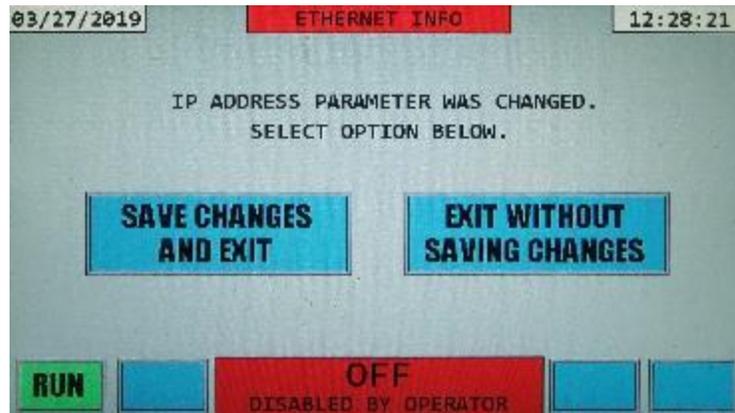
3. Press the button CHANGE TO A DHCP IP ADDRESS. You will see a message which says GETTING IP ADDRESS VIA DHCP PLEASE WAIT... See following picture.



The system will now determine an IP address, Subnet Mask, and Default Gateway Address via DHCP, and display the new information on the screen. The option to go back to a static IP address is still available via the CHANGE TO A STATIC IP ADDRESS button which now appears at the top. See the following picture.



4. To save the new DHCP IP address to memory, press the EXIT button on the bottom right of the display. A new display opens with a message saying IP ADDRESS PARAMETER WAS CHANGED. SELECT OPTION BELOW. Now you have a choice, SAVE CHANGES AND EXIT if you want to save the DHCP obtained IP address to system memory and set it DHCP (meaning every time the system powers up, a new IP Address will automatically be found via DHCP), or EXIT WITHOUT SAVING CHANGES if you don't want the changes to take effect, and want the IP Address to remain static. After pressing one of these two buttons, the display exits to the MENU display. See picture below.



### 5.9.3 ETHERNET USING CROSSOVER CABLE OR AUTO-MDIX

Often in the field, there is no Ethernet network available, and to communicate with the HMI module, the operator must connect the HMI directly to a computer or laptop over Ethernet. This can be accomplished in three ways: using a crossover Ethernet cable between the HMI and computer, connecting both the HMI and computer to an Ethernet switch using 2 standard Ethernet patch cables, or using a standard Ethernet patch cable directly between the HMI and a computer equipped with Auto-MDIX.

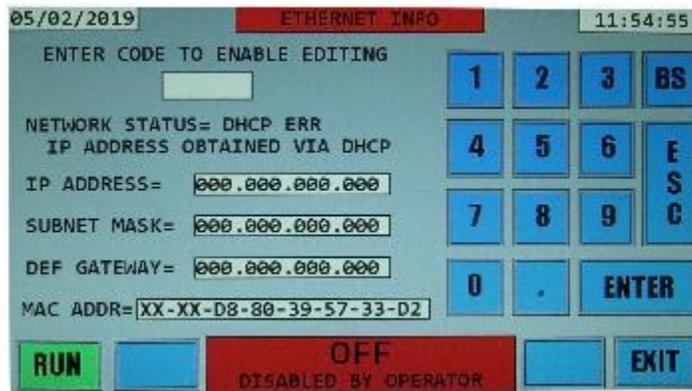
Auto-MDIX or Automatic medium-dependent interface crossover is a feature found on most modern computers. This allows the operating system to automatically configure the Ethernet connection without the need for a crossover cable. If you are unsure if your computer has Auto-MDIX and you don't have a crossover Ethernet cable, try the procedure below with a straight through Ethernet cable. If you find that it doesn't work, you may need to use one of the other methods previously mentioned to connect to the HMI.

In both cases, the procedure for setting up the AHF and your computer or laptop is the same. This procedure assumes a Windows 7 or Windows 10 operating system. For other operating systems, the procedure should be similar, and information on specific details can easily be found by doing an online search.

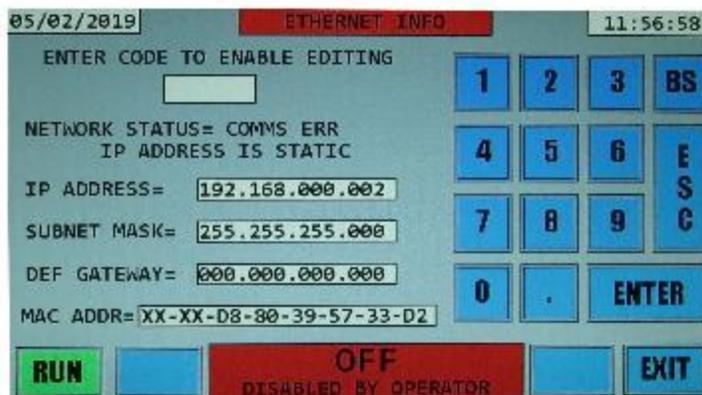


1. You could open the enclosure of the AHF and connect to the HMI via the top weatherproof connector as shown at the beginning of section 5.9. However, there is a preferred, alternative way to connect which can be done without opening the AHF enclosure. Remove the front cover on the HMI exposing the internal contents shown in the picture to the left. The Ethernet cable exposed is the connection between the HMI Ethernet and the weatherproof connector. Remove the cable from the RJ45 connector inside this cavity. Connect your Ethernet crossover or patch cable to the HMI via this RJ45 connector. Connect the other end of the cable to either your computer directly or to an Ethernet switch if using that method. Your computer should not be connected to any other network over Ethernet.

2. Open the ETHERNET INFO display from the MENU display. You will see the message "GETTING NETWORK INFO PLEASE WAIT..." for possibly up to 30 seconds as the AHF tries to find an IP address via DHCP. Ultimately this will fail and eventually a display will open showing NETWORK STATUS = DHCP ERR. See picture below.

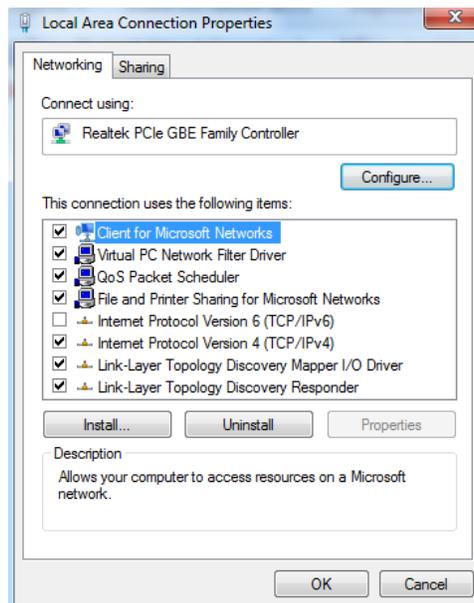


3. Now a static IP address needs to be entered. Please see section 5.9.1 for details on setting a static IP address. Note: If your IP address is already static, you would go through the procedure in section 5.9.2, but instead of pressing the Change to DHCP button, you would type in a new IP address as indicated in the next step.
4. Using the procedure in section 5.9.1, enter the IP address **192.168.000.002** and press Enter. Note that you will need to use the BS backspace key first to delete the leading 000.000.000 in the IP address box.
5. Now press the Subnet Mask button and using the BS backspace button on the keypad erase the current Subnet Mask, in our example 000.000.000.000.
6. Now using the keypad enter the following Subnet mask **255.255.255.000** and press Enter.
7. Don't worry about the Def Gateway. Now press the EXIT button.
8. As was described in section 5.9.1 you will see a display open up saying IP ADDRESS PARAMETER WAS CHANGED. SELECT OPTION BELOW. Press the SAVE CHANGES AND EXIT button.
9. Now to confirm that your IP Address has been correctly set, from the MENU display, go back to the ETHERNET INFO display. You should see something similar to the following picture:

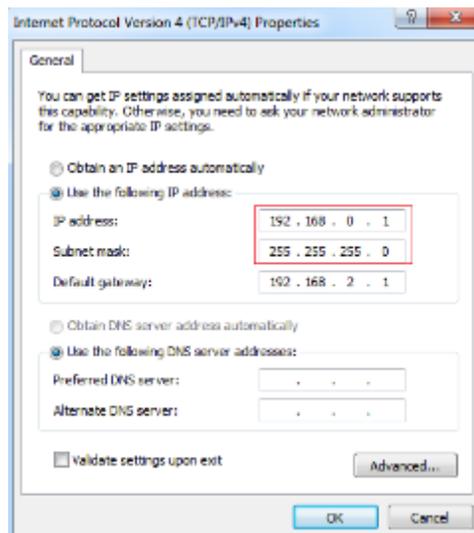


Note: you may get the “GETTING NETWORK INFO PLEASE WAIT...” message for a few seconds and NETWORK STATUS= COMMS OK may be displayed instead of COMMS ERR as in the above picture. That is okay. The important thing to confirm is that the IP Address and Subnet Mask have been set static and to the same numbers as in the picture above.

10. Now we will set a static IP address on your computer. This example uses the Windows 7 operating system, but the procedure for other Windows operating system versions also have a similar procedure for this.
11. Go to Control Panel\All Control Panel Items\Network and Sharing Center and click on Change adapter settings. You should see an icon for Local Area Connection or something similar for your Ethernet connection. Right click on this icon and go to Properties. You should see something similar to the following picture.



12. Double click on Internet Protocol Version 4 (TCP/IPv4). You should see something similar to the following picture.



Select “Use the following IP address:” and type in 192.168.000.001 for the IP Address and 255.255.255.000 for the Subnet mask. It doesn’t matter what the Default Gateway is. These are circled red in the picture above.

Now click OK. If you get a Warning that the default gateway is not the same network segment message, ignore it. That is only important if you were connected to the network, and doesn’t apply when connecting the computer and AHF directly.

13. Now that your computer has an IP address, and the AHF has an IP address, you can communicate to the AHF from a terminal program. At this point if your computer has Auto-MDIX everything will work regardless of what type of Ethernet cable you have. If it doesn’t work, you may need a crossover cable or using an Ethernet switch with two normal Ethernet cables, one connecting to the HMI and the other connecting to the computer.

In this example we will be using Tera Term. Section 6 of this manual has more information about choosing a terminal program. Set up Tera Term with the Ethernet settings as in the following picture.



Note that the IP Address is 192.168.0.2. Tera Term will not connect if you include the leading zeros in the IP Address. Also, note that this is the IP Address that we set in the HMI in step 4. The TCP port is 10001. If you click OK, and then press the Enter key, you should see > prompt symbols. Type s and press Enter. You should see the system status information. This verifies that the HMI is communicating with your computer.

#### 5.9.4 “ETHERNET/IP OR MODBUS TCP INFO” DISPLAY

Systems equipped with ETHERNET/IP or MODBUS TCP capability have this information display to be able to show the present IP Address and other network related information, and to set a static IP Address so that a PLC or HMI can be programmed with this IP address and automatically connect to the HMI.

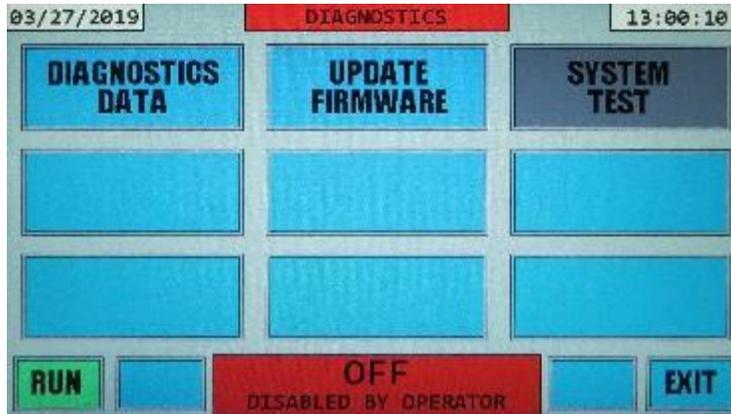
Note: Systems without ETHERNET/IP or MODBUS TCP capability will show INDUSTRIAL NETWORK on the MENU display and the button will be gray to indicate that it is disabled.

The ETHERNET/IP or MODBUS TCP INFO display is identical to the ETHERNET INFO display described earlier in this section. The only difference is the IP Address and other network information is shown for the HMS Anybus Industrial Network module in the HMI. Please refer to the Ethernet display details described earlier in this section on how to use this display, and to section 7 for details about setting up ETHERNET/IP and MODBUS TCP.

#### 5.10 “DIAGNOSTICS” DISPLAY

The DIAGNOSTICS display is similar to the MENU display and contains multiple buttons which open various Diagnostic sub-displays. DIAGNOSTICS DATA currently just shows the HMI reset reason. This

is useful for troubleshooting. This feature is still being developed, and will have other functionality in a future firmware update. UPDATE FIRMWARE is used to update both the HMI and AHF firmware as described in section 5.10.1. SYSTEM TEST is a gray button which indicates that it is currently disabled. This is a future feature that will allow to system tests to be performed to assist in troubleshooting. It will be available in a future firmware update. The buttons without text are empty spaces for future Diagnostic displays. An example of a DIAGNOSTICS display follows:



### 5.10.1 “UPDATE FIRMWARE” DISPLAY

The UPDATE FIRMWARE display allows the operator to update the AHF firmware with new features, upgrades, and bug fixes, by simply plugging in a USB flash drive, and pressing a few buttons on the screen. The firmware update process is intuitive, simple, and takes only a few minutes. This section will describe how to update the AHF firmware.

On the MENU display, open the DIAGNOSTICS display by pressing the DIAGNOSTICS button. Then from the DIAGNOSTICS display, press the UPDATE FIRMWARE button. The following display will open. See the following picture.



To Update the AHF Firmware, please perform the following steps:

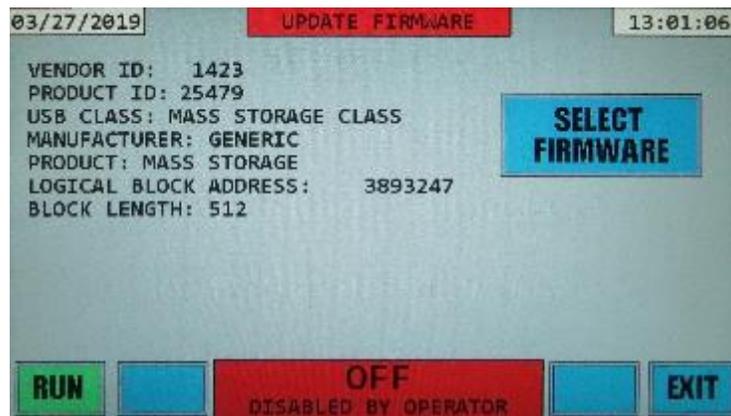
1. Obtain a USB flash drive (2GB or larger, most modern flash drives fit this requirement). Upload the new firmware on the flash drive. The factory will provide you with the new firmware files. These files will have the format hmixxxxx.bin or dspxxxxx.bin where xxxxx is a 5-digit version number of the firmware.

**Important:** These files **MUST** be in the root directory of the flash drive, otherwise the system will not detect them.

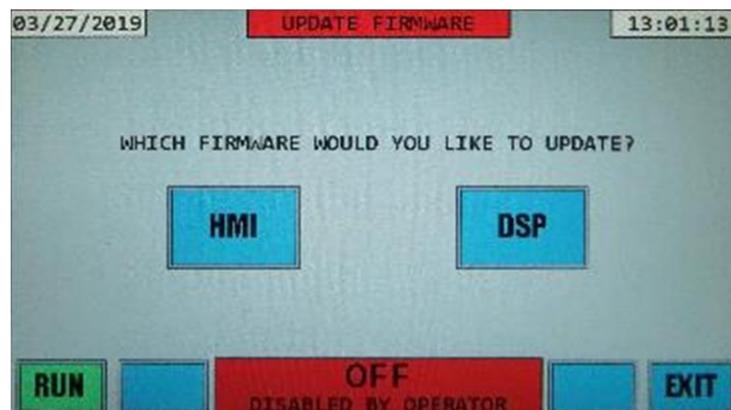
2. Plug a USB flash drive into the USB port in the HMI. The flash drive USB port is located under the protective cover to the right of the LCD screen on the front panel of the HMI. Refer to section 3.5.6 on opening the cover and locating the USB port.
3. Enter the code “1076” using the keypad and press Enter. Use the backspace “BS” button to erase incorrectly entered characters. A message will briefly appear saying “USB ENUMERATION IN PROGRESS PLEASE WAIT”. If the flash drive is not already plugged in as you enter the code, the message “PLEASE CONNECT A USB FLASH DRIVE” will appear. Simply plug the flash drive into the USB port.

After USB Enumeration is complete, you will see USB related information displayed, such as the Vendor ID, Product ID, Manufacturer, Product, and etc. If you multiply the Logical Block Address by the Block Length, you will get the flash drive size in bytes. This information will be specific to your flash drive. This information may be useful in troubleshooting any potential USB issues.

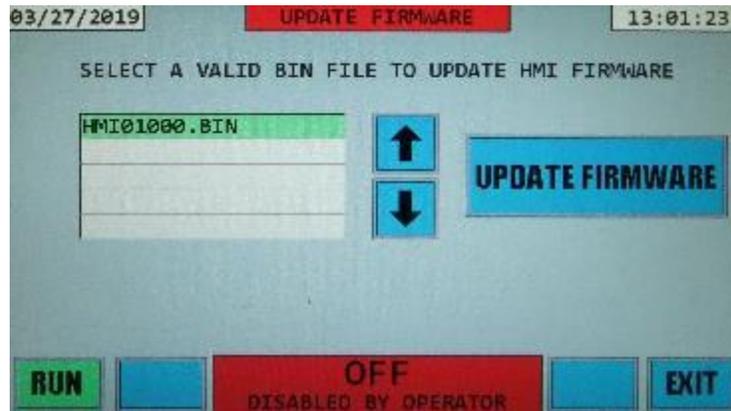
Most importantly, successful USB enumeration indicates that the USB flash drive was successfully read by the AHF. If for some reason USB enumeration fails, the system may automatically reset to try and fix the issue. The most common cause of this is a flash drive which was not pushed in all the way into the USB port. Disconnect, and reconnect the flash drive and try again. See section 9 Troubleshooting for more information. Please see the following picture for an example of the USB enumeration information you will see.



4. Press the SELECT FIRMWARE button. The following screen will open. See picture below.



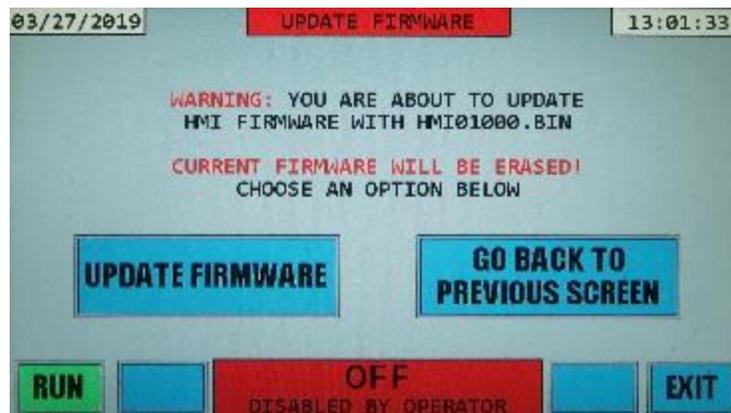
5. The factory will inform you if you need to update the HMI or DSP firmware. Press the appropriate button HMI or DSP. In our example we will press the HMI button. The following screen will open. See picture below.



6. You should see the message SELECT A VALID BIN FILE TO UPDATE HMI FIRMWARE, and a table with 5 rows. These rows show the valid HMI firmware files located in the root directory of your flash drive, up to 5 files. This will not show the other files on your flash drive, only the files in the format hmixxxx.bin. If you pressed the DSP button, the same would be true except only files called dspxxxxx.bin would be visible. In our example, you can see the file HMI01000.BIN displayed and 4 empty rows. This means that it's the only valid HMI firmware file found on the flash drive. Use the arrows to select the firmware file as instructed by the factory

Before pressing UPDATE FIRMWARE, make sure that the unit is disabled by pressing the red STOP button on the lower left of the display if the unit is currently enabled. If the unit is disabled, you will see a green RUN button as in the preceding picture of a display . If you try to press UPDATE FIRMWARE while the unit is operating, you will see a red warning message YOU MUST DISABLE UNIT BEFORE UPDATING FIRMWARE displayed on the screen. See section 5.11 for more information on how to disable the unit using the STOP button.

Press the UPDATE FIRMWARE button. A new screen will open. See the following picture.



This screen gives a warning that you are about to erase the current HMI firmware and replace it with HMI01000.BIN and gives you a choice to proceed by pressing the UPDATE FIRMWARE button, or to go back and select another file by pressing GO BACK TO PREVIOUS SCREEN. You can also press EXIT to go back to the DIAGNOSTICS display.

7. Now you will update the HMI firmware. It's very important to make sure that the correct file is selected as instructed by the factory and that the flash drive is NOT removed after you press UPDATE FIRMWARE. If the flash drive is accidentally removed, this will NOT corrupt the AHF firmware, however it may corrupt the flash drive. Please see the troubleshooting section 9 for more information on what will happen if the flash drive is accidentally unplugged, and how to fix this issue.

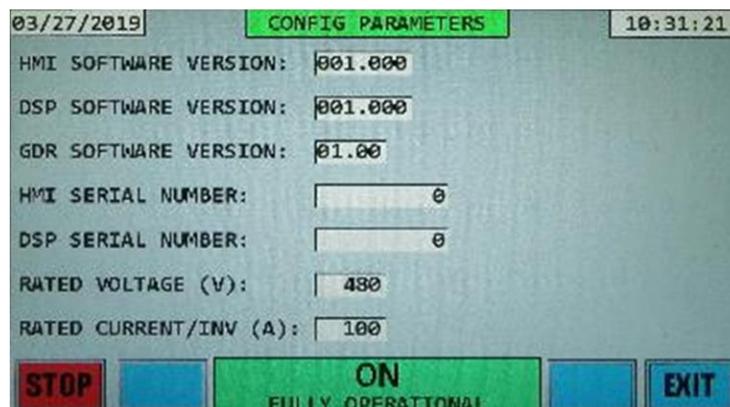
- Press UPDATE FIRMWARE. The HMI firmware will now begin being updated. A Blue screen will open up saying UPLOADING NEW HMI FIRMWARE. PLEASE WAIT UP TO 10 SECONDS. UNIT WILL AUTOMATICALLY RESET. See the picture below.



- After the firmware is updated, the unit will automatically reset and the splash screen with the logo will appear. At the bottom of the splash screen you will see a message saying HMI UPDATED TO FIRMWARE VERSION XXX.XXX where XXX are numbers 0-9. Seeing this message verifies that the firmware was updated correctly. See picture below.

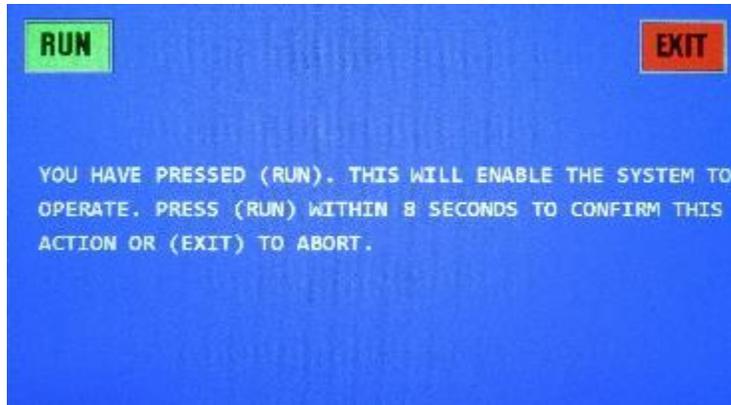


As an additional verification you can open the CONFIGURATION PARAMETERS DISPLAY as described in section 5.6.3 and verify that the HMI Software version matches the version number of the file. In our example we updated the HMI firmware with HMI01000.BIN, and in the CONFIGURATION PARAMETERS display the HMI Software Version is 001.000. See picture below.



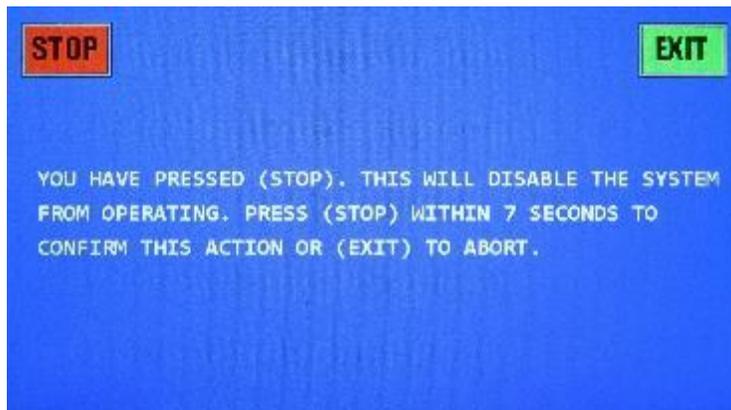
## 5.11 ENABLING OR DISABLING THE AHF USING THE RUN OR STOP BUTTONS

The system can be enabled or disabled by pressing the “RUN” or “STOP” buttons located in the bottom left corner of the “Status” section on the touch screen. All screens will have one of these buttons. If the system is presently disabled, the green “RUN” button will be present on the screen. The operator can enable the system by pressing this “RUN” button. The following “confirmation” display will appear once the “RUN” button is pressed:



The green “RUN” button on this display will have to be pressed before the 10 second timer on this display expires, for the system to become enabled. Pressing the “EXIT” button on this display will result in immediately going back to the previous display without enabling the system. Once a system is enabled, a red “STOP” button will appear on all “Status” sections of displays in place of the green “RUN” button. Enabling a system does not necessarily result in a system running. There may be other conditions that prevent a unit from running.

If the system is presently enabled, the red “STOP” button will be present in the lower left corner of “Status” section of all displays. The system may not necessarily be running (“ON” status), as some condition may be keeping the system from running. The following “confirmation” display will appear once the red “STOP” button is pressed:

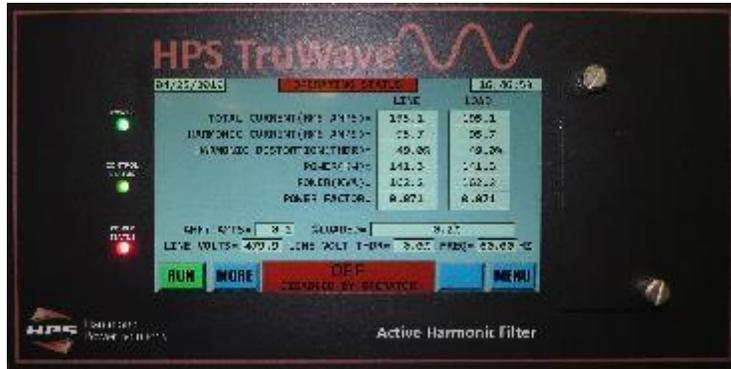


The red “STOP” button on this display will have to be pressed before the 10 second timer on this display expires, for the system to become disabled. Pressing the “EXIT” button on this display will result in immediately going back to the previous display without disabling the system. Once a system is disabled, a green “RUN” button will appear on all “Status” sections of displays in place of the red “STOP” button. Disabling a system will immediately stop a system from running.

## 5.12 FRONT PANEL STATUS LEDS

The AHF has 3 LEDs located on the front panel HMI to the left of the LCD touchscreen. These LEDs are: Power, Control Status, and Power Status. These LEDs are used to indicate the status of the system. The

picture below shows a front panel with the unit disabled. Note the LED colors in the case where the unit is disabled.



The Power LED is on and green when the HMI module has power. It is off when the HMI module does not have power. If you are having problems with the Front Panel LCD turning on, make sure that the Power LED is on, if not there is likely an issue with power going to the HMI Front Panel.

The Control Status LED indicates the status of the HMI onboard processor. If this LED is green, the processor is running correctly, if this LED is red, the processor is having problems, contact the factory.

The Power Status LED indicates the operational status power output (Harmonic current correction and/or Linear power factor correction) of the system.

If the Power Status LED is green, the system is operating correctly and can be in the following states: ON, ON MAX LOAD, PRECHARGING, STARTING, WAITING, IDLE.

If the Power Status LED is red, the power output of the system is OFF and not correcting harmonics or power factor.

If the Power Status LED is yellow the system is in one of the following states: ON MAX LOAD, INVERTER TEST, THYRISTOR TEST, CONTACTOR TEST, VDC TEST.

ON MAX LOAD means the system is running, but is at maximum output. The load is requiring more harmonic and/or linear current correction than the unit is rated for.

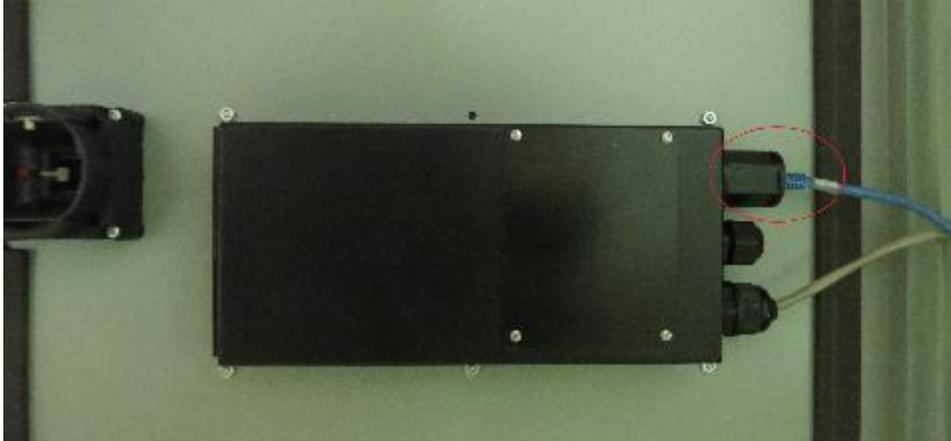
Note that for the Power Status LED, the colors are the same as the colors of the top and bottom status sections of every display on the LCD screen. In the picture above, the system is off and the Power Status LED is red, and in addition the status sections on the Operating Status display are red.

## 6. ETHERNET COMMUNICATIONS

An Ethernet communications interface is provided on the AHF to allow the unit to be configured and data collected from the unit. The Ethernet interface is capable of 10/100 Mbps and uses the TCP/IP protocol.

### 6.1 USING THE ETHERNET COMMUNICATIONS INTERFACE

The Ethernet port is located on the back of the HMI front panel assembly on the right side when looking at the back of the front panel. It's the top weatherproof connector. See picture below. The Ethernet port is circled in red. There is a blue Ethernet Cat 5 cable connected to the port in the picture.



Connect one end of an Ethernet patch cable to the Ethernet port on the HMI, and the other end either to a switch connected to your network (see section 5.9 on how to set up the Ethernet port to communicate on your network).

**Note:** You can also connect to the Ethernet port on the HMI directly to a computer or laptop. See section 5.9.3 of this manual for important information regarding how to do this.

One can communicate with the HMI over the network using a terminal program. One such terminal program on many Windows based computers is Hyperterminal. Unfortunately, WindowsXP was the last Windows operating system that this terminal program was provided free with the operating system. Other free, open source terminal programs exist that can be downloaded for free over the internet. One such program that works quite well is Tera Term. After obtaining a suitable terminal program, you will need to set it up with the proper signaling protocol that follows in order to communicate with the AHF:

Set up Hyperterminal properties to “Connect using” TCP/IP. Input the IP address for the AHF as the “Host Address” (format xxx.xxx.xxx.xxx where you put in the actual IP address in place of the x’s – e.g. 192.168.10.20). Finally, input 10001 as the port address. For using Tera Term, consult the same documentation cited earlier for installing/configuring Tera Term.

Once the connection is made between the equipment and the terminal, the AHF (and hence the HMI) is powered, and your computer is running a terminal program, you should see the message “RESET HMI” followed by the prompt character >. Press the <Esc> key on your computer a few times. The monitor of the terminal should display “<Esc>” every time you press the <Esc> key. If not, recheck your wiring and protocol setup. Note: For Tera Term you will have to press Enter every time after pressing the <Esc> key.

### 6.2 ETHERNET COMMUNICATIONS COMMANDS

Once you receive the prompt character “>”, you may enter a command to obtain information that you desire from the unit. Each command begins with a letter followed by additional parameter characters,

terminated with the **<Enter>** key. Either upper or lower case characters may be used as the interface is not case-sensitive. The following keyboard keys have special meaning:

- <Esc>** The escape key can be pressed at any time to abort any command. After pressing the escape key, the unit will display **<ESC>** to indicate such a key was pressed followed by a new ">" prompt. At such a time a new command can be entered. Note: For Tera Term you will have to press Enter every time after pressing the <Esc> key.
- <Enter>** The "Enter" key is pressed to send the command to the AHF. Up until the "Enter" key is pressed, the command may be typed and altered using the "Backspace" key. No action will be taken by the AHF on the command until the "Enter" key is pressed.

Commands begin with a letter, with the most commonly used summarized in Table 6.1. Additional information about these commands appears in subsequent sections. In the format for these commands, items contained within brackets "[" and "]" are optional parameters that may be entered. A value "n" is a one digit number and "nn" is a one or two digit number. "hh", "mm", and "ss" are two digit numbers for hours (00-23), minutes (00-59), and seconds (00-59). "mm", "dd", and "yy" are two digit numbers for month (01-12), day (00-31), and year (00-99). On-line command help is available. A ? command entered will display the list of available command letters. The command letter listed followed by a ? will display information about that command. For example sending a ? command will display:

AVAILABLE COMMANDS:

A, B, G, H, K, O, Q, S, T, V, Z

Following this up by sending an **A?** command results in the following on-line information being displayed about command(s) that begin with the letter A:

```
(A)CEN/(A)CDIS command. Enables/Disables the AHF.
Command format is:
>ACEN
    Enables the AHF.
>ACDIS
    Disables the AHF.
```

<b>Command</b>	<b>Format</b>	<b>Function</b>
A	ACEN or ACDIS	Enables or disables operation of the unit
H	HO[nn][-][mm][,v] or HR[nn][-][mm]	HO is the "on/off" history HR is the "reset" history
K	KSET	Displays programmable parameter values
O	OPT	Displays firmware version and system options configuration
Q	QOFF	Displays measured DC content in several monitored parameters
S	S[x]	Status display. Displays operational values.

T	TI or TT=hh:mm[:ss] or TD=mm/dd/yy	TI displays current date and time. TT sets time. TD sets date.
V	V[x]	Similar to S command, but continuously displays values until <b>&lt;Esc&gt;</b> key is pressed.
Z	ZCAL	Displays readings of parameters measured by the system.
?	?	Displays list of available command letters

### 6.2.1 “A” ACEN/ACDIS COMMAND

Sending the ACEN command is identical to pressing the “RUN” button on the LCD touchscreen display. If other operating conditions are OK for the system to operate, sending the ACEN command will allow the system to start operating. Sending the ACDIS command is identical to pressing the “STOP” button on the LCD touchscreen display. If the system was operating, ACDIS will shut it down and the system will not run again until either the ACEN command is sent or the “RUN” button on the LCD touchscreen display is pressed. The last entered command is “remembered” through power off/power on cycles. If an ACDIS command was last sent or “STOP” button was last pressed prior to removing power to the unit (by either turning off the front power switch or loss of utility power), the next time power is reapplied to the unit, the unit will stay in the disabled state and will not operate until enabled. If an ACEN command was last sent or “RUN” button was last pushed prior to removing power to the unit, the next time power is reapplied to the unit, the unit will be in the enabled state and will operate if all other conditions are OK for the system to operate.

### 6.2.2 “HF” HISTORY FDR COMMAND

This is a troubleshooting tool that you may be instructed to perform by a factory representative should you be experiencing a possible problem. This displays the same information as the HISTORY FDR display in section 5.8.4. If for some reason the method of saving an FDR via the USB flash drive as described in section 5.8.4 fails, you may need to use this Ethernet command instead.

### 6.2.3 “H” HISTORICAL EVENT DATABASE DISPLAY COMMAND

The AHF provides two event historical databases – an “On/Off” and a “Reset” database. Records of both the databases are numbered starting with 1. Up to 480 “On/Off” events and 1856 “Reset” events are stored. Once the limit is reached, the oldest event is discarded to make room for the newest event. The events are numbered with 1 being the most recent event, followed sequentially by earlier recorded events. These recorded events are saved in battery backed up memory, so loss of power to the unit will not result in any events being lost.

#### 6.2.3.1 “HO” HISTORICAL ON/OFF EVENT DATABASE DISPLAY COMMAND

The first of these databases contains the date and time the system starts operating (correcting harmonics, etc.) and stops operating. The reason for a unit to stop operating could be intentional (system is disabled) caused by an operator pressing the STOP button on the front panel LCD display, by an operator issuing an ACDIS command over the communications connection, or by receiving an external disable signal (if that feature is activated). The reason for a unit to stop operating could be due to an unavoidable external condition such as loss of utility voltage (or dropping out of tolerance) either due to unit being powered off via the front power switch or a utility interruption. The reason for a shutdown could be due to a temporary condition that the unit was unable to deal with requiring the unit to shut down and restart, such as a hardware current trip. Also, the reason could be due to a problem such as over-temperature (dirty filter or inoperable fan) or internal problem detected. Each time the AHF’s power inverter shuts down, a snapshot of several operating parameters (voltages, currents, temperature, etc.) are saved along with the reason for the shutdown. The last 480 “on-off” events are stored in non-volatile flash memory inside

the AHF on the DSP Control board (PC-C), thus this information is preserved even when the unit is totally powered down.

The information in this database may be viewed by using the "HO" command issued over the Ethernet interface. The full format of the command is **HO[nn][-[mm]][,v]** where: nn and mm are on/off record event numbers. The best way to understand the format of this command is through examples.

In the following examples nn=10 and mm=20:

HO displays newest (or latest) record.

HO10 displays 10th newest record.

HO- displays all records from newest to oldest.

HO-10 displays all records from newest to 10th newest.

HO10-20 displays all records from 10th newest to 20th newest.

HO10- displays all records from 10th newest to oldest

The optional ",V" attribute may be added to the command to display the "verbose" data. Without the ",V" suffix added, only the date and time for when the system started and stopped, and the reason for the system stopping will be displayed. Adding the ",V" suffix results in all of the parameters saved at the time of the shutdown to be displayed as well.

For example entering HO-3 would produce something similar to the following.

```
OPERATIONAL HOURS =          20, ON/OFF EVENTS = 58
  1.          58 04/02/19 16:00:46.40 - 04/02/19 16:12:34.74
      OFF BECAUSE:DISABLED BY OPERATOR
  2.          57 03/29/19 15:32:19.78 - 03/29/19 17:42:04.61
      OFF BECAUSE:DISABLED BY OPERATOR
  3.          56 03/26/19 14:14:08.56 - 03/26/19 14:15:23.47
      OFF BECAUSE:DISABLED BY OPERATOR
```

This shows the 3 newest (or latest) events. It begins with the number of OPERATIONAL HOURS. This is a tally of the cumulative number of hours the AHF has been operating (producing correction current, not just powered up). ON/OFF EVENTS indicates the number of ON/OFF events that have been recorded. Once the maximum of 480 is reached, the oldest records are discarded as new events occur, resulting in the newest 480 events being kept.

This is followed by two lines of data for each stored event. The first line contains the internal data base number, the date and time the unit started operating, followed by the date and time the unit shut down. The second line indicates the reason the unit shut down. The time that the unit ran last (in record 1) was 11 minutes, 48.34 seconds (04/02/19 16:12:34.74 minus 04/02/19 16:00:46.40) before an operator disabled the system by either sending an ACDIS command over the communications interface or pressing the STOP button on the LCD touchscreen.

Prior to this event, event 2 indicates the unit ran for 2 hours, 9 minutes, 45 seconds, again being shut down by an operator. In between events 2 and 1, the unit stayed off for 4 days 40 minutes, 14.96 seconds. (04/02/19 16:12:34.74 minus 03/29/19 15:32:19.78).

An example of a stored event recalled with the ",V" option follows:

```

OPERATIONAL HOURS =      2176, ON/OFF EVENTS =255
1.      255 04/30/19 12:00:43.33 - 04/30/19 12:01:25.47
OFF BECAUSE:DISABLED BY OPERATOR
VLINE: RMS=479.8/479.8/479.8   INST= 566.7/ 39.7/-606.6
ILINE: RMS= 85.0/ 85.0/ 85.0   INST= 118.7/ -54.4/ -64.2
ILOAD: RMS= 97.5/ 97.5/ 97.5   INST= 68.4/ -34.2/ -34.2
IAHF : RMS= 46.4/ 46.4/ 46.4   INST= 50.2/ -20.2/ -30.1
IINV : RMS= 46.4/ 46.5/ 46.4   INST= 49.3/ -18.3/ -31.0
IAHF-HF = 1.7/ 1.7/ 1.7       IAHF-DC= 0.0/ 0.0/ 0.0
VLINE-HARM= 0.1/ 0.1/ 0.1     IAHF-INV= 0.9/ 1.9/ 0.9
ILINE-HARM= 1.4/ 1.4/ 1.4     ILOAD-HARM= 47.8/ 47.8/ 47.8
LINEKW/KVA= 70.6/ 70.6/ .999  LOADKW/KVA= 70.6/ 81.1/ .871
VDC:DES=821.3 ACT=821.3 LO+HI=410.7+410.7/410.7+410.7FILT
LINE FREQ=60.00 TEMPS: DSP= 28, GDR= 28, HS1= 41, HS2= 42
VDC START=694.1 PCTIME= 0.955 MAX AMPS= 1.3 AVG AMPS= 1.2

```

Following the OPERATIONAL HOURS and ON/OFF EVENTS header line will be the verbose records of all ON/OFF events asked for. Each event will have 14 lines of information about that event. The first 2 lines are identical to the lines displayed with the non-verbose option. The “extra” 12 lines contain operational information at the time the unit shut down. A detailed explanation of this data can be found in section 5.8.2. All of the information in the HO command can also be viewed in the HISTORY ON/OFF display described in sections 5.8.1 and 5.8.2.

### 6.2.3.2 “HR” HISTORICAL RESET EVENT DATABASE DISPLAY COMMAND

A second database contains information about each time the AHF DSP Control is reset. Information recorded includes date and time when the event occurred and the cause of the reset. A reset occurs every time power is applied to the unit; therefore, most resets that appear in this data base will be “POWER-UP” resets. However, the appearance of abnormal resets may be useful in diagnosing a possible problem. The last 1856 “Reset” events are stored in non-volatile flash memory.

To obtain “Reset” records over the Ethernet communications interface, use the following command format:

```
HR[nn][-[mm]]
```

where: nn and mm are reset record event numbers

See the following examples where nn=10 and mm=20:

HR displays newest (or latest) record.

HR10 displays 10th newest record.

HR- displays all records from newest to oldest.

HR-10 displays all records from newest to 10th newest.

HR10-20 displays all records from 10th newest to 20th newest.

HR10- displays all records from 10th newest to oldest

The command **HR-3** would result in information similar to the following being displayed:

```

OPERATIONAL HOURS =      20, RESET EVENTS = 55
1.      55 04/02/19 13:11:30.31
RESET BECAUSE:POWER-UP

```

2.           54 03/29/19 10:48:53.89  
RESET BECAUSE:POWER-UP
3.           53 03/26/19 13:31:35.84  
RESET BECAUSE:POWER-UP

Similar to the HO command, the AHF operational hours are display, along with the number of reset events stored in the database (maximum 1856). This is followed by the reset events starting from the newest (or latest) event first. This is followed by the internal database number and the time and date the unit reset, followed by the reset cause on the next line.

All of the information in the HR command can also be viewed in the HISTORY RESET display described in section 5.8.3.

### 6.2.4 “K” KSET (SYSTEM OPERATING PARAMETERS) SERIAL COMMAND

The AHF has several customer accessible parameters that can be altered in the field. These parameters may have to be altered to adapt your system to your particular application. These changes can be made either using the LCD front panel touchscreen “VIEW/SET PARAMETERS” displays or over the communications link using the **KSET** command. Typing in the **KSET** command will result in information similar to the following list being displayed:

#### CUSTOMER SETUP CONFIGURATION

```

CT CURRENT RATIO (N:5):                2000
CT PLACEMENT (LINE OR LOAD):           LINE
NUMBER OF CTS (2 OR 3):                2
%LOAD TO BE CORRECTED BY THIS UNIT:    100
%THDR GOAL TO BE ACHIEVED BY THIS UNIT: 3
POWER FACTOR GOAL TO BE ACHIEVED BY THIS UNIT: 0.82
CURRENT LIMIT % OF RATING:             100
CURRENT LIMIT (1 PHASE % OF TOTAL RATING): 104
UNIT DISABLED IF LOAD POWER BELOW THIS %: 0
THDR OR THDF DISPLAYED:               THDR
DISPLAY FILTERING (0-100 = MIN-MAX):    50
HARMONIC CALC FILTERING (0-100 = MIN-MAX): 20
UNIT WILL NOT START IF LOAD PF LESS THAN: 0.65
EXTERNAL ENABLE INPUT:                 NOT USED
ETHERNET/IP EXT ENABLE INPUT:          NOT USED

```

Changing these parameters is password protected to prevent unauthorized personnel from making changes. In order to change the customer accessible parameters under the Customer Setup Configuration you must perform the following numbered steps listed below. The **<enter>** designation is instructing you to hit the enter key. You may type either capital letters or lower case letters, the system is not sensitive to the case used. If you make a mistake during this procedure, you may hit the **<Esc>** key on your computer’s keyboard to abort the procedure. Aborting the procedure will result in no changes to any of the parameters being saved as no changes are actually implemented until you go through all of the parameters and exit the procedure normally (indicated by the **>** prompt once again being displayed).

**Note: The first three parameters (all having to do with the CT setup) listed in the Customer Setup Configuration cannot be changed unless the AHF is disabled either via the ACDIS command over the communications link or by pressing the “STOP” button on the LCD display. Also, if the LCD display is presently in the “VIEW/SET PARAMETERS” screens, the KSET**

**command will not allowed and if in the KSET;CH command, the “VIEW/SET PARAMETERS” LCD screen will not be allowed.**

1. Type **DCS <enter>**
2. System should respond with “ACCESS OK”
3. Type **KSET;CH <enter>**
4. System should respond with “CUSTOMER SETUP CONFIGURATION:” and then start listing each customer accessible parameter individually followed by the question “ADJUST (Y/N)?”
5. Type **N<enter>** until you reach the parameter you want to change
6. When you have reached the parameter you want to change type **Y<enter>**
7. If there are only two available choices for this parameter, the system will change the parameter and move on to the next line. If there are more than two choices for a parameter, the system will respond with “New Value” followed by a “\_” prompt, or several numbered options to choose from. At this point you can respond by typing a numeric value after the “\_” prompt followed by **<enter>**, or type in the number that corresponds to one of the choices followed by **<enter>**.
8. Answer **N <enter>** to all remaining “ADJUST (Y/N)?” questions until the “>” prompt is displayed indicating you have exited the parameter setup function
9. Type **kset<enter>** to verify that the parameter you selected has been changed

***For detailed descriptions of each of these parameters, please see section Error! Reference source not found..1 of this manual***

### **6.2.5 “O” OPT (OPTIONS CONFIGURATION) COMMAND**

This command lists the firmware versions programmed into the 3 processors used in the AHF (the HMI, the DSP Control, and the Gate Drive control) along with factory programmed options. An example of information sent in response to an OPT command is:

```
SYSTEM OPTIONS CONFIGURATION

HMI SOFTWARE VERSION:      001.000
DSP SOFTWARE VERSION:      000.040
GDR SOFTWARE VERSION:      01.00
HMI SERIAL NUMBER:         9580
DSP SERIAL NUMBER:         9578
RATED VOLTAGE (V) :        480
RATED CURRENT/INV (A) :    100
```

This information indicates that the system is set up for 480 Vac nominal voltage and is a 100 amp capacity AHF. The 100 amp capacity indicates that the average rms current correction supplied by the AHF (of all 3 phases) will be limited to 100 amps.

### **6.2.6 “Q” QOFF SERIAL COMMAND**

The QOFF command displays DC offsets of several parameters monitored by the control. All but the VHI, VLO, and V24 will normally be around 0. This is sometimes a useful diagnostic tool.

### **6.2.7 “S” OR “V” STATUS SERIAL COMMANDS**

An **S** or **V** followed by an optional single letter command corresponding to a particular parameter may be sent to the AHF to obtain operating status. The following summarizes these commands:

**Commands:** AHF status information may be examined using the following commands:

**Sn** **Status** command displays the present status of a parameter. To display the status of a particular parameter, type **Sn<enter>**. "S" indicates the status command, "n" represents a character (letter or number) designating the parameter you desire to observe, and **<enter>** indicates an enter key, which is used to terminate the command. Table 6.2 contains the list of available parameters that may be examined. As an example, if the present AC line voltage is to be examined, one would type **SA** followed by striking the **<enter>** key. One can also just enter **S<enter>** with no parameter letter and obtain a status update of the most useful parameters all at once.

**Vn** **View** command is similar to the Status command except the View command will continually display the status of the selected parameter until one presses the escape key on the computer keyboard. To continually view the status of a particular parameter, type **Vn<enter>**. "V" indicates the View command, "n" represents a character designating the parameter to be viewed, and **<enter>** indicates a carriage return (or Enter key) which is used to terminate the command. Again, Table 6.2 contains the list of available parameters that may be examined. As an example, if the AC line voltage is to be viewed continuously, one would type **VA** followed by striking the **<enter>** key. One can also just enter **V<enter>** with no parameter letter and continually view the status of the most useful parameters all at once.

**Table 6.2: Status Display Parameters**

<b>S/V option</b>	<b>Status Parameter</b>	<b>Units</b>
A	AC Line Voltages	RMS volts
B	Line Frequency	Hertz
C	Line THDR (or THDF) percent voltage harmonic distortion on the line	% of line voltage
D	AHF Currents	RMS amperes
E	CT% (% of line CT rating that current thru the CTs represents) / Neutral Amps (Neutral current – only valid if 3 line CTs are used)	% of rating / RMS amperes
F	AHF Loading for each phase	% of rating
G	Line Currents (Current drawn from the utility)	RMS amperes
H	Load Currents (Current drawn by the load)	RMS amperes
I	Line_THDR (or THDF) percent current harmonic distortion on the line	% of line current
J	Load_THDR (or THDF) percent current harmonic distortion on the load	% of load current
K	Total current harmonics drawn from the utility	RMS amperes
L	Total current harmonics drawn by the load	RMS amperes
M	Line Power (Real Power/ Kvolt-amperes/ power factor) drawn from the utility)	KW/KVA/PF
N	Load Power (Real Power/ Kvolt-amperes/ power factor) drawn by the load)	KW/KVA/PF
O	DC Fan status and current	Fan status/ DC Amps
P	DC Capacitor Bus Voltage (sum of lower half + upper half of capacitor bank)	Volts DC
Q	AHF Mode	
R	AHF Status	
S	Temperature (HMI internal/DSP Control board/Gate Drive board/Heatsink 1/Heatsink 2)	°C
T	Inverter Currents – internal parameter roughly equal to AHF Currents	RMS amperes
U	Amount of high frequency current produced by AHF (should be less than 1% of the AHF current rating)	RMS amperes

V	Amount of DC produced by AHF (will vary between positive and negative values, usually < 3% of the AHF current rating)	DC Amps
W	Internal 24V main control & fan supply voltage	Volts DC
X	(AHF – Inv) currents (should be around 10-20% of the AHF current rating)	RMS amperes
Y	Phase shifts between line-to-neutral line voltage and fundamental load current for the 3 phases, followed by # of CTs used (2 or 3) and phase rotation (+ or -)	Degrees
None	Parameters A through S displayed all at once	

These parameters are identical to most of the parameters displayed on the LCD display via the OPERATING STATUS MORE display. For additional explanations on a parameter, please see the description of that parameter in sections 5.2 and 5.3 of this manual.

If an **S** (or **V**) command without a following letter is entered, parameters A through S will be displayed as a page of data similar to the screen shot shown in the example that follows. The group of parameters displayed are considered the most useful parameters to observe.

### S Command Sample Output

\*\*\* HPS TRUWAVE STATUS (05/06/2019,11:52:53.64) \*\*\*

```

LINE_VOLT AB/BC/CA= 479.9/479.9/479.9  LINE_FREQUENCY(HZ)= 60.00
VLT_THDR% AB/BC/CA= 0.0/ 0.0/ 0.0  AHF_AMPS A/B/C = 0.0/ 0.0/ 0.0
CT% / NEUTRAL AMPS= 5% / 0.0  AHF_LOAD% A/B/C = 0/ 0/ 0
LINE_AMPS A/B/C = 97.5/ 97.5/ 97.5  LOAD_AMPS A/B/C = 97.5/ 97.5/ 97.5
LINE_THDR% A/B/C = 49.0/ 49.0/ 49.0  LOAD_THDR% A/B/C = 49.0/ 49.0/ 49.0
LINE_AMPS HARMONIC= 47.8/ 47.8/ 47.8  LOAD_AMPS HARMONIC= 47.8/ 47.8/ 47.8
LINE_PWR KW/KVA/PF= 70.6/ 81.1/ .871  LOAD_PWR KW/KVA/PF= 70.6/ 81.1/ .871
FANS(54321) = 00000 / 0.024  DC_VOLT(LO+HI=SUM)= 0.0+ 0.0= 0.0
MODE = OFF  STATUS = DISABLED BY OPERATOR
TEMP HMI/DSP/GDR/HS1/HS2 = 28/ 28/ 28/ 41/ 42

```

### 6.2.8 “T” DATE AND TIME COMMAND

The HMI has an internal timekeeper that is used to timestamp when events occur. The time is not used in any critical systems in the AHF and will not affect its performance. To display the current time setting, enter TI at the command prompt. The current date and time will be displayed in 24 hour format (0-11 hours are AM, 12-23 hours are PM).

To change the date of the AHF, use the TD command. The complete date must be entered in month/day/year format, using a backslash as a delimiter. Each value must be exactly 2 characters long. For example, if the date is June 22, 2019, the following command needs to be entered:

**TD=06/22/19**

To change the time of the AHF, use the TT command. The complete time (seconds may be left off) must be entered in hours:minutes:seconds format, using a colon as a delimiter. Each value must be exactly 2 characters long. For example, if the time to be entered is 2:40PM, the following command needs to be entered:

**TT=14:40:00** or **TT=14:40**

Please see section 5.5 for additional details.

### 6.2.9 “Z” ZCAL COMMAND

The ZCAL command displays several parameters monitored by the control. This is sometimes a useful diagnostic tool.

## 7. ETHERNET/IP AND MODBUS TCP FOR ETHERNET/IP EQUIPPED SYSTEMS

The Ethernet/IP version of the AHF is capable of Implicit I/O data communication with a PLC, HMI, SCADA or other Ethernet/IP scanner device. AHF status and troubleshooting information can be sent to a scanner device, and the AHF can be enabled or disabled by a scanner device via Ethernet/IP. Ethernet/IP or Modbus TCP industrial communications is an option that can be added to the AHF's HMI module. The Ethernet/IP module is fully ODVA compliant.

The AHF's HMI can communicate with an Ethernet/IP device via Implicit or I/O messaging at a periodic rate of up to 10Hz (100mS). During such a connection, a scanner device (PLC/HMI/SCADA) can periodically scan the adapter device (HMI) for operating status, attention code, voltage, current, power, and other status information. Please see Table 7.2 for a list of the available status data registers. The AHF's HMI can be actively monitored in real time using such input assembly data. In addition, the scanner device (PLC/HMI/SCADA) can periodically send the enable/disable signal to the adapter device (AHF's HMI). The AHF can be enabled or disabled via Ethernet/IP using such output assembly data. Please see Figure 7.1 for a graphic representation of assembly data transfer via Ethernet/IP.

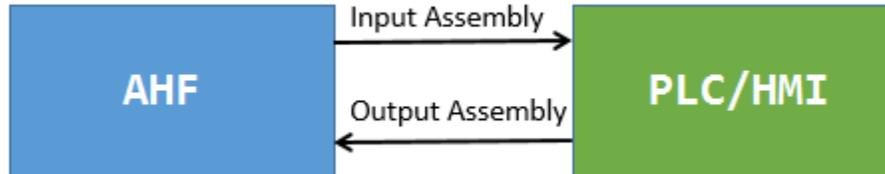


Figure 7.1: Ethernet/IP I/O Assembly

### 7.1 ETHERNET/IP DATA INFORMATION

The following tables show the input assembly data which is available to be read from the AHF's HMI by the Ethernet/IP Scanner device. It consists of 51 (signed 16 bit) registers.

The Operating Status register has 5 possible integer values which indicate the system operating status. See Table 7.1: Ethernet/IP parameters for Input Assembly Data for details.

The Attention Code register is a 16 bit data field. Each value has a different meaning and represents a different attention code. Please see for the meaning of each attention code.

Registers 3-51 (Bytes 4-101) represent sampled real numbers such as voltage, current, power, etc. Please see the "value/bit" to properly convert and display these values in volts, amps, watts, and etc. For example for Line Volts (register 3 or bytes 4-5 in Table 7.2), if you read a signed 16 bit value of 4800, multiply it by 0.1 (.1 volt/bit from Table 7.2) in your PLC program and convert to a float or double to get 480.0 volts.

### INPUT ASSEMBLY (READ DATA)

**Table 7.1: Ethernet/IP parameters for Input Assembly Data**

**Note: This applies to all 102 bytes**

OBJECT	DIRECTION	INSTANCE ID	CONNECTION TYPE	MESSAGE TYPE	MAXIMUM REQUESTED PACKET INTERVAL (RPI)
Assembly Object	Target to Initiator	100 (0x64)	CLASS 1	CIP GENERIC	10 Hz (100ms)

**Table 7.2: AHF Ethernet/IP Input Assembly Data**

Bytes	Name	Info	Data Type
0-1	Operating Status	0=off, 1=precharging, 2=idle, 3=on-less than max, 4=on-max	INT (Signed Integer, 16 bits)
2-3	Attention Code	0=OK, non-zero value indicates attention needed (see Table 7.3)	
4-5	Line Volts (avg)	Avg of all 3 line-to-line rms voltages (.1 volt/bit)	
6-7	Line Amps (avg)	Avg of all 3 line rms currents (.1 amp/bit)	
8-9	Load Amps (avg)	Avg of all 3 load rms currents (.1 amp/bit)	
10-11	AHF % Loaded	AHF % loaded (.1 %/bit)	
12-13	Line Harm Amps (avg)	Avg of all 3 line harmonic rms currents (.1 amp/bit)	
14-15	Line Harm THDR/F%	THDF or THDR of line harmonics (.1%/bit)	
16-17	Load Harm Amps (avg)	Avg of all 3 load harmonic rms currents (.1 amp/bit)	
18-19	Load Harm THDR/F%	THDF or THDR of load harmonics (.1%/bit)	
20-21	Volt Harm THDR/F%	THDF or THDR of voltage harmonics (.1%/bit)	
22-23	Line KVA	Line KVA (.1 KVA/bit)	
24-25	Line KW	Line KW (.1 KW/bit)	
26-27	Line PF	Line PF (.001/bit)	
28-29	Load KVA	Load KVA (.1 KVA/bit)	
30-31	Load KW	Load KW (.1 KW/bit)	
32-33	Load PF	Load PF (.001/bit)	
34-35	Line Freq	Line Frequency (.01 Hz/bit)	
36-37	Neutral Amps	Neutral amps (.1 amp/bit) [0 if only 2 line/load CTs]	
38-39	Temperature – DSP	DSP PC board temperature (.1 C/bit)	
40-41	Temperature – HSB 1	Heatsink (left side) temperature #1 (.1 C/bit)	
42-43	Temperature – HSB 2	Heatsink (right side) temperature #2 (.1 C/bit)	
44-45	DC Fan Amps	DC Fan current (.001 amps/bit)	
46-47	DC Bus Voltage	DC Bus Voltage (.1 volt/bit)	
48-49	Line Volts (Vab)	Vab Line-to-line rms voltage (.1 volt/bit)	
50-51	Line Volts (Vbc)	Vbc Line-to-line rms voltage (.1 volt/bit)	

52-53	Line Volts (Vca)	Vca Line-to-line rms voltage (.1 volt/bit)
54-55	Line Amps (A)	Phase A Line rms current (.1 amp/bit)
56-57	Line Amps (B)	Phase B Line rms current (.1 amp/bit)
58-59	Line Amps (C)	Phase C Line rms current (.1 amp/bit)
60-61	Load Amps (A)	Phase A Load rms current (.1 amp/bit)
62-63	Load Amps (B)	Phase B Load rms current (.1 amp/bit)
64-65	Load Amps (C)	Phase C Load rms current (.1 amp/bit)
66-67	AHF% Load (A)	Phase AN AHF % loaded (.1%/bit)
68-69	AHF% Load (B)	Phase B AHF % loaded (.1%/bit)
70-71	AHF% Load (C)	Phase C AHF % loaded (.1%/bit)
72-73	Line Harm Amps (A)	Phase A Line Harmonic rms current (.1 amp/bit)
74-75	Line Harm Amps (B)	Phase B Line Harmonic rms current (.1 amp/bit)
76-77	Line Harm Amps (C)	Phase C Line Harmonic rms current (.1 amp/bit)
78-79	Line Harm THDR/F% (A)	Phase A Line current Harmonic THDR or THDF (.1%/bit)
80-81	Line Harm THDR/F% (B)	Phase B Line current Harmonic THDR or THDF (.1%/bit)
82-83	Line Harm THDR/F% (C)	Phase C Line current Harmonic THDR or THDF (.1%/bit)
84-85	Load Harm Amps (A)	Phase A Load Harmonic rms current (.1 amp/bit)
86-87	Load Harm Amps (B)	Phase B Load Harmonic rms current (.1 amp/bit)
88-89	Load Harm Amps (C)	Phase C Load Harmonic rms current (.1 amp/bit)
90-91	Load Harm THDR/F% (A)	Phase A Load current Harmonic THDR or THDF (.1%/bit)
92-93	Load Harm THDR/F% (B)	Phase B Load current Harmonic THDR or THDF (.1%/bit)
94-95	Load Harm THDR/F% (C)	Phase C Load current Harmonic THDR or THDF (.1%/bit)
96-97	Volt Harm THDR/F% (Vab)	Vab Line-to-line Harmonic THDR or THDF (.1%/bit)
98-99	Volt Harm THDR/F% (Vbc)	Vbc Line-to-line Harmonic THDR or THDF (.1%/bit)
100-101	Volt Harm THDR/F% (Vca)	Vca Line-to-line Harmonic THDR or THDF (.1%/bit)

**Table 7.3: Meaning of AHF Attention Code Register**

Attention Code	Condition	Comments	Action to Take
0	No attention needed	None	None – AHF on, operating without a problem
1	Upper Cap Vdc High	Voltage across upper half of dc link caps went too much higher than voltage across lower half.	Internal failure – contact factory – PC-H, PC-C, R1 (upper bleeder), R2 (lower bleeder), cables between PC-H-P6 and PC-C-P4 or PC-H-P3 and PC-C-P5, or wiring between PC-H, R1, R2, and DC link caps.
2	Lower Cap Vdc High	Voltage across lower half of dc link caps went too much higher than voltage across upper half.	Internal failure – contact factory – PC-H, PC-C, R1 (upper bleeder), R2 (lower bleeder), cables between PC-H-P6 and PC-C-P4 or PC-H-P3 and PC-C-P5, or wiring between PC-H, R1, R2, and DC link caps.
3	Mult. Overcurrents	Too many AHF rms overcurrents	Normally, system will software limit AHF currents to rated values; however, external transient conditions could result in software limits not being responsive enough. If this occurs often, contact factory.
4	Precharge Failure	Unit failed to precharge	Check History ON/OFF to determine cause of precharge failing.
5	Reserved		Contact factory
6	Too Many Itrips	Too many inverter current trips	If unit is newly installed, check to make sure CTs are in the correct place. If not newly installed, and only occurs occasionally, could be due to a high number of transients on the line (due to unstable power). If occurs multiple times, could be a system resonance problem or an internal problem due to fault in PC-C, inverter, or gate drives in inverter. If system resonance ruled out, perform low power inverter test to try to isolate problem.
7	Too Many Ptrips	Too many inverter pole trips	Internal problem – Inverter, gate drives, or PC-C. Perform low power inverter test to isolate problem.
8	Contactors Problem	Ac contactor failed to close	Internal problem – K1, PC-C, internal current sensors, or wiring.
9	AHF Isensor	Not enough current detected in AHF current sensors when Ac contactor is closed	Internal problem – internal current sensors, K1, PC-C, wiring, or power filtering (check fuses associated with PC-T).
10	Line Isensor	Not enough current detected in external CTs when Ac contactor is closed	External CTs may not be installed correctly or shorting bars may be installed shorting their output. Also possible internal problem, involving PC-R, PC-C, or cable connecting these 2 boards together.

11	Hi Freq In IAHF	High frequency detected in AHF current	Internal problem – PC-T failure and/or blown protection fuses associated with it. Look at AHF_HFAMPS in history ON/OFF to determine phase(s) that caused the fault.
12	Dc In IAHF	Dc detected in AHF current	Internal problem – IGBT device firing problem. Look at AHF_DCAMPS in history (largest value may indicate pole that device is in that is at fault)
13	AHF/Inv Isensor	Difference detected between AHF and inverter current sensors.	Internal problem – Possible failure in either one or more current sensors CS1-CS4 or PC-C board. Look at AHF-INV RMS AMPS in history to determine phase(s) that caused the fault.
14	AHF Ineffective	Diagnostic – AHF is ineffective at correcting harmonics	Problem with CTs being incorrectly positioned or a system resonance exists, resulting in current produced by AHF not effectively reducing harmonic currents in the line current. Check CTs using CT Setup LCD screen. Make sure CT physical locations (line or load side) agree with location programmed into system.
15	Uart Transmit	Internal problem with PC-C	Contact factory
16	Uart Receive	Internal problem with PC-C	Contact factory
17	Shutdowns	Too many inverter shutdowns in a short period of time	Make sure CTs are correctly positioned. Check ON/OFF history for shutdown reasons. Could be caused by temporary abnormal line power or load conditions. If persists contact factory.
18	Cont. Openings	Too many contactor openings in a short period of time	
19-32	Reserved		Contact factory
33	Disabled By Operator	System's power inverter disabled by operator	Press the RUN button on the touchscreen display to enable the system.
34	Disabled Externally	External disable capability selected (see section 5.6.3) and externally generated signal connected to HMI's P11 connector is disabling AHF.	Either provide correct signal to HMI's P11 connector to enable AHF or deselect external disable capability via LCD display.
35	Disabled By Network	External Disable via Ethernet/IP or Modbus TCP capability selected (see section 5.6.1) and enable command has not been received via Ethernet/IP or Modbus TCP	Disable this feature via the LCD front panel (see section 5.6.1) or change firmware in your PLC to send an enable to the AHF via the Ethernet/IP or Modbus TCP network. See Table 7.4 & Table 7.5.
36	Lost Hmi-Dsp Comm	Communications between HMI module and PC-C DSP control board in AHF has been lost	Problem with HMI module, PC-C, or cable connecting the two.
37	HS1 Over-Temperature	Temperature sensor on left side of heatsink exceeded limits.	Check for dirty air filter(s) on unit. Check fans for proper operation. Check ON/OFF history to find temperatures of

38	HS2 Over-Temperature	Temperature sensor on left side of heatsink exceeded limits.	all sensors. If HS1 much different from HS2, could be a bad sensor. If a sensor is very different from other sensors, could be a bad sensor.
39	DSP Over-Temperature	Temperature sensor on PC-C DSP control board exceeded limits.	
40	GDR Over-Temperature	Temperature sensor on PC-G or PC-GP gate drive board exceeded limits.	
41	+24V Low	+24V main supply too low	
42	DSP +15V Low	+15V supply on DSP bad	+24V supply or PC-C board problem
43	DSP -15V Low	-15V supply on DSP bad	PC-C board problem
44	Line Rms Volts Too Low	Line voltage too low for unit to run.	When utility voltage returns to normal unit will operate again. If voltage is OK, problem with PC-H, PC-C, or internal wiring.
45	Line Rms Volts Too High	Line voltage too high for unit to run.	
46	Line Freq Too High/Low	Frequency beyond +/- 5 Hz from nominal.	If running from a generator, Table 7.5 check generator for proper output.
47	No Phaselock To Line	System not phaselocked to ac line	None – temporary condition – Either system is in process of phaselocking to AC line or frequency of line is presently outside operational specifications.
48	Bad HMI Nvram	Internal problem with HMI	Contact factory
49-69	Reserved		Contact factory
70	Lost DSP-Gate Dr Comm	Communications lost between PC-C and PC-G or PC-GP gate drive boards	Problem with PC-C, PC-G or PC-GP, or cables connecting them together.
71	Gate Dr Sw Version Wrong	Gate drive board software version incompatible with DSP software version	Contact factory to update software versions.
72	Gate Dr Can't Read Temps	PC-G or PC-GP Gate drive board can't read temperatures	PC-G or PC-GP board problem
73	Gate Drive Misc Problem	Misc problem found by PC-G or PC-GP gate drive bd.	PC-G or PC-GP board problem
74	Not Ready A-	Device A- gate drive problem.	24V not getting to gate drive. Power supply or other circuitry associated with that gate drive not working. For units > 100 amps, ribbon cable problem going to gate drive board on IGBT module. Problem with the IGBT module.
75	Not Ready A+	Device A+ gate drive problem.	
76	Not Ready B-	Device B- gate drive problem	
77	Not Ready B+	Device B+ gate drive problem	
78	Not Ready C-	Device C- gate drive problem	
79	Not Ready C+	Device C+ gate drive problem	
80	Pole Trip A-	Pole trip received from a- igbt	Check unit's "History" to see if an inordinate number of these have been occurring. If so, a possible problem with an IGBT device, gate drives, or connection between IGBT devices and gate drives may exist.
81	Pole Trip A+	Pole trip received from a+ igbt	
82	Pole Trip B-	Pole trip received from b- igbt	

83	Pole Trip B+	Pole trip received from b+ igbt	
84	Pole Trip C-	Pole trip received from c- igbt	
85	Pole Trip C+	Pole trip received from c+ igbt	
86	Pole Trip Misc	Pole trip occurred, but cause could not be determined.	Should not occur. Contact factory if it does.
87-119	Reserved		Contact factory
120	Software Missing	Internal firmware problem	Contact factory
121	Power-Up Delay	Normal system power up delay	None – temporary condition
122	DSP Nvram Not Initialized	Internal problem with PC-C	Contact factory
123	Bad Nvram Options Data	Internal problem with PC-C	Contact factory
124	Bad Nvram B-Setup Data	Internal problem with PC-C	Contact factory
125	Bad Nvram G-Setup Data	Internal problem with PC-C	Contact factory
126	Bad Nvram K-Setup Data	Internal problem with PC-C	Contact factory
127	Bad Nvram Offset Data	Internal problem with PC-C	Contact factory
128	Bad Nvram Gain Data	Internal problem with PC-C	Contact factory
129	Contactor Closing	Ac contactor K1 is in the process of closing	None - temporary condition
130	Contactor Opening	Ac contactor K1 is in the process of opening	None – temporary condition
131	Inverter Test	System is in inverter test mode	Only occurs if test mode requested via Ethernet comm.
132	Thyristor Test	System is in thyristor test mode	Only occurs if test mode requested via Ethernet comm.
133	Contactor Test	System is in contactory test mode	Only occurs if test mode requested via Ethernet comm.
134	Vdc Test	System is in dc voltage test mode	Only occurs if test mode requested via Ethernet comm.
135-140	Reserved		Contact factory
141	Dc Cap Voltage Too High	Dc cap voltage went too high to continue operation	If ON/OFF history shows multiple occurrences, check external line or load CTs for proper installation. Otherwise can be a temporary condition caused by some external anomaly with the line or load. As soon as DC voltage reduces, system will start operating again.
142	IAHF Too High When Roff	Too much AHF current detected when ac contactor is open.	Possible internal problem with AC contactor, AHF current sensors, or PC-C. Observe AHF currents on LCD display to determine which phase problem is with.
143	IAHF Too Low When Ron	Not enough AHF current detected when ac contactor is closed.	None – usually a temporary condition. If condition persists, will be followed by AHF ISENSOR indication.

144	Line Current Too Low	Not enough line current detected when ac contactor is closed and inverter not yet operating.	Some minimal line current should register when AC contactor is closed and inverter is not yet operating. If not, external CTs may not be properly located or may have shorting strips in place, shorting their output. If this is not the case, a possible internal problem could exist with PC-R, PC-C or cable interconnecting these.
145	Load Too Low	Load power too low to operate	If "UNIT DISABLED IF LOAD POWER BELOW THIS %" parameter (see section <b>Error! Reference source not found.</b> ) is set to a non-zero value, system is either OFF if not previously operating or IDLE if previously operating because load power is too low. Once load power increases, unit will resume operation. This is normal operation unless the load is actually high enough but the external line/load CTs are not reading current correctly.
146	Hw Itrip Stuck On	Internal problem	Problem with PC-C board.
147	Waiting For Fdr To Finish	DSP is finishing storing FDR recorded at last shutdown	None – temporary condition
148	Dsp Is Being Reprogrammed	Dsp is being programmed with new firmware	None – temporary condition
149	Gate Drive test in progress	Before inverter is started each time a test on the gate drive signals between PC-C and PC-G or PC-GP is done	None – temporary condition
150	Gate Drive test failed	Problem with gate drive signals detected between PC-C and PC-G or PC-GP	Problem with PC-C, PC-G or PC-GP, or cables connecting the two together.
151	Load Amps too low	When external CTs are on load side, some load current must exist for AHF to run.	When load current exists, unit will run. If sure that load current exists, check to make sure unit is seeing load current on all 3 phases. If not, CTs may be positioned or wired incorrectly or shorting bars are shorting their output. Could also be internal problem with PC-R, PC-C or cable connecting the two.
152	Load PF too low	AHF will not run if linear load power factor (harmonic currents filtered out) is too low.	If linear load power factor is below value set in 5.6.1, AHF won't run. Check CTs for proper placement and wiring.
149-255	Reserved		Contact factory
256	Upper>Lower Dc Cap Volts	Voltage across upper half of dc link caps much higher than lower half. if this continues, upper cap vdc high will shut down unit.	See UPPER CAP VDC HIGH Remedy.

257	Lower>Upper Dc Cap Volts	Voltage across lower half of dc link caps much higher than upper half. if this continues, lower cap vdc high will shut down unit.	See DIAG: LOWER CAP VDC HIGH Remedy.
258	HS1 High-Temperature	Temperature sensor on left side of heatsink is high.	If temperature continues to climb, unit will shut down due to overtemp. Check for dirty air filter(s) on unit. Check fans for proper operation. If HS1 much different from HS2, could be a bad sensor. If a sensor is very different from other sensors, could be a bad sensor.
259	HS2 High-Temperature	Temperature sensor on right side of heatsink is high.	
260	DSP High-Temperature	Temperature sensor on DSP control board is high.	
261	GDR High-Temperature	Temperature sensor on Gate drive board is high.	
262-	Reserved		Contact factory

The following tables show the output assembly data which is available to be written to the AHF by the Ethernet/IP Scanner device. It consists of 1 (16 bit) register.

This register is sent by the PLC/HMI device to Enable or Disable the AHF. Please see Table 7.4 and Table 7.5 for more information.

<b>Table 7.4: Ethernet/IP parameters for Output Assembly Data</b>					
<b>Note: This applies to all 2 bytes</b>					
<b>OBJECT</b>	<b>DIRECTION</b>	<b>INSTANCE ID</b>	<b>CONNECTION TYPE</b>	<b>MESSAGE TYPE</b>	<b>MAXIMUM REQUESTED PACKET INTERVAL (RPI)</b>
Assembly Object	Initiator to Target	150 (0x96)	CLASS 1	CIP GENERIC	10 Hz (100ms)

#### **OUTPUT ASSEMBLY (WRITE DATA)**

<b>Table 7.5: AHF Ethernet/IP Output Assembly Data</b>		
<b>Bytes</b>	<b>Register Name</b>	<b>Info</b>
0-1	AHF_EIP_ENABLE	Disable AHF= hex 0000 Enable AHF = hex 0001

## **7.2 IP ADDRESS CONFIGURATION FOR ETHERNET/IP**

In order to use Ethernet/IP with a PLC/HMI/SCADA device, the AHF Ethernet/IP module needs an IP address. These steps explain how to obtain the IP address via DHCP or set it static for use in your Ethernet/IP network.

These steps assume that the AHF unit is energized but may or may not be enabled and correcting harmonics.

Refer to sections 5.9 and 5.9.1 in this manual for detailed pictures of the procedure. These steps are identical to the steps in that section, the only difference being the message Ethernet/IP Info at the top of the display instead of Ethernet Info.

1. Connect a Cat-5 Ethernet cable to the Anybus CompactCom M40 module on the back of the AHF front panel. There should be 2 Ethernet ports next to each other, connect to either one. Connect this Ethernet cable to your Ethernet/IP Network. See the picture below. The Ethernet port is circled in red. There is a white Ethernet cable coming out of the Ethernet port in the picture.



2. From the MENU display, press the ETHERNET/IP INFO button. The Ethernet/IP info display will open showing the present IP address of the Anybus CompactCom M40 module.

2. The unit comes with DHCP set by default. If you intend to use DHCP, simply copy the network address information from this screen and input it into your PLC/HMI software. See an example of this in section 7.3 with RSLOGIX 5000.

3. If you intend to set a static IP Address, follow the directions in section 5.9.1 of this manual (note that the Ethernet/IP Info screen is nearly identical to the Ethernet Info screen), and then use the network address info you entered in your PLC/HMI software.

It is also possible to set the IP Address and configure other network information in the Anybus CompactCom M40 module using the built in web server using an Internet browser window.

First find the DHCP determined IP Address using the Ethernet/IP Info screen as described in the steps above. Then type that IP Address into the browser window address bar. A window similar to the following picture will open.



Click on Status under NETWORK to see more detailed network information. Click on Configuration under NETWORK to set a Static IP Address.

### 7.3 USING AHF'S HMI WITH RSLOGIX 5000 VIA ETHERNET/IP

This example will walk you through setting up RSLogix 5000 to enable a generic PLC to communicate with the AHF's HMI via Ethernet/IP. This is a generic example which should be used as a guide when setting up your system. If you have further questions, please see the RSLogix 5000 user manual or contact the manufacturer.

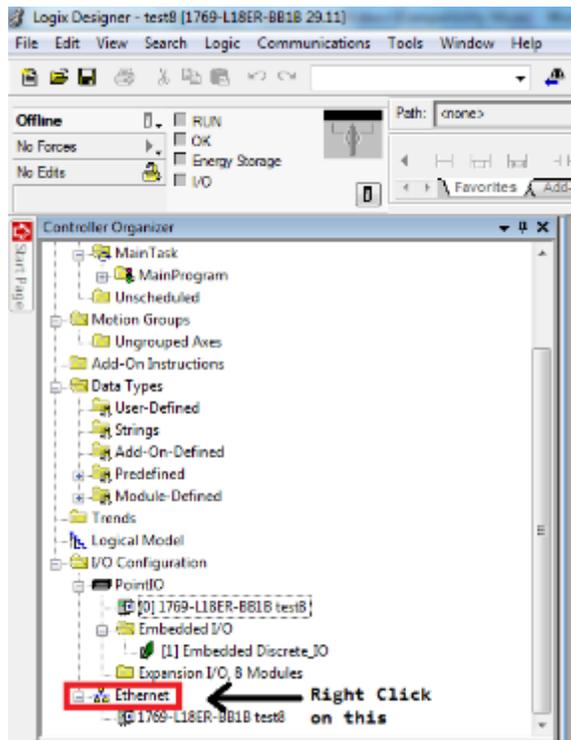
#### 7.3.1 REQUIRED MATERIALS

1. Ethernet/IP Enabled HPS TruWave AHF HMI connected to the Ethernet/IP network.
2. RSLogix5000 on a PC or laptop.
3. Ethernet/IP capable PLC or HMI device of your choice

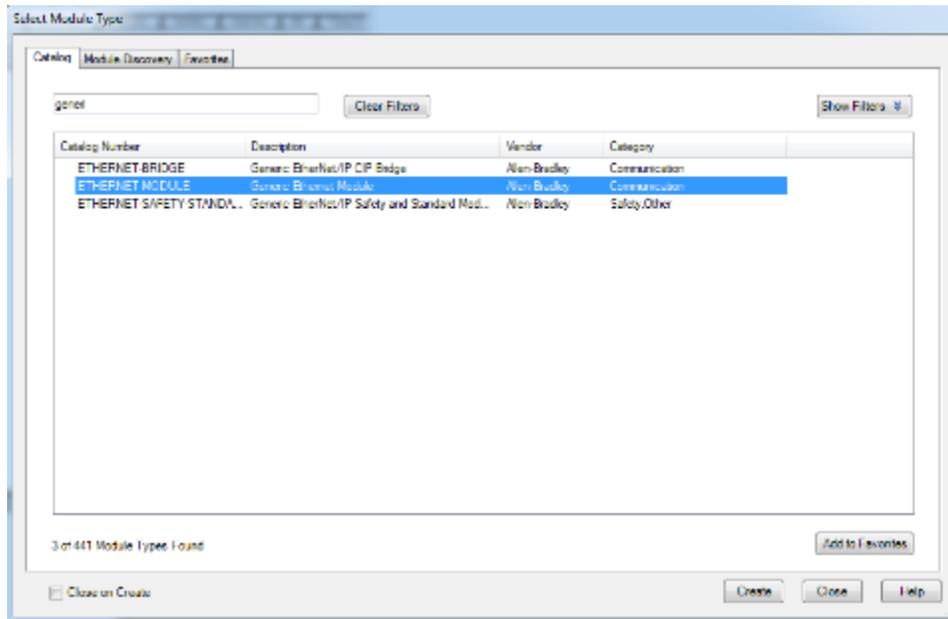
**Note:** Before you begin, please make sure that the AHF HMI's Ethernet/IP port is connected to your network (see section 7.2 of this manual) and the PLC or HMI is connected to your network

#### 7.3.2 RSLOGIX 5000 CONFIGURATION

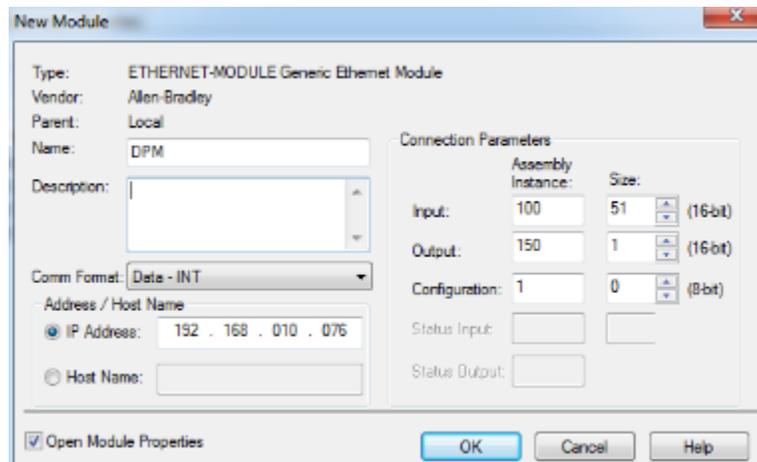
1. Open Studio 5000 and create a new project. Choose your PLC and the number of Expansion I/O modules your PLC has.
2. In the Studio 5000 Controller Organizer window you will see I/O Configuration and Ethernet with the name of your PLC and project name under that. Right click on the word Ethernet and select New Module. See screenshot below, the text you should right click on is circled in red.



3. Search for and choose Generic Ethernet Module and click Create. See screenshot below.

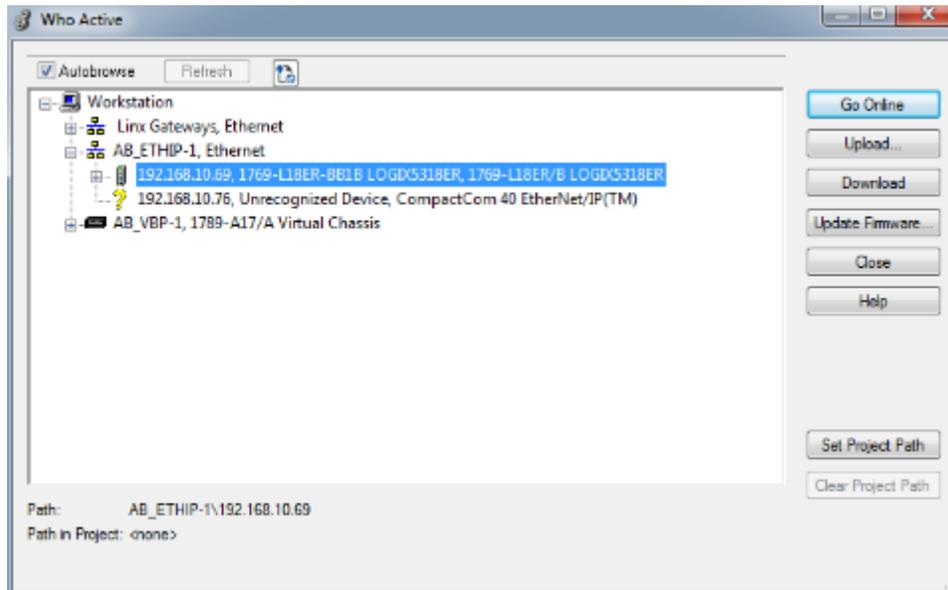


4. In the window that pops up, type in the data to match the following screenshot. Note that the IP Address should match the IP Address found in section 7.2 of this manual.



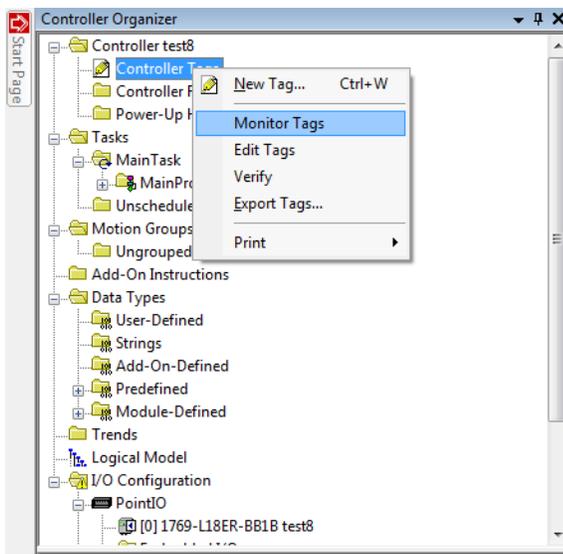
5. Click OK and in the Connection tab, put 100mS for the Requested Packet Interval (RPI).

6. Now go to Communications, Who Active. Select AB\_ETHIP-1 and select the PLC. Click Go Online. See screenshot that follows.



7. In the window which opens, click Download to program your PLC.

8. Now the PLC should be communicating with the AHF's HMI and reading status data. To view the status data, right click on Controller Tags and click on Monitor Tags. See screenshot below.



9. The screenshot below shows an example of Controller Tags showing AHF status data.

Name	Value	Force Mask	Style	Data Type	Description	Constant
+	DPM:C	{...}	{...}	AB:ETHERNET_...		<input type="checkbox"/>
-	DPM:I	{...}	{...}	AB:ETHERNET_...		<input type="checkbox"/>
-	DPM:I Data	{...}	{...}	Decimal	INT[51]	
+	DPM:I.Data[0]	0		Decimal	INT	
+	DPM:I.Data[1]	35		Decimal	INT	
+	DPM:I.Data[2]	4799		Decimal	INT	
+	DPM:I.Data[3]	975		Decimal	INT	
+	DPM:I.Data[4]	975		Decimal	INT	
+	DPM:I.Data[5]	0		Decimal	INT	
+	DPM:I.Data[6]	478		Decimal	INT	
+	DPM:I.Data[7]	490		Decimal	INT	
+	DPM:I.Data[8]	470		Decimal	INT	
+	DPM:I.Data[9]	490		Decimal	INT	
+	DPM:I.Data[10]	0		Decimal	INT	
+	DPM:I.Data[11]	011		Decimal	INT	
+	DPM:I.Data[12]	706		Decimal	INT	
+	DPM:I.Data[13]	071		Decimal	INT	
+	DPM:I.Data[14]	011		Decimal	INT	
+	DPM:I.Data[15]	706		Decimal	INT	
+	DPM:I.Data[16]	071		Decimal	INT	

DPM:I Data shows the input data. Location 0 is the Operating Status (see Table 7.2) and is showing 0 meaning the AHF is OFF. Location 1 is the Attention Code and is showing 35 meaning “Disabled By Network” (see Table 7.3).

Location 2 is Line Volts (avg) and is showing 4799 which is actually 479.9 volts. As was mentioned in section 7.1, to properly interpret the data in locations 2-50, look at the conversion factor in Table 7.2. For line volts its (.1 volt/bit) which means 4799 should be multiplied by 0.1 to get 479.9 volts. In your PLC ladder logic program, take location 2 and multiply it by 0.1 and then convert to a float or double to properly display the Line Volts value.

## 7.4 MODBUS/TCP FOR ETHERNET/IP EQUIPPED SYSTEMS

Modbus TCP (Modbus TCP/IP) is the Modbus RTU protocol sent over the network via Ethernet. If you ordered the Modbus-TCP version of the AHF, the Anybus CompactCom M40 module inside the AHF’s HMI unit is able to communicate to a PLC/HMI via Modbus-TCP. The same Input and Output data defined for Ethernet/IP is available for Modbus-TCP. Please refer to all Tables in section 7.1.

The following example will show how to communicate with the AHF’s HMI via Modbus-TCP. This example uses a free Modbus Master Simulator tool which will simulate a Modbus-TCP enabled PLC.

It can be downloaded free of charge at the following link.  
<http://en.radzio.dxp.pl/modbus-master-simulator/>

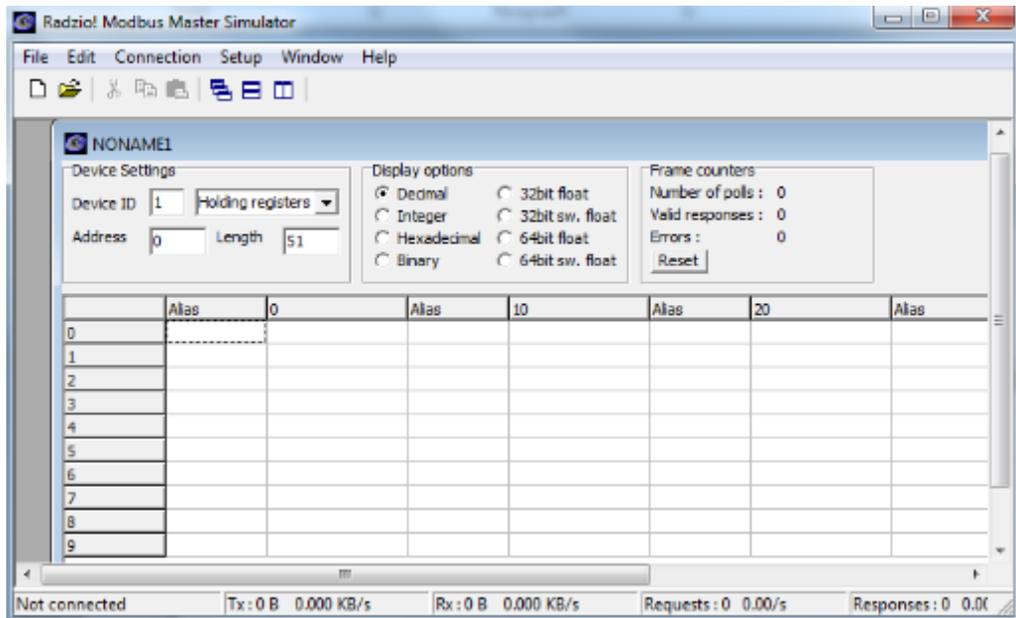
### 7.4.1 REQUIRED MATERIALS

1. Ethernet/IP Enabled HPS TruWave AHF’s HMI connected to the Modbus-TCP network.
2. Radzio! Modbus Master Simulator on a PC or laptop.

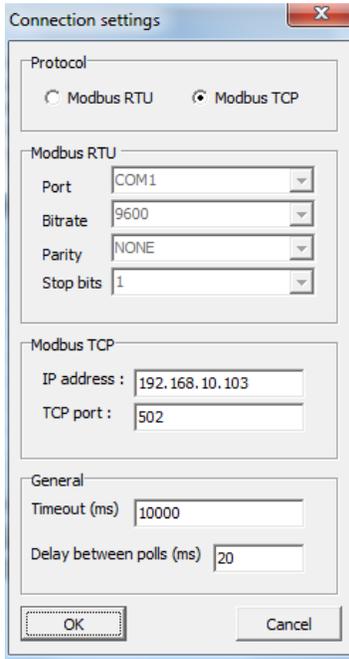
### 7.4.2 MODBUS-TCP EXAMPLE

1. Install Radzio! Modbus Master Simulator on your PC or laptop and plug your computer Ethernet cable into the network.
2. Open Radzio! Modbus Master Simulator

3. Go to File/New. Select Holding Registers and enter 51 for the length. Device ID should be 1. Address should be 0. See screenshot below.



4. Go to Connection/Settings and select Modbus TCP. Enter the IP address that you found in section 7.2 of this manual. Click Ok. See screenshot below.



5. Go to Setup/Data definition, and for the Scan rate, enter the rate at which you would like to periodically request data from the AHF. The fastest rate at which you can poll the AHF is 10Hz, so the smallest number you can enter is 100mS.
6. Go to Connection/Connect.
7. You should now see the AHF status data updated in real time on the screen. See screenshot below.

	Alias	0	Alias	10	Alias	20	Alias	30	Alias	40
0		0	Operating Status	190		0		6		232
1		35		0		0		4		194
2		1		0		7525		8		2
3		5		0		2		1		2
4		5		0		1		1		2
5		1		0		1		1		188
6		2		0		2		2		234
7		199		0		5		2		216
8		2		0		4		2		226
9		213	Load Harm THDR/F%	2246		8		172		147

Line Harm THDR/F% (C)

Velt Harm THDR/F% (Vca)

192.168.10.103:502    Tx: 7.10 KB 0.000 KB/s    Rx: 65.69 KB 0.000 KB/s    Requests: 606 0.00/s    Responses: 606 0.00/s

The data in the screenshot above represents the registers of Table 7.2.

In order to enable or disable the AHF via Modbus-TCP, send a Modbus “write single register” command and send a “1” to enable the AHF and a “0” to disable the AHF.

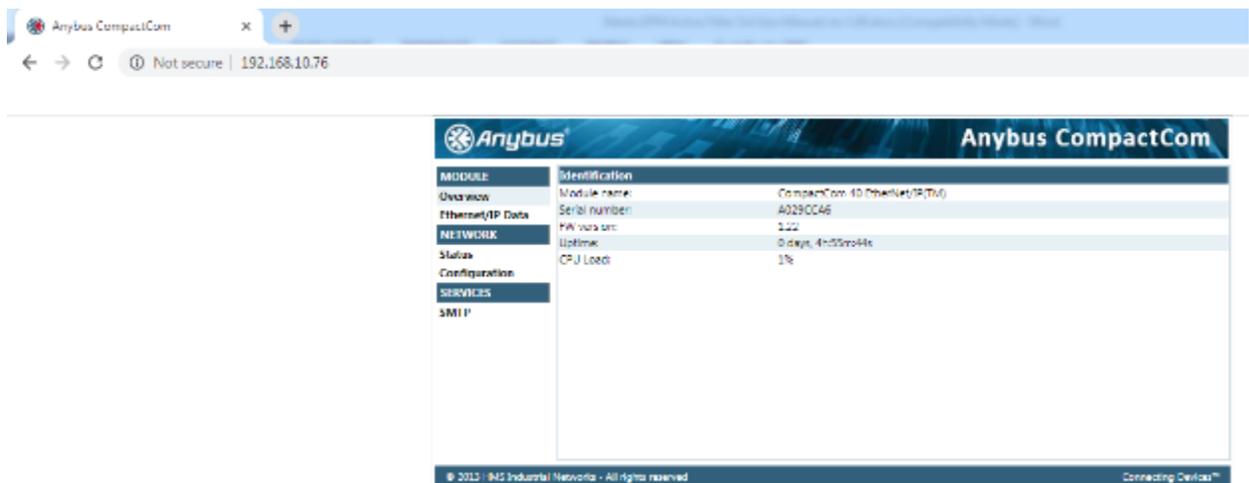
This example shows how the AHF can be used to communicate with a Modbus-TCP master device such as a PLC/HMI/SCADA. Please use this example as a guide when setting up your Modbus-TCP network. If you have further questions, please contact HPS.

## 7.5 VIEWING ETHERNET/IP DATA ON A WEBSITE

The AHF has an optional capability to view the Ethernet/IP Input Assembly Data by using a website via regular Ethernet on port 80. This eliminates the need for a PLC/HMI in order to access the same data that can be accessed via Ethernet/IP.

To view the data on a website follow these steps:

1. Make sure that the AHF’s HMI Industrial Network Ethernet Port is connected to the Ethernet network via an Ethernet cable. See section 7.2 of this manual. This can be the same network as you use for Ethernet/IP. Connect a desktop or laptop computer to the network.
2. Find the IP Address of the Anybus CompactCom M40 by going to the ETHERNET/IP INFO display as described in section 5.9.4 of this manual.
3. Open a web browser such as Google Chrome or Internet Explorer and in the address bar, type in the IP Address you found in step 2. You should see something similar to the following picture.



4. Click on the Ethernet/IP Data tab underneath Overview. A window similar to the following picture will open.

Refresh Data



### AHF Ethernet/IP Input Assembly Data

The following is real time AHF I/O status data. This is the same data that is available via the Ethernet IP Input Assembly Instance 100. Click on Refresh Data button to refresh the data.

Please click the following link to see a table describing the meaning of each AHF status register and the meaning of Attention Code. It is recommended to right click on the link and select "Open Link in New\_Tab" to see the meaning of the data in another window as a reference while looking at the data. [AHF register info](#)

Operating Status	0
Attention Code	33
Line Frequency (hz)	60.00
Neutral Current (amps)	0.0
Temperature DSP (c)	29.2
Temperature HSA (c)	41.0
Temperature HSB (c)	42.0
DC Fan Current (amps)	0.024
DC Bus Voltage (volts)	0.0
AHF % Loaded Total:(A/B/C)	0.0: (0.0/ 0.0/ 0.0)

	Line	Load
RMS Voltage Average (Vab/Vbc/Vca) (volts)	479.9: (479.9/ 479.9/ 479.9)	N/A
RMS Current Average:(A/B/C) (amps)	195.1: (195.1/ 195.1/ 195.1)	195.1: (195.1/ 195.1/ 195.1)
Harmonic Current Average: (A/B/C) (amps)	95.7: (95.7/ 95.7/ 95.7)	95.7: (95.7/ 95.7/ 95.7)
THDR/F% Current Average: (A/B/C) (%)	49.0: (49.0/ 49.0/ 49.0)	49.0: (49.0/ 49.0/ 49.0)
THDR/F% Voltage Average: (Vab/Vbc/Vca) (%)	0.0: (0.0/ 0.0/ 0.0)	N/A
KW/KVA/PF	141.3/ 162.2/ 0.871	141.3/ 162.2/ 0.871

5. This page shows the same AHF Status data which is available over Ethernet/IP or Modbus TCP. To read the latest data from the AHF, click on the Refresh Data button at the top of the page.

6. To find out the meaning of this data, right click on the AHF register info link and select "Open Link in New\_Tab". This will display a page showing a copy of Table 7.2 and Table 7.3 from section 7.1 of this manual. See the following picture.



### Ethernet/IP Input Assembly Data Information

Name	Info
Operating Status	0-on, 1-precharge, 2-off; 3-on-less than max, 4-on-max
Attention Code	0-OK, non-zero value indicates attention needed
Line Volts (avg)	Avg of all 3 line-to-line rms voltages
Line Amps (avg)	Avg of all 3 line rms currents
Load Amps (avg)	Avg of all 3 load rms currents
AHF % Loaded	AHF % Loaded @ 100%
Line Hzrms Amps	Avg of all 3 line harmonic rms currents
Line Hzrms THDR.F%	THDF or THDR of line harmonics
Load Hzrms Amps (avg)	Avg of all 3 load harmonic rms currents
Load Hzrms THDR.F%	THDF or THDR of load harmonics
Volt Hzrms THDR.F%	THDF or THDR of voltage harmonics
Line KVA	Line Apparent Power
Line KW	Line Real Power
Line PF	Power Factor
Load KVA	Load Apparent Power
Load KW	Load Real Power
Load PF	Power Factor
Line Frequency	Frequency in Hertz
Neutral Amps	0 if only 3 line load CTs

Attention code	Condition	Course of action
0	No attention needed	None, AHF operating without a problem
1	Upper Cap Vdc High	Internal failure contact factory PC-H, PC-C, R1 (upper bleeder), R1 (lower bleeder), cables between PC-H-P6 and PC-C-P1 or PC-11-P3 and PC-C-P5, or wiring between PC-H, R1, R2, and DC link caps.
2	Lower Cap Vdc High	Internal failure contact factory PC-H, PC-C, R1 (upper bleeder), R2 (lower bleeder), cables between PC-H-P6 and PC-C-P4 or PC-H-P3 and PC-C-P5, or wiring between PC-H, R1, R2, and DC link caps.
3	Multi Overcurrents	Normally, system will software limit DPM currents to rated values; however, external transient conditions could result in software limits not being responsive enough. If this occurs often, contact factory.
4	Precharge Failure	Check History ON OFF to determine cause of precharge failure.
5	Reserved	Contact factory.
6	Too Many Trips	If unit is newly installed, check to make sure CTs are in the correct place. If not newly installed, and only occurs occasionally, could be due to a high number of transients on the line (due to unstable power). If occurs multiple times, could be a system resonance problem or an internal problem due to fault in PC-C, inverter, or gate drives in

For the example in the above screenshot, if you look in the first table, Operating Status value of 3 means on-less than max, which indicates that the system is enabled and fully operational.

This web server interface is very useful to troubleshoot Ethernet/IP or Modbus TCP. If you open this web page and the data is correctly displayed and updated from the AHF, the issue is most likely on the PLC/HMI side of the connection.

## 8. PREVENTATIVE MAINTENANCE

**WARNING: Operating a system continuously with dirty air filters, inoperable fans, or in a high room ambient temperature may decrease the operational life of any electrical equipment, including your AHF.**

The following preventative maintenance items should be performed on a monthly basis or as needed, depending on the environment that the unit is installed.

- Check installation environment to verify that it is free from water, metal filings, excessive dust or other conductive impurities and corrosive chemicals.
- Clean or change the intake air filter(s) as required, depending on the environmental conditions. Type 1 units use air filter media housed in reusable metal frames. Clean or replace fiberglass filter media with media shown in Table 8.1 or equivalent.

<b>Table 8.1: Replacement Air Filter Media for Type 1 Enclosed AHFs</b>			
<b>AHF Size (Amp rating)</b>	<b>Media Size (inches)</b>	<b>HPS part #</b>	<b>McMaster-Carr part #</b>
50 or 100	12x16x1	00002749.00	2173K4*
150 or 200	16x20x1**	00002750.00	2173K3
300	24x24x1	00002751.00	2173K7
<p>*2173K4 comes as 16x25 piece. Cut off 1" to make it 16x24, then cut in half to make two 12x16 pieces. Use one piece now and save the other for later.</p> <p>**2 pieces required per 150 or 200 Amp AHF, as these AHFs have front and bottom intake air filters.</p>			

- Make sure all air inlet and exhaust openings are clear and free from any obstructions.
- Check the fan current on the LCD display. If AHF is enabled and running, a lower than normal fan current being displayed may indicate a fan needs to be replaced. See section 5.3 for additional information on checking the fan current.

Once or twice per year (depending on the environment), it is recommended that a qualified technician, exercising proper safety procedures (See "Safety Precautions" section) perform the following preventive maintenance inside the enclosure:

- Check for excessive dust/dirt buildup inside system. Clean as necessary.
- Check interior of unit for indication of overheated components and/or connections or any signs of corrosion.

**Any preventative or corrective maintenance performed inside the cabinet should only be performed by a qualified technician, exercising proper safety procedures.**

## 9. TROUBLESHOOTING

### WARNING

Risk of **Electric Shock**. Only qualified personnel should open an AHF system and attempt to repair it. Personnel entering the cabinet may be exposed to an electrical shock hazard that could result in death or injury or further damage to the AHF. It is highly advised to contact factory if you suspect a problem with your system.

Your AHF is equipped with extensive diagnostic capabilities. It will convey problems detected via messages displayed on the LCD display, Ethernet, or Ethernet/IP or Modbus TCP connections. At the center, bottom of all LCD display pages is a status indication (ON, OFF, PRECHARGING, etc.). For additional information on this status indication, refer to section 5.

Below this status indication will appear another message in smaller font, elaborating on the status. When operating normally, the status will display “ON” and the message underneath will normally be “FULLY OPERATIONAL”. If a “warning” condition such as a high temperature exists, the message underneath will indicate that condition. These warning messages and any other messages displayed might require attention.

### 9.1 FRONT PANEL HMI DISPLAY STATUS (FAULT) MESSAGES

Possible “fault” messages that can be displayed are listed in the following **Error! Reference source not found.** It is possible that a problem may be detected that is due to some temporary condition, that once that condition passes, the system can return to normal operation. Your AHF has the capability in most cases to “forgive” faults in hopes that the condition passes; therefore, simply getting one to a few of these fault messages may not necessarily mean that there is a definite problem. If a “fault” occurs, the system will attempt to try operating again. In cases where a “DIAG” message is displayed, the DSP control may perform a full system reset after a short period of time. If the “DIAG” condition persists, after a few resets, the system will give up. A system reset record will be saved in the History Reset storage data base (HR) is such a reset occurs. Such “temporary” faults do not necessarily indicate a problem exists with your system; however, if faults begin to appear in numbers, action may need to be taken to correct the situation.

“DIAG” conditions that persist to the point where the system no longer resets itself to clear the diagnostic and Over-temperature shutdowns will require power cycling the AHF to clear the fault. This power cycling should only be done once. If the problem re-occurs in a short period of time, the problem should be resolved prior to attempting additional power cycling. Continuing power cycling to clear such faults may result in damage to the system.

**Table 9.1: Fault Messages**

LCD Message	Comments	Action to Take
DIAG: UPPER CAP VDC HIGH	Voltage across upper half of DC link caps went too much higher than voltage across lower half.	Internal failure – contact factory – PC-H, PC-C, R1 (upper bleeder), R2 (lower bleeder), cables between PC-H-P6 and PC-C-P4 or PC-H-P3 and PC-C-P5, or wiring between PC-H, R1, R2, and DC link caps.
DIAG: LOWER CAP VDC HIGH	Voltage across lower half of DC link caps went too much higher than voltage across upper half.	
DIAG: MULT. OVERCURRENTS	Too many AHF rms overcurrents	Normally, system will software limit AHF currents to rated values; however, external transient conditions could result in software limits not being responsive enough. If this occurs often, contact factory.
DIAG: PRECHARGE FAILURE	Unit failed to precharge	Check History ON/OFF to determine cause of precharge failing.

DIAG: TOO MANY ITRIPS	Too many inverter current trips	If unit is newly installed, check to make sure CTs are in the correct place. If not newly installed, and only occurs occasionally (look at On/Off history to determine how often), could be due to a high number of transients on the line (due to unstable power). If occurs multiple times, could be a system resonance problem or an internal problem due to fault in PC-C, inverter, or gate drives in inverter. If system resonance ruled out, perform low power inverter test to try to isolate problem.
DIAG: TOO MANY PTRIPS	Too many inverter pole trips	Internal problem – Inverter, gate drives, or PC-C. Perform low power inverter test to isolate problem. Look at On/Off history to determine device(s) causing the pole trips.
DIAG: CONTACTOR PROBLEM	AC contactor failed to close	Internal problem – K1, PC-C, internal current sensors, or wiring.
DIAG: AHF ISENSOR	Not enough current detected in AHF current sensors when AC contactor is closed	Internal problem – internal current sensors, K1, PC-C, wiring, or power filtering (check fuses associated with PC-T).
DIAG: LINE ISENSOR	Not enough current detected in external CTs when AC contactor is closed	External CTs may not be installed correctly or shorting bars may be installed shorting their output. Also possible internal problem, involving PC-R, PC-C, or cable connecting these 2 boards together.
DIAG: HI FREQ IN IAHF	High frequency detected in AHF current	Internal problem – PC-T failure and/or blown protection fuses (F4 – F6). Look at AHF_HFAMPS in history to determine phase(s) that caused the fault.
DIAG: DC IN IAHF	DC detected in AHF current	Could be caused by a transient line or load condition or could be due to an internal problem – IGBT device firing problem. Look at AHF_DCAMPS in history (largest value may indicate pole that device is in that is at fault)
DIAG: AHF/INV ISENSOR	Difference detected between AHF and Inverter current sensors.	Internal problem – Possible failure in either one or more current sensors CS1-CS4 or PC-C board. Look at AHF-INV RMS AMPS in history to determine phase(s) that caused the fault.
DIAG: AHF INEFFECTIVE	Diagnostic – AHF is ineffective at correcting harmonics	Problem with CTs being incorrectly positioned or a system resonance exists, resulting in current produced by AHF not effectively reducing harmonic currents in the line current. Check CTs using CT Setup LCD screen. Make sure CT physical locations (line or load side) agree with location programmed into system.
DIAG: UART TRANSMIT	Internal problem with PC-C	Contact factory
DIAG: UART RECEIVE	Internal problem with PC-C	Contact factory
DIAG: SHUTDOWNS	Too many inverter shutdowns in a short period of time	Make sure CTs are correctly positioned. Check ON/OFF history for shutdown reasons. Could be caused by temporary abnormal line power or load conditions. If persists contact factory.
DIAG: CONT. OPENINGS	Too many contactor openings in a short period of time	
DIAG: #13- DIAG: #00	Reserved diagnostic	
DISABLED BY OPERATOR	System's power inverter disabled by operator	Press the RUN button on the touchscreen display to enable the system.
DISABLED EXTERNALLY	External disable capability selected (see section 5.6.3) and externally generated signal connected to HMI's P11 connector is disabling AHF.	Either provide correct signal to HMI's P11 connector to enable AHF or deselect external disable capability via LCD display (see section 5.6.1).
DISABLED BY NETWORK	External disable via Ethernet/IP or Modbus TCP capability selected (see section <b>Error! Reference source not found.</b> ) and enable command has not been received via Ethernet/IP or Modbus TCP	Disable this feature via the LCD front panel (see section 5.6.1) or change firmware in your PLC to send an enable to the AHF via the Ethernet/IP or Modbus TCP network. See Table 7.4 & Table 7.5.
LOST HMI-DSP COMM	Communications between HMI module and PC-C DSP control board in AHF has been lost	Problem with HMI module, PC-C, or cable connecting the two.
HS1 OVER-TEMPERATURE	Temperature sensor on left side of heatsink exceeded limits.	Check for dirty air filter(s) on unit. Check fans for proper operation. Check ON/OFF history to find temperatures of

HS2 OVER-TEMPERATURE	Temperature sensor on left side of heatsink exceeded limits.	all sensors. If HS1 much different from HS2, could be a bad sensor. If a sensor is very different from other sensors, could be a bad sensor. Will need to power cycle system to clear the fault.
DSP OVER-TEMPERATURE	Temperature sensor on PC-C DSP control board exceeded limits.	
GDR OVER-TEMPERATURE	Temperature sensor on PC-G or PC-GP gate drive board exceeded limits.	
+24V LOW	+24V main supply too low	+24V supply or PC-C board problem
DSP +15V LOW	+15V supply on DSP bad	PC-C board problem
DSP -15V LOW	-15V supply on DSP bad	PC-C board problem
LINE RMS VOLTS TOO LOW	Line voltage too low for unit to run.	When utility voltage returns to normal, unit will operate again. If voltage is OK, problem with PC-H, PC-C, or internal wiring.
LINE RMS VOLTS TOO HIGH	Line voltage too high for unit to run.	
LINE FREQ TOO HIGH/LOW	Frequency beyond +/- 5 Hz from nominal.	If running from a generator, check generator for proper output.
NO PHASELOCK TO LINE	System not phaselocked to AC line	None – temporary condition – Either system is in process of phaselocking to AC line or frequency of line is presently outside operational specifications.
BAD HMI NVRAM	Internal problem with HMI	Contact factory
LOST DSP-GATE DR COMM	Communications lost between PC-C and PC-G or PC-GP gate drive boards	Problem with PC-C, PC-G or PC-GP, or cables connecting them together.
GATE DR SW VERSION WRONG	Gate drive board software version incompatible with DSP software version	Contact factory to update software versions.
GATE DR CANT READ TEMPS	PC-G or PC-GP Gate drive board can't read temperatures	PC-G or PC-GP board problem
GATE DRIVE MISC PROBLEM	Misc problem found by PC-G or PC-GP gate drive bd.	PC-G or PC-GP board problem
NOT READY A-	A- IGBT gate drive problem.	24V not getting to gate drive. Power supply or other circuitry associated with that gate drive not working. For units > 100 amps, ribbon cable problem going to gate drive board on IGBT module. Problem with the IGBT module.
NOT READY A+	A+ IGBT gate drive problem.	
NOT READY B-	B- IGBT gate drive problem	
NOT READY B+	B+ IGBT gate drive problem	
NOT READY C-	C- IGBT gate drive problem	
NOT READY C+	C+ IGBT gate drive problem	
POLE TRIP A-	Pole trip received from A- IGBT	Check unit's "History" to see if more than a few of these have been occurring. If so, a possible problem with the inverter, gate drives, or PC-C board may exist.
POLE TRIP A+	Pole trip received from A+ IGBT	
POLE TRIP B-	Pole trip received from B- IGBT	
POLE TRIP B+	Pole trip received from B+ IGBT	
POLE TRIP C-	Pole trip received from C- IGBT	
POLE TRIP C+	Pole trip received from C+ IGBT	
POLE TRIP MISC	Pole trip occurred, but cause could not be determined.	Should not occur. Contact factory if it does.
SOFTWARE MISSING	Internal firmware problem	Contact factory
POWER-UP DELAY	Normal system power up delay	None – temporary condition
DSP NVRAM NOT INITIALIZED	Internal problem with PC-C	Contact factory
BAD NVRAM OPTIONS DATA	Internal problem with PC-C	Contact factory
BAD NVRAM B-SETUP DATA	Internal problem with PC-C	Contact factory
BAD NVRAM G-SETUP DATA	Internal problem with PC-C	Contact factory
BAD NVRAM K-SETUP DATA	Internal problem with PC-C	Contact factory
BAD NVRAM OFFSET DATA	Internal problem with PC-C	Contact factory
BAD NVRAM GAIN DATA	Internal problem with PC-C	Contact factory
CONTACTOR CLOSING	AC contactor K1 is in the process of closing	None - temporary condition
CONTACTOR OPENING	AC contactor K1 is in the process of opening	None – temporary condition
INVERTER TEST	System is in inverter test mode	Only occurs if test mode requested via Ethernet comm.

THYRISTOR TEST	System is in thyristor test mode	Only occurs if test mode requested via Ethernet comm.
CONTACTOR TEST	System is in contactory test mode	Only occurs if test mode requested via Ethernet comm.
VDC TEST	System is in DC voltage test mode	Only occurs if test mode requested via Ethernet comm.
DC CAP VOLTAGE TOO HIGH	DC Cap voltage went too high to continue operation	If ON/OFF history shows multiple occurrences, check external line or load CTs for proper installation. Otherwise can be a temporary condition caused by some external anomaly with the line or load. As soon as DC voltage reduces, system will start operating again.
IAHF TOO HIGH WHEN ROFF	Too much AHF current detected when AC contactor is open.	Possible internal problem with AC contactor, AHF current sensors, or PC-C. Observe AHF currents on LCD display to determine which phase problem is with.
IAHF TOO LOW WHEN RON	Not enough AHF current detected when AC contactor is closed.	None – usually a temporary condition. If condition persists, will be followed by DIAG: AHF ISENSOR indication.
LINE CURRENT TOO LOW	Not enough line current detected when AC contactor is closed and inverter not yet operating.	Some minimal line current should register when AC contactor is closed and inverter is not yet operating. If not, external CTs may not be properly located or may have shorting strips in place, shorting their output. If this is not the case, a possible internal problem could exist with PC-R, PC-I, PC-C or cables interconnecting these.
LOAD TOO LOW	Load power too low to operate	If “UNIT DISABLED IF LOAD POWER BELOW THIS %” parameter (see section <b>Error! Reference source not found.</b> ) is set to a non-zero value, system is either OFF if not previously operating of IDLE if previously operating because load power is too low. Once load power increases, unit will resume operation. This is normal operation unless the load is actually high enough but the external line/load CTs are not reading current correctly.
HW ITRIP STUCK ON	Internal problem	Problem with PC-C board.
WAITING FOR FDR TO FINISH	DSP is finishing storing FDR recorded at last shutdown	None – temporary condition
DSP IS BEING REPROGRAMMED	Dsp is being programmed with new firmware	None – temporary condition
INVERTER STARTUP TEST	Before inverter is started each time, a test on the gate drive signals between PC-C and PC-G or PC-GP is done	None – temporary condition
INVERTER START TEST FAIL	Problem with gate drive signals detected between PC-C and PC-G or PC-GP	Problem with PC-C, PC-G or PC-GP, or cables connecting the two together.
LOAD CURRENT TOO LOW	When external CTs are on load side, some load current must exist for AHF to run.	When load current exists, unit will run. If sure that load current exists, check to make sure unit is seeing load current on all 3 phases. If not, CTs may be positioned or wired incorrectly or shorting bars are shorting their output. Could also be internal problem with PC-R, PC-C or cable connecting the two.
LOAD POWER/PF TOO LOW	AHF will not run if linear load power factor (harmonic currents filtered out) is too low.	If linear load power factor is below value set in 5.6.1, AHF won't run. Check CTs for proper placement and wiring.
UPPER>LOWER DC CAP VOLTS	Voltage across upper half of DC link caps much higher than lower half. If this continues, DIAG: UPPER CAP VDC HIGH will shut down unit.	See DIAG: UPPER CAP VDC HIGH Remedy.
LOWER>UPPER DC CAP VOLTS	Voltage across lower half of DC link caps much higher than upper half. If this continues, DIAG: LOWER CAP VDC HIGH will shut down unit.	See DIAG: LOWER CAP VDC HIGH Remedy.
HS1 HIGH-TEMPERATURE	Temperature sensor on left side of heatsink is high.	If temperature continues to climb, unit will shut down due to overtemp. Check for dirty air filter(s) on unit. Check fans for proper operation. If HS1 much different from HS2, could be a bad sensor. If a sensor is very different from other sensors, could be a bad sensor.
HS2 HIGH-TEMPERATURE	Temperature sensor on right side of heatsink is high.	
DSP HIGH-TEMPERATURE	Temperature sensor on DSP control board is high.	
GDR HIGH-TEMPERATURE	Temperature sensor on Gate drive board is high.	

## 9.2 SHUTDOWN HISTORY MESSAGES

A very useful tool for diagnosing problems occurring with an AHF is the “History” database storage. This function is accessed over the LCD display or Ethernet communications as indicated in sections **Error! Reference source not found.** and 6.2.3. Every time an AHF starts performing current correction, an entry is created in the “ON/OFF” database, storing the date and time the AHF started. When the AHF eventually stops performing current correction, this entry in the data base is closed. At that time, the date and time the AHF stopped and the reason for the AHF having to stop is saved. Also, dozens of operating parameters (see section 5.8.1 and 5.8.2 for details) are also stored. This information can be analyzed to determine if a problem exists and if so what that problem is. This analysis can then be used to determine corrective action to fix the problem. **Error! Reference source not found.** contains shutdown reasons that can be displayed by the “HO” history command or in the ON/OFF HISTORY display.

**Table 9.2: Shutdown Reasons**

Shutdown Reason	Comments	Action to Take
DIAG: UPPER CAP VDC HIGH	Voltage across upper half of DC link caps went too much higher than voltage across lower half.	Internal failure – contact factory – PC-H, PC-C, R1 (upper bleeder), R2 (lower bleeder), cables between PC-H-P6 and PC-C-P4 or PC-H-P3 and PC-C-P5, or wiring between PC-H, R1, R2, and DC link caps.
DIAG: LOWER CAP VDC HIGH	Voltage across lower half of DC link caps went too much higher than voltage across upper half.	
DIAG: MULT. OVERCURRENTS	Too many AHF rms overcurrents	Normally, system will software limit AHF currents to rated values; however, external transient conditions could result in software limits not being responsive enough. If this occurs often, contact factory.
DIAG: PRECHARGE FAILURE	Unit failed to precharge	Check verbose ON/OFF History to determine cause of precharge failing.
DIAG: TOO MANY ITRIPS	Too many inverter current trips	If unit is newly installed, check to make sure CTs are in the correct place. If not newly installed, and only occurs occasionally (look at On/Off history to determine how often), could be due to a high number of transients on the line (due to unstable power). If occurs multiple times, could be a system resonance problem or an internal problem due to fault in PC-C, inverter, or gate drives in inverter. If system resonance ruled out, perform low power inverter test to try to isolate problem.
DIAG: TOO MANY PTRIPS	Too many inverter pole trips	Internal problem – Inverter, gate drives, or PC-C. Perform low power inverter test to isolate problem. Look at On/Off history to determine device(s) causing the pole trips.
DIAG: CONTACTOR PROBLEM	AC contactor failed to close	Internal problem – K1, PC-C, internal current sensors, or wiring.
DIAG: AHF ISENSOR	Not enough current detected in AHF current sensors when AC contactor was closed	Internal problem – internal current sensors, K1, PC-C, wiring, or power filtering (check fuses associated with PC-T).
DIAG: LINE ISENSOR	Not enough current detected in external CTs when AC contactor was closed	External CTs may not be installed correctly or shorting bars may be installed shorting their output. Also possible internal problem, involving PC-R, PC-C, or cable connecting these 2 boards together.
DIAG: HI FREQ IN IAHF	High frequency detected in AHF current	Internal problem – PC-T failure and/or blown protection fuses (F4 – F6). Look at AHF_HFAMPS in history to determine phase(s) that caused the fault.
DIAG: DC IN IAHF	DC detected in AHF current	Could be caused by a transient line or load condition or could be due to an internal problem – IGBT device firing problem. Look at AHF_DCAMPS in history (largest value may indicate pole that device is in that is at fault)
DIAG: AHF/INV ISENSOR	Difference detected between AHF and Inverter current sensors.	Internal problem – Possible failure in either one or more current sensors CS1-CS4 or PC-C board. Look at AHF-INV RMS AMPS in history to determine phase(s) that caused the fault.

DIAG: AHF INEFFECTIVE	Diagnostic – AHF was ineffective at correcting harmonics	Problem with CTs being incorrectly positioned or a system resonance exists, resulting in current produced by AHF not effectively reducing harmonic currents in the line current. Check CTs using CT Setup LCD screen. Make sure CT physical locations (line or load side) agree with location programmed into system.
DIAG: UART TRANSMIT	Internal problem with PC-C	Contact factory
DIAG: UART RECEIVE	Internal problem with PC-C	Contact factory
DIAG: SHUTDOWNS	Too many inverter shutdowns in a short period of time	Make sure CTs are correctly positioned. Check ON/OFF history for shutdown reasons. Could be caused by temporary abnormal line power or load conditions. If persists contact factory.
DIAG: CONT. OPENINGS	Too many contactor openings in a short period of time	
DIAG: #13- DIAG: #00	Reserved diagnostics	Contact factory
DISABLED BY OPERATOR	System's power inverter disabled by operator	Press the RUN button on the touchscreen display to re-enable the system.
DISABLED EXTERNALLY	External disable capability selected (see section 5.6.3) and externally generated signal connected to HMI's P11 connector disabled the AHF.	None. If feature is no longer wanted disable (see section 5.6.3).
DISABLED BY NETWORK	External disable via Ethernet/IP or Modbus TCP capability selected (see section 5.6.3) and disable command was received via Ethernet/IP or Modbus TCP	None. If feature is no longer wanted disable (see section 5.6.3).
LOST HMI-DSP COMM	Communications between HMI module and PC-C DSP control board in AHF was lost	Problem with HMI module, PC-C, or cable connecting the two.
HS1 OVER-TEMPERATURE	Temperature sensor on left side of heatsink exceeded limits.	Check for dirty air filter(s) on unit. Check fans for proper operation. Check verbose ON/OFF history to find temperatures of all sensors. If HS1 much different from HS2, could be a bad sensor. If a sensor is very different from other sensors, could be a bad sensor.
HS2 OVER-TEMPERATURE	Temperature sensor on left side of heatsink exceeded limits.	
DSP OVER-TEMPERATURE	Temperature sensor on PC-C DSP control board exceeded limits.	
GDR OVER-TEMPERATURE	Temperature sensor on PC-G or PC-GP gate drive board exceeded limits.	
+24V LOW	+24V main supply too low	+24V supply or PC-C board problem
DSP +15V LOW	+15V supply on DSP bad	PC-C board problem
DSP -15V LOW	-15V supply on DSP bad	PC-C board problem
LINE RMS VOLTS TOO LOW	Line voltage too low for unit to run.	Utility voltage went out of range
LINE RMS VOLTS TOO HIGH	Line voltage too high for unit to run.	
LINE FREQ TOO HIGH/LOW	Frequency beyond +/- 5 Hz from nominal.	Frequency of utility voltage went out of range
NO PHASELOCK TO LINE	System not phaselocked to AC line	Voltage or Frequency of utility voltage went out of range or frequency changed very rapidly.
BAD HMI NVRAM	Internal problem with HMI	Contact factory
LOST DSP-GATE DR COMM	Internal problem with PC-C	Contact factory
GATE DR SW VERSION WRONG	Gate drive board software version incompatible with DSP software version	Contact factory to update software versions.
GATE DR CANT READ TEMPS	PC-G or PC-GP Gate drive board can't read temperatures	PC-G or PC-GP board problem
GATE DRIVE MISC PROBLEM	Misc problem found by PC-G or PC-GP gate drive bd.	PC-G or PC-GP board problem
NOT READY A-	A- IGBT gate drive problem.	24V not getting to gate drive. Power supply or other circuitry associated with that gate drive not working. For units > 100 amps, ribbon cable problem going to gate drive board on IGBT module.
NOT READY A+	A+ IGBT gate drive problem.	
NOT READY B-	B- IGBT gate drive problem	

NOT READY B+	B+ IGBT gate drive problem	Problem with the IGBT module. Check unit's "History" to see if an inordinate number of these have been occurring
NOT READY C-	C- IGBT gate drive problem	
NOT READY C+	C+ IGBT gate drive problem	
POLE TRIP A-	Pole trip received from A- IGBT	Check unit's "History" to see if an inordinate number of these have been occurring. If so, a possible problem with the inverter, gate drives, or PC-C board may exist.
POLE TRIP A+	Pole trip received from A+ IGBT	
POLE TRIP B-	Pole trip received from B- IGBT	
POLE TRIP B+	Pole trip received from B+ IGBT	
POLE TRIP C-	Pole trip received from C- IGBT	
POLE TRIP C+	Pole trip received from C+ IGBT	
POLE TRIP MISC	Pole trip occurred, but cause could not be determined.	
UNKNOWN PWM CAUSE		Should not occur. Contact factory if it does.
VDC TOO HIGH	Inverter DC capacitor voltage went too high	If ON/OFF history shows multiple occurrences, check external line or load CTs for proper installation. Otherwise can be a temporary condition caused by some external anomaly with the line or load. As soon as DC voltage reduces, system starts operating again.
VDC TOO LOW	Inverter DC capacitor voltage dropped too low	Most likely due to a transient condition with the line voltage or load.
HW CURRENT TRIP	Hardware current trip occurred	Normally, software limits AHF current; however, line voltage transients or large load changes can result in hardware limits being reached. Contact factory if inordinate numbers of these are seen in the ON/OFF history.
VAC PEAK VOLTAGE TOO LOW	Line voltage peak voltage too low.	Most likely due to a transient condition with the line voltage.
VDC TEST MODE ENTERED	Vdc test mode selected by operator.	Only occurs if test mode requested via Ethernet comm.
AHF CURRENTS TOO LOW		Should not occur. Contact factory if it does.
LINE CURRENTS TOO LOW		Should not occur. Contact factory if it does.
AHF CURRENTS TOO HIGH	AHF Rms currents exceeded rating for too long	Most likely due to a line voltage transient condition or very large load change.
AHF CURRENTS VERY HIGH	AHF Rms currents greatly exceeded rating for too long	
LINE HIGHER THAN LOAD CURRENTS		Should not occur. Contact factory if it does.
AHF HIGHER THAN LOAD CURRENTS		Should not occur. Contact factory if it does.

If unit fails to precharge, the shutdown reason in the On/Off history for the event will start with the text "PRECHARGE FAIL". The last line of the verbose ON/OFF history records contains values acquired during the precharge portion of starting up and contains additional troubleshooting information. A precharge failure can be caused by many of the shutdown reasons shown in Table 9.2. In addition, the following Table contains additional shutdown reasons that can occur only during precharge. Sometimes precharging can occasionally fail due to a temporary transient occurring on the AC line. Such occasional failures will be recorded in the On/Off History and be followed by additional attempts to precharge. If additional attempts also fail, a diagnostic is declared. Occasionally seeing precharge failures may not be a problem; however, persistent failures may be. In the following table, items not marked with any "Action to Take" fall in that category. The factory should be contacted if persistent precharge failures are observed.

<b>Table 9.3: Additional Shutdown Reasons that Only Occur During Precharge</b>		
<b>Shutdown Reason</b>	<b>Comments</b>	<b>Action to Take</b>

UPPER CAP VDC TOO HIGH	Voltage on upper half of DC capacitance exceeded limits	Internal problem. Contact factory.
LOWER CAP VDC TOO HIGH	Voltage on lower half of DC capacitance exceeded limits	Internal problem. Contact factory.
LESS THAN 10% VDC ATTAINED	Unable to charge DC capacitance beyond 10%	Check verbose ON/OFF history for failed precharge event. If MAX AMPS or AVG AMPS in last line (precharge info line) is less than 1 amp, check fuse F4 on PC-H. If fuse is open, replace. If fuse fails again, problem with PC-H, PC-C, or wiring.
PRECHARGE TIMED OUT	Unable to fully charge DC capacitance in allotted time.	
VAB PEAK CALC TOO LOW	Peak of line voltage too low	
VAB PEAK CALC TOO HIGH	Peak of line voltage too high	
AHF CURRENTS WENT TOO HIGH	AHF rms currents too high	
VAB TOO LOW AT THYRISTOR TIME	Line voltage too low when time to turn on thyristor	
VAB TOO HIGH AT THYRISTOR TIME	Line voltage too high when time to turn on thyristor	

If unit precharges but encounters a problem while closing the AC contactor, the shutdown reason in the On/Off history for the event will start with the text “ACC FAIL”. An AC contactor failure can be caused by many of the shutdown reasons shown in Table 9.2. In addition, the following Table contains additional shutdown reasons that can occur only during the closure of the AC contactor.

**Table 9.4: Additional Shutdown Reasons that Only Occur During AC Contactor Closures**

Shutdown Reason	Comments	Action to Take
NO IAHF WHILE CLOSING ACC	AHF current not observed in 1 or more phases during attempt to close AC Contactor.	Either K1 failed to close in a timely fashion, PC-C problem, or wiring problem is to blame. Check verbose ON/OFF history record for AHF currents at time of failure.
IAHF TOO LOW WITH ACC CLOSED	Insufficient AHF rms current observed in 1 or more phases when AC Contactor closed.	After AC Contactor closes, but prior to starting the inverter, the AC capacitors in the AHF’s power filtering should draw some minimal current. If such current doesn’t materialize, could be due to failure in the filtering (check fuses associated with PC-T, AC capacitors and components on PC-T) Also, could be due to an internal current sensor or PC-C failure. Check verbose ON/OFF history record for AHF currents at time of failure.
ACC ON WITH AHF OFF TOO LONG	Once AC Contactor closed, something happened so that system could not continue on to start inverter within a timeout period.	Unlikely to happen. If it does, a subsequent retry should fix the situation.

### 9.3 RESET HISTORY MESSAGES

Another useful tool for diagnosing problems occurring with an AHF is the RESET HISTORY database storage. This function is accessed over the LCD display or Ethernet communications as indicated in sections 5.8.3 and **Error! Reference source not found..** Every time the DSP control board resets, an entry is created in the “RESET” database, storing a reset “event number”, the date and time the reset occurs, and the reason for the reset. The following table contains the possible “Reset Reasons” that can be recorded. The vast majority of the resets will be “Power-up” resets. Every time power is applied to the AHF the DSP control board resets and records the reason as “Power-up”. Reset Reasons that do not list an “Action to Take” could occasionally occur due to electrical noise or other unusual transient condition. If several of these start showing up in the Reset History, the factory should be contacted as there may be a problem with the PC-C board.

Concerning “L1 DIAG” through “L4 DIAG” resets, as indicated in the following table, these are resets that occur after a “diagnostic” condition is detected. A “diagnostic” condition is serious enough to keep the

unit from restarting; however, a remedy is provided to allow the system to wait a period of time (in case problem is due to an external event that is transitory in nature), and then reset itself and try to restart up to a certain number of times. Presently, up to 2 levels of “diagnostic” resets can occur before the unit will stop resetting and remain in the off (due to a diagnostic condition) state. This means a if the same diagnostic condition occurs a third time, the unit will stop trying to operate. Note that if the system successfully recovers following a reset, and operates without a diagnostic occurring for a period of time, those previous diagnostics will be “forgiven” meaning that the diagnostic level will be lowered one level for each period of time it operates without problems.

To determine the cause of the diagnostic conditions, the RESET HISTORY and the ON/OFF HISTORY data bases can be viewed.

Table 9.5: Reset Reasons		
Reset Reason	Comments	Action to Take
POWER-UP	Normal reason that occurs every time AHF controls are powered up.	None – normal occurrence
HARDWARE WATCHDOG	In case processor gets “lost” a hardware watchdog timer will reset it to “bring it back”.	
FLASH REPROGRAMMED	Occurs if DSP Control board is reprogrammed with firmware.	None – normal occurrence
SIMULATED	Should not see this, as it is the result of a factory procedure.	
LOW PWM/RTC EXECUTION RATIO	Various reasons that processor had to be reset due to certain procedures not being executed at the proper time.	
HIGH PWM/RTC EXECUTION RATIO		
VOLTAGE A/D PROBLEM		
BAD CONTROL STATE		
L1 DIAG: followed by a diagnostic reason	If a problem persists that is detrimental to the continued operation of the unit, a diagnostic is declared. The first time a diagnostic is declared, a L1 (level 1) diagnostic reset occurs in a short period of time in hopes that a short delay and/or system reset will fix the problem. If that same diagnostic condition occurs again within a short period of time, a L2 (level 2) diagnostic reset occurs after a bit longer period of time. This can continue to a level 3 and level 4. Once the maximum level is attained and the same diagnostic occurs again, the system will not reset again and will instead remain off until power is cycled off and on. (see notes in text for additional info)	If several of these resets start to be found, the problem should be investigated. If you get to the final level and system stays off, power can be cycled off and on to clear the problem; however, if problem re-occurs, do not keep cycling power as doing so could result in system damage. Call factory instead.
L2 DIAG: followed by a diagnostic reason		
L3 DIAG: followed by a diagnostic reason		
L4 DIAG: followed by a diagnostic reason		

#### 9.4 TROUBLESHOOTING THE FRONT PANEL HMI DISPLAY

The HMI is equipped with a reset button on the front panel. The reset button is useful if the HMI display gets stuck due to some internal issue. For example if you touch a button on the touchscreen and expect an action to occur, and this action does not occur, i.e. pressing the MENU button on the OPERATING STATUS display does not open the MENU display, pressing the reset button will usually solve the issue.

See section 3.5.6 for how to access the reset button by removing the cover on the front panel.

The front panel HMI can sometimes automatically reset if there is an issue with the Ethernet communications, USB communications, touchscreen, display, or another HMI related issue. When the HMI resets, the AHF will stop operating momentarily if its presently running. The HMI reset will cause the HPS TruWave splashscreen (see section **Error! Reference source not found.** of this manual) to be displayed along with the HMI reset reason on the bottom of the splashscreen. Note: pressing the reset button does not cause a message to be displayed on the bottom of the splashscreen as this is considered a normal power up reset.

Table 9.6 lists the possible HMI reset reason messages and actions to take to solve the issue.

<b>Table 9.6: HMI Reset Reasons</b>		
<b>Reset Reason</b>	<b>Comments</b>	<b>Action to Take</b>
EXTERNAL HMI RESET	HMI was reset by external source	You will normally never see this message
HMI-DSP LOST COMMS	This may happen due to noise on PC-C or HMI, if the noise goes away, the HMI will stop resetting	If this keeps happening for about 10 minutes or more, contact the factory.
USART RX DMA FAIL	Internal problem with PC-C	Contact factory
USART TX DMA FAIL	Internal problem with PC-C	Contact factory
TOUCHSCREEN ERROR	Front panel touchscreen hardware error	Contact factory
USB ENUMERATE FAIL	This will happen if there is a bad connection between the flash drive and the USB port	Remove the flash drive and plug it back in to the USB port making sure there is a good connection. If this does not solve the issue, contact the factory.
USB COMMS STUCK DURING FDR	There may be a bad connection between the flash drive and USB port or other flash drive internal issue.	Exit the History FDR screen. Remove the flash drive and plug it back in to the USB port making sure there is a good connection. If this keeps happening, try another flash drive or contact the factory
USB ENUMERATE FAIL DURING UPDATE FIRMWARE	This will happen if there is a bad connection between the flash drive and the USB port	Remove the flash drive and plug it back in to the USB port making sure there is a good connection. If this does not solve the issue, contact the factory.
FLASH DRIVE DIRECTORY CANT BE READ	Internal flash drive error	Try another flash drive or contact the factory
USB COMMS STUCK WHILE READING BIN FILE	Internal flash drive error	Try another flash drive or contact the factory
USB FAT FILE SYSTEM ERROR	Internal flash drive error	Try another flash drive or contact the factory
I2C STUCK WHILE READING ETHERNET ADDRESS	Internal HMI error	Contact the factory
ETHERNET MAC CORE ERROR	Internal HMI error	Contact the factory
ETHERNET PHY READ ERROR	Internal HMI error	Contact the factory
ETHERNET PHY WRITE ERROR	Internal HMI error	Contact the factory
USB CORE RESET FAILED	This may happen if there is a bad connection between the flash drive and the USB port	Remove the flash drive and plug it back in to the USB port making sure there is a good connection. If this does not solve the issue, contact the factory.
FLASH MEM ERROR,HMI WAS NOT PROGRAMMED	Error occurred while updating HMI firmware	Contact the factory
HMI SOFTWARE WATCHDOG	HMI operation got stuck and automatically recovered	The error was automatically fixed by the HMI. If no further issues are observed, no action is needed.
HARDWARE WATCHDOG RESET	HMI operation got stuck and automatically recovered	The error was automatically fixed by the HMI. If no further issues are observed, no action is needed.
HMI POWER-UP	HMI powered up normally	This message is only visible in DIAGNOSTIC DATA display
HMI FIRMWARE UPDATED	HMI firmware was successfully updated with the USB flash drive	The HMI firmware was just updated with the latest firmware. See section 5.11.1 for more information

## 10. AHF SPECIFICATIONS AND DRAWINGS

Note: Specifications are subject to change

<b>Table 10.1: Specifications for 50 Amp AHF</b> voltage rating of unit (240 or 480)						
Parameter	Symbol	Condition	Min.	Nom.	Max.	Unit
<b>Power (3Φ Delta):</b>						
RMS Voltage (Line-to-line)	$V_{line}$	240 in part# & 208 selected as nom volt.	177	208	233	Volts
Frequency	$F_{line}$		55	60	65	Hz
RMS Voltage (Line-to-line)	$V_{line}$	240 in part# & 240 selected as nom volt.	204	240	269	Volts
Frequency	$F_{line}$		55	60	65	Hz
RMS Voltage (Line-to-line)	$V_{line}$	480 in part# & 400 selected as nom volt.	340	400	448	Volts
Frequency	$F_{line}$		45	50	55	Hz
RMS Voltage (Line-to-line)	$V_{line}$	480 in part# & 480 selected as nom volt.	408	480	538	Volts
Frequency	$F_{line}$		55	60	65	Hz
Correction Current (see note 1)	$I_{AHF}$ (rms)	Average of all 3 phases			50	Amps
Correction Current	$I_{AHF}$ (rms)	Any single phase			52.5	Amps
Correction Current	$I_{AHF}$ (peak)	Any phase	-150		+150	Amps
Full load Efficiency	Eff	$I_{AHF}(rms)= \text{Max.}, V_{line}= \text{Nom}$		98		%
Full load Losses	$P_{Loss}$				900	
<b>Performance:</b>						
Resultant Line Current Distortion (see notes 1 & 2)	$I_{line}$ thdr	$I_{load}$ harmonics = $I_{AHF}$ Max.		3.0	5.0	%thdr
Resultant Power Factor (linear correction enabled)	$I_{line}$ pf	$I_{load}$ harmonics and reactive < $I_{AHF}$ Max.	0.998			
<b>Physical:</b>						
Operating Temperature	$T_{oper}$	Ambient (see note 3)	0		40	°C
Storage Temperature	$T_{st}$	Ambient	-20		60	°C
Altitude above sea level	Alt	(see note 3)			5000	ft
Audible Noise produced					60	dBA
<b>Type 1 Enclosed:</b> 50A						
Enclosure Height	Power switch protrudes 2.13" out from front surface of enclosure. Height does not include 1" air filter on bottom of unit. See drawings that follow for additional dimensions.				53	inches
Enclosure Width					21	inches
Enclosure Depth					14.25	inches
Panel Weight					230	lbs.
<b>Open Panel:</b> 50A						
Panel Height	Depth of panel varies – only maximum depth is shown in this table (depth may need to increase 0.25" for screws protruding out of panel). See drawings that follow for additional dimensions.				45	inches
Panel Width					16.9	inches
Panel Depth					12.71	inches
Panel Weight					135	lbs.
Cabinet Air flow needed	Supplied by Integrator		375			cfm

**Table 10.2: Specifications for 100 Amp AHF**  
voltage rating of unit (240 or 480)

Parameter	Symbol	Condition	Min.	Nom.	Max.	Unit
<b>Power (3Φ Delta):</b>						
RMS Voltage (Line-to-line)	$V_{line}$	240 in part# & 208 selected as nom volt.	177	208	233	Volts
Frequency	$F_{line}$		55	60	65	Hz
RMS Voltage (Line-to-line)	$V_{line}$	240 in part# & 240 selected as nom volt.	204	240	269	Volts
Frequency	$F_{line}$		55	60	65	Hz
RMS Voltage (Line-to-line)	$V_{line}$	480 in part# & 400 selected as nom volt.	340	400	448	Volts
Frequency	$F_{line}$		45	50	55	Hz
RMS Voltage (Line-to-line)	$V_{line}$	480 in part# & 480 selected as nom volt.	408	480	538	Volts
Frequency	$F_{line}$		55	60	65	Hz
Correction Current (see note 1)	$I_{AHF}$ (rms)	Average of all 3 phases			100	Amps
Correction Current	$I_{AHF}$ (rms)	Any single phase			105	Amps
Correction Current	$I_{AHF}$ (peak)	Any phase	-300		+300	Amps
Full load Efficiency	Eff	$I_{AHF}$ (rms)= Max., $V_{line}$ = Nom		98		%
Full load Losses	$P_{Loss}$			1700		Watts
<b>Performance:</b>						
Resultant Line Current Distortion (see notes 1 & 2)	$I_{line}$ pf	$I_{load}$ harmonics = $I_{AHF}$ Max.		3.0	5.0	%thdr
Resultant Power Factor (linear correction enabled)		$I_{load}$ harmonics and reactive < $I_{AHF}$ Max.	0.998			
<b>Physical:</b>						
Operating Temperature	$T_{oper}$	Ambient (see note 3)	0		40	°C
Storage Temperature	$T_{st}$	Ambient	-20		60	°C
Altitude above sea level	Alt	(see note 3)			5000	ft
Audible Noise produced					60	dBa
<b>Type 1 Enclosed:</b> 100A unit						
Enclosure Height	Power switch protrudes 2.13" out from front surface of enclosure. Height does not include 1" air filter on bottom of unit. See drawings that follow for additional dimensions.				53	inches
Enclosure Width					21	inches
Enclosure Depth					14.25	inches
Panel Weight					270	lbs.
<b>Open Panel:</b> 100A unit						
Panel Height	Depth of panel varies – only maximum depth is shown in this table (depth may need to increase 0.25" for screws protruding out of panel). See drawings that follow for additional dimensions.				45	inches
Panel Width					12.9	inches
Panel Depth					12.83	inches
Panel Weight					175	lbs.
Cabinet Air flow needed	Supplied by Integrator		500			cfm

**Table 10.3: Specifications for 150 Amp AHF**  
voltage rating of unit (240 or 480)

Parameter	Symbol	Condition	Min.	Nom.	Max.	Unit
<b>Power (3Φ Delta):</b>						
RMS Voltage (Line-to-line)	$V_{line}$	240 in part# & 208 selected as nom volt.	177	208	233	Volts
Frequency	$F_{line}$		55	60	65	Hz
RMS Voltage (Line-to-line)	$V_{line}$	240 in part# & 240 selected as nom volt.	204	240	269	Volts
Frequency	$F_{line}$		55	60	65	Hz
RMS Voltage (Line-to-line)	$V_{line}$	480 in part# & 400 selected as nom volt.	340	400	448	Volts
Frequency	$F_{line}$		45	50	55	Hz
RMS Voltage (Line-to-line)	$V_{line}$	480 in part# & 480 selected as nom volt.	408	480	538	Volts
Frequency	$F_{line}$		55	60	65	Hz
Correction Current (see note 1)	$I_{AHF}$ (rms)	Average of all 3 phases			150	Amps
Correction Current	$I_{AHF}$ (rms)	Any single phase			157.5	Amps
Correction Current	$I_{AHF}$ (peak)	Any phase	-450		+450	Amps
Full load Efficiency	Eff	$I_{AHF}$ (rms)= Max., $V_{line}$ = Nom		98		%
Full load losses	$P_{Loss}$			2500		Watts
<b>Performance:</b>						
Resultant Line Current Distortion (see notes 1 & 2)	$I_{line}$ pf	$I_{load}$ harmonics = $I_{AHF}$ Max.		3.0	5.0	%thdr
Resultant Power Factor (linear correction enabled)		$I_{load}$ harmonics and reactive < $I_{AHF}$ Max.	0.998			
<b>Physical:</b>						
Operating Temperature	$T_{oper}$	Ambient (see note 3)	0		40	°C
Storage Temperature	$T_{st}$	Ambient	-20		60	°C
Altitude above sea level	Alt	(see note 3)			5000	ft
Audible Noise produced					65	dBa
<b>Type 1 Enclosed:</b> 150A unit						
Enclosure Height	Power switch protrudes 2.13" out from front surface of enclosure. Height does not include 1" air filter on bottom of unit. See drawings that follow for additional dimensions.				63.5	inches
Enclosure Width					27	inches
Enclosure Depth					16.5	inches
Panel Weight					440	lbs.
<b>Open Panel:</b> 150A unit						
Panel Height	Depth of panel varies – only maximum depth is shown in this table (depth may need to increase 0.25" for screws protruding out of panel). See drawings that follow for additional dimensions.				54	inches
Panel Width					22	inches
Panel Depth					12.54	inches
Panel Weight					245	lbs.
Cabinet Air flow needed	Supplied by Integrator		800			cfm

**Table 10.4: Specifications for 200 Amp AHF**  
voltage rating of unit (240 or 480)

Parameter	Symbol	Condition	Min.	Nom.	Max.	Unit
<b>Power (3Φ Delta):</b>						
RMS Voltage (Line-to-line)	$V_{line}$	240 in part# & 208 selected as nom volt.	177	208	233	Volts
Frequency	$F_{line}$		55	60	65	Hz
RMS Voltage (Line-to-line)	$V_{line}$	240 in part# & 240 selected as nom volt.	204	240	269	Volts
Frequency	$F_{line}$		55	60	65	Hz
RMS Voltage (Line-to-line)	$V_{line}$	480 in part# & 400 selected as nom volt.	340	400	448	Volts
Frequency	$F_{line}$		45	50	55	Hz
RMS Voltage (Line-to-line)	$V_{line}$	480 in part# & 480 selected as nom volt.	408	480	538	Volts
Frequency	$F_{line}$		55	60	65	Hz
Correction Current (see note 1)	$I_{AHF}$ (rms)	Average of all 3 phases			200	Amps
Correction Current	$I_{AHF}$ (rms)	Any single phase			210	Amps
Correction Current	$I_{AHF}$ (peak)	Any phase	-600		+600	Amps
Full load Efficiency	Eff	$I_{AHF}$ (rms)= Max., $V_{line}$ = Nom		98		%
Full load losses	$P_{Loss}$			3300		Watts
<b>Performance:</b>						
Resultant Line Current Distortion (see notes 1 & 2)	$I_{line}$ pf	$I_{load}$ harmonics = $I_{AHF}$ Max.		3.0	5.0	%thdr
Resultant Power Factor (linear correction enabled)		$I_{load}$ harmonics and reactive < $I_{AHF}$ Max.	0.998			
<b>Physical:</b>						
Operating Temperature	$T_{oper}$	Ambient (see note 3)	0		40	°C
Storage Temperature	$T_{st}$	Ambient	-20		60	°C
Altitude above sea level	Alt	(see note 3)			5000	ft
Audible Noise produced					65	dBa
<b>Type 1 Enclosed:</b> 200A unit						
Enclosure Height	Power switch protrudes 2.13" out from front surface of enclosure. Height does not include 1" air filter on bottom of unit. See drawings that follow for additional dimensions.				63.5	inches
Enclosure Width					27	inches
Enclosure Depth					16.5	inches
Panel Weight					480	lbs.
<b>Open Panel:</b> 200A unit						
Panel Height	Depth of panel varies – only maximum depth is shown in this table (depth may need to increase 0.25" for screws protruding out of panel). See drawings that follow for additional dimensions.				54	inches
Panel Width					22	inches
Panel Depth					13.54	inches
Panel Weight					280	lbs.
Cabinet Air flow needed	Supplied by Integrator		900			cfm

**Table 10.5: Specifications for 300 Amp AHF**  
voltage rating of unit (240 or 480)

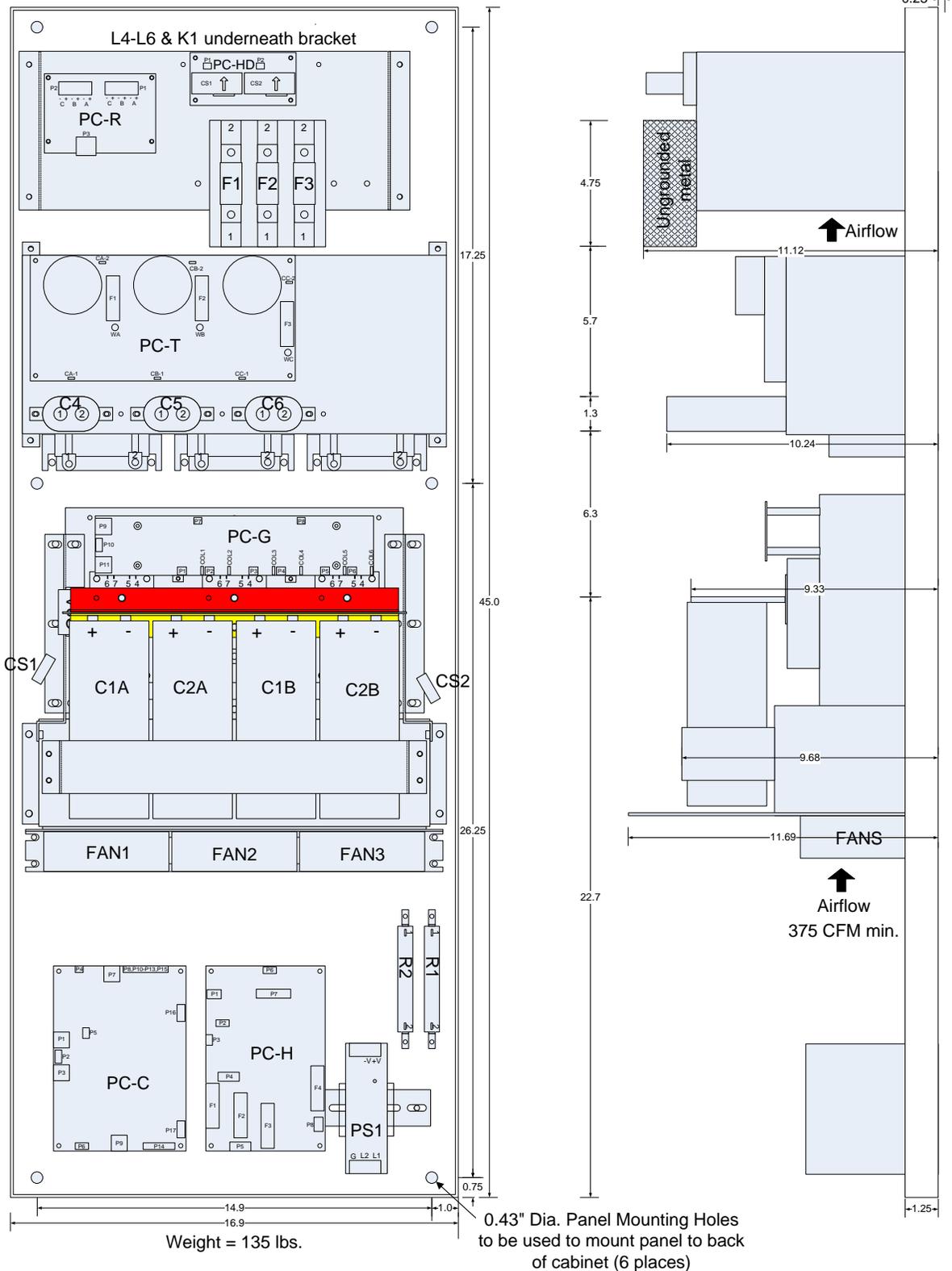
Parameter	Symbol	Condition	Min.	Nom.	Max.	Unit
<b>Power (3Φ Delta):</b>						
RMS Voltage (Line-to-line)	$V_{line}$	240 in part# & 208 selected as nom volt.	177	208	233	Volts
Frequency	$F_{line}$		55	60	65	Hz
RMS Voltage (Line-to-line)	$V_{line}$	240 in part# & 240 selected as nom volt.	204	240	269	Volts
Frequency	$F_{line}$		55	60	65	Hz
RMS Voltage (Line-to-line)	$V_{line}$	480 in part# & 400 selected as nom volt.	340	400	448	Volts
Frequency	$F_{line}$		45	50	55	Hz
RMS Voltage (Line-to-line)	$V_{line}$	480 in part# & 480 selected as nom volt.	408	480	538	Volts
Frequency	$F_{line}$		55	60	65	Hz
Correction Current (see note 1)	$I_{AHF}$ (rms)	Average of all 3 phases			300	Amps
Correction Current	$I_{AHF}$ (rms)	Any single phase			315	Amps
Correction Current	$I_{AHF}$ (peak)	Any phase	-900		+900	Amps
Full load Efficiency	Eff	$I_{AHF}$ (rms)= Max., $V_{line}$ = Nom		98		%
Full load losses	$P_{Loss}$			5100		Watts
<b>Performance:</b>						
Resultant Line Current Distortion (see notes 1 & 2)	$I_{line}$ thdr	$I_{load}$ harmonics = $I_{AHF}$ Max.		3.0	5.0	%thdr
Resultant Power Factor (linear correction enabled)	$I_{line}$ pf	$I_{load}$ harmonics and reactive < $I_{AHF}$ Max.	0.998			
<b>Physical:</b>						
Operating Temperature	$T_{oper}$	Ambient (see note 3)	0		40	°C
Storage Temperature	$T_{st}$	Ambient	-20		60	°C
Altitude above sea level	Alt	(see note 3)			5000	ft
Audible Noise produced					65	dBA
<b>Type 1 Enclosed:</b> 300A unit						
Enclosure Height	Power switch protrudes 1.75" out from front surface of enclosure. See drawings that follow for additional dimensions.				75	inches
Enclosure Width					33	inches
Enclosure Depth					18	inches
Panel Weight					630	lbs.
<b>Open Panel:</b> 300A unit						
Panel Height	Depth of panel varies – only maximum depth is shown in this table (depth may need to increase 0.25" for screws protruding out of panel). See drawings that follow for additional dimensions.				56	inches
Panel Width					27	inches
Panel Depth					13.56	inches
Panel Weight					400	lbs.
Cabinet Air flow needed			1300			cfm

**Notes pertaining to all previous specification tables:**

- System will automatically current limit at max. rms and peak values shown. If load requires correction exceeding these values, excess amount will come from utility. This automatic limiting will allow the system to continuously run at max. output, providing its maximum amount of correction; however, the line current ( $I_{line}$ ) thdr will increase as the excess current that is needed increases, and will soon exceed the max. %thdr listed.
- Depending on the severity of the harmonic currents drawn by the load, and how loaded the AHF is, the resultant line current distortion will vary. The maximum 5% THDR shown is achievable down to as low as 15-20% AHF loading for normal loads (30-35% THDR). Higher distorted loads will require the AHF to be loaded a bit more to attain the 5% max. line THDR.

3. Standard maximum operating ambient room temperature is 40 degrees C. On request, if higher ambient temperatures are anticipated, systems can be configured for operating in up to a 50 degree C room ambient. Above 40 degrees, system will “self de-rate” at about 2.5% per degree, so that when the room ambient is at 50 degrees, system will limit itself to produce about 75% of its rated output current. When operating at 40 degrees or lower, system will produce full rated current. Also, equipment can operate at higher altitudes at full rated current if ambient operating temperature is kept lower than 40C. At ambient temperatures approaching 40 C and higher altitudes, system will “self de-rate” its output current, thus allowing operation to continue, but at a reduced maximum current. It is not recommended to operate at both higher altitudes and higher than 40C ambient temperatures.

Fasteners holding components to panel may protrude out the back of the panel as much as 0.23"; therefore, spacers having at least 0.25" thickness will probably be needed between back of panel and surface that panel is mounted to.



**Figure 10.1: 50 Amp AHF Panel Layout Drawings**

Fasteners holding components to panel may protrude out the back of the panel as much as 0.23"; therefore, spacers having at least 0.25" thickness will probably be needed between back of panel and surface that panel is mounted to.

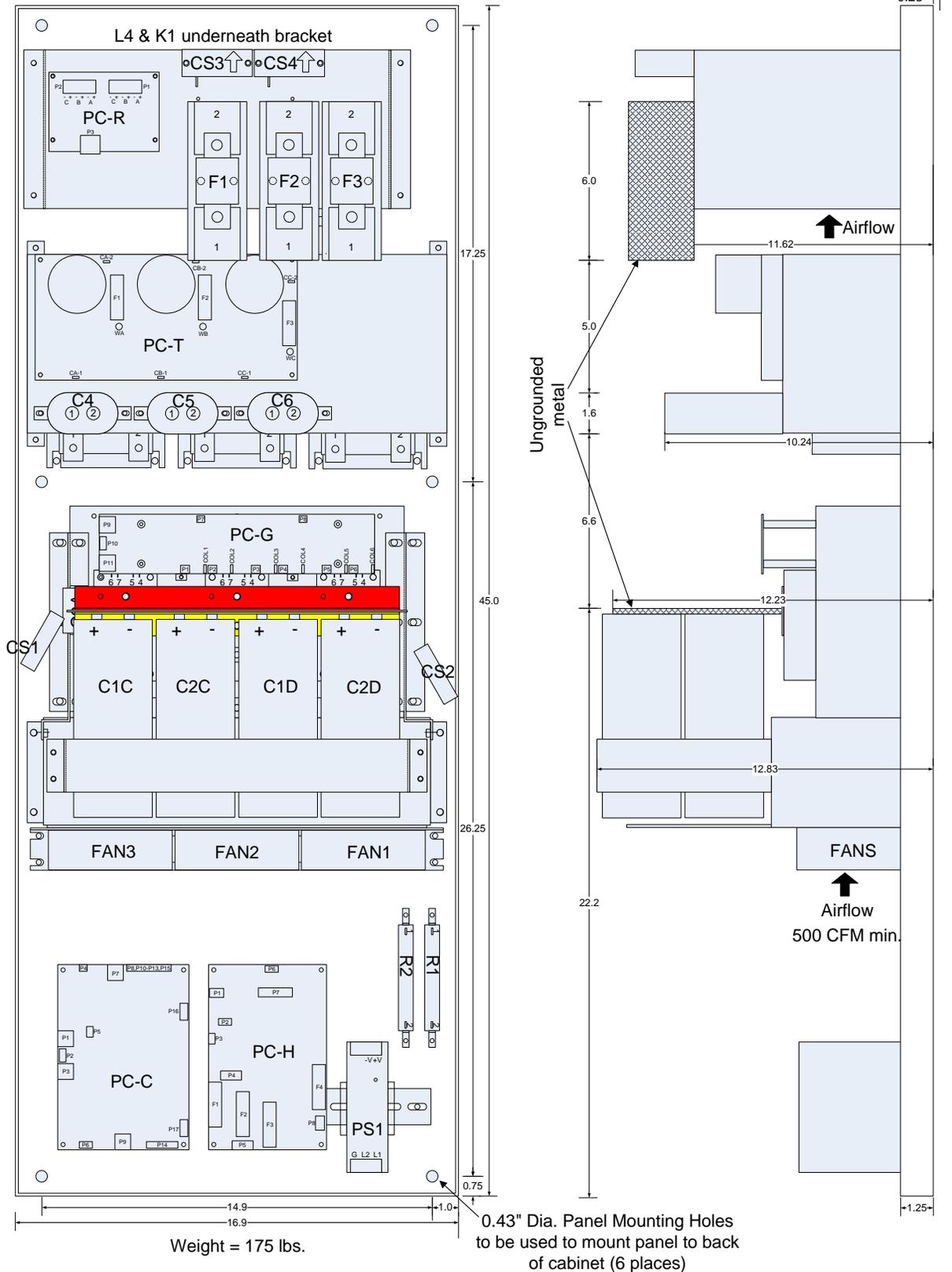


Figure 10.2: 100 Amp AHF Panel Layout Drawings

Fasteners holding components to panel may protrude out the back of the panel as much as 0.23"; therefore, spacers having at least 0.25" thickness will probably be needed between back of panel and surface that panel is mounted to.

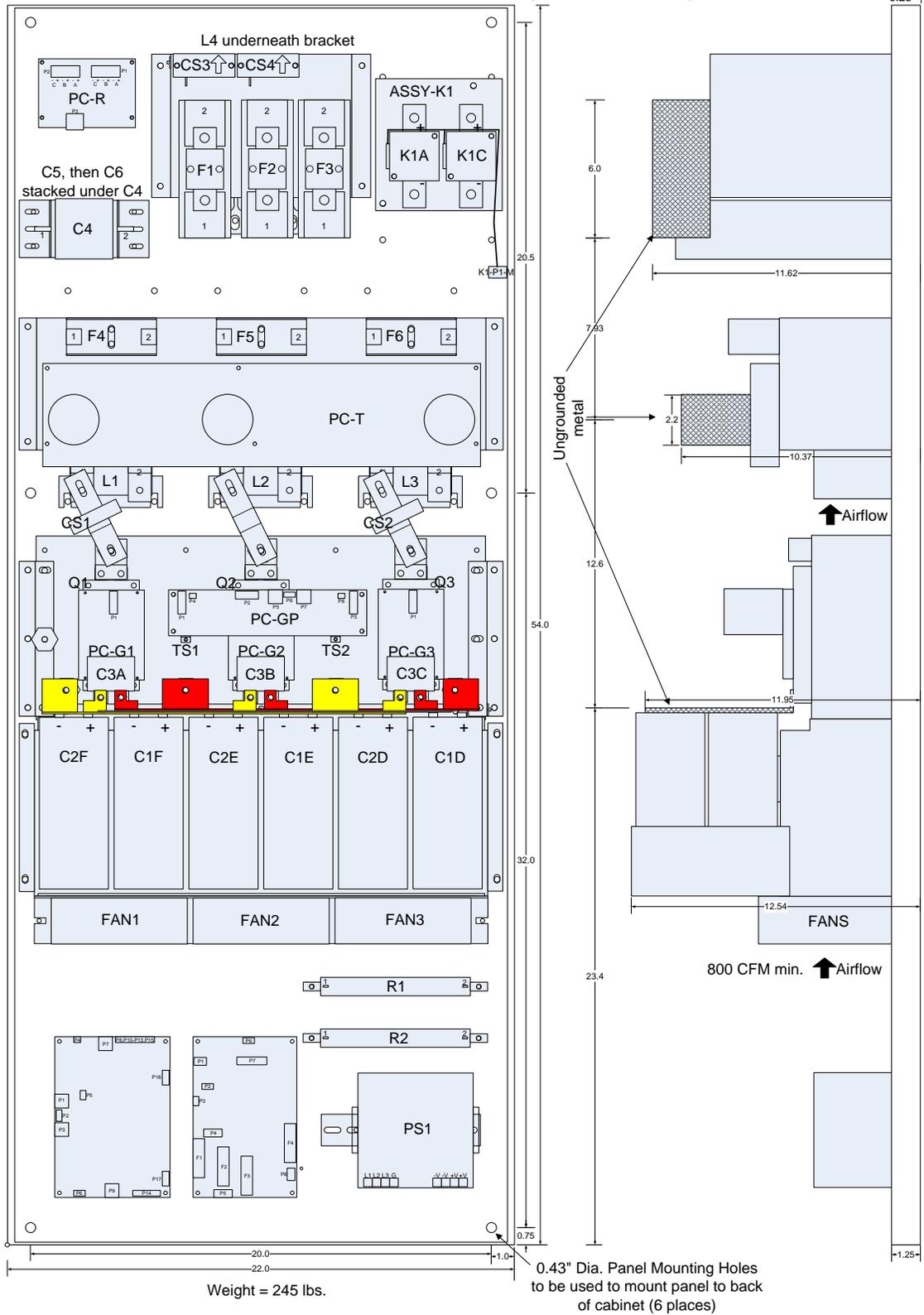


Figure 10.3: 150 Amp AHF Panel Layout Drawings

Fasteners holding components to panel may protrude out the back of the panel as much as 0.23"; therefore, spacers having at least 0.25" thickness will probably be needed between back of panel and surface that panel is mounted to.

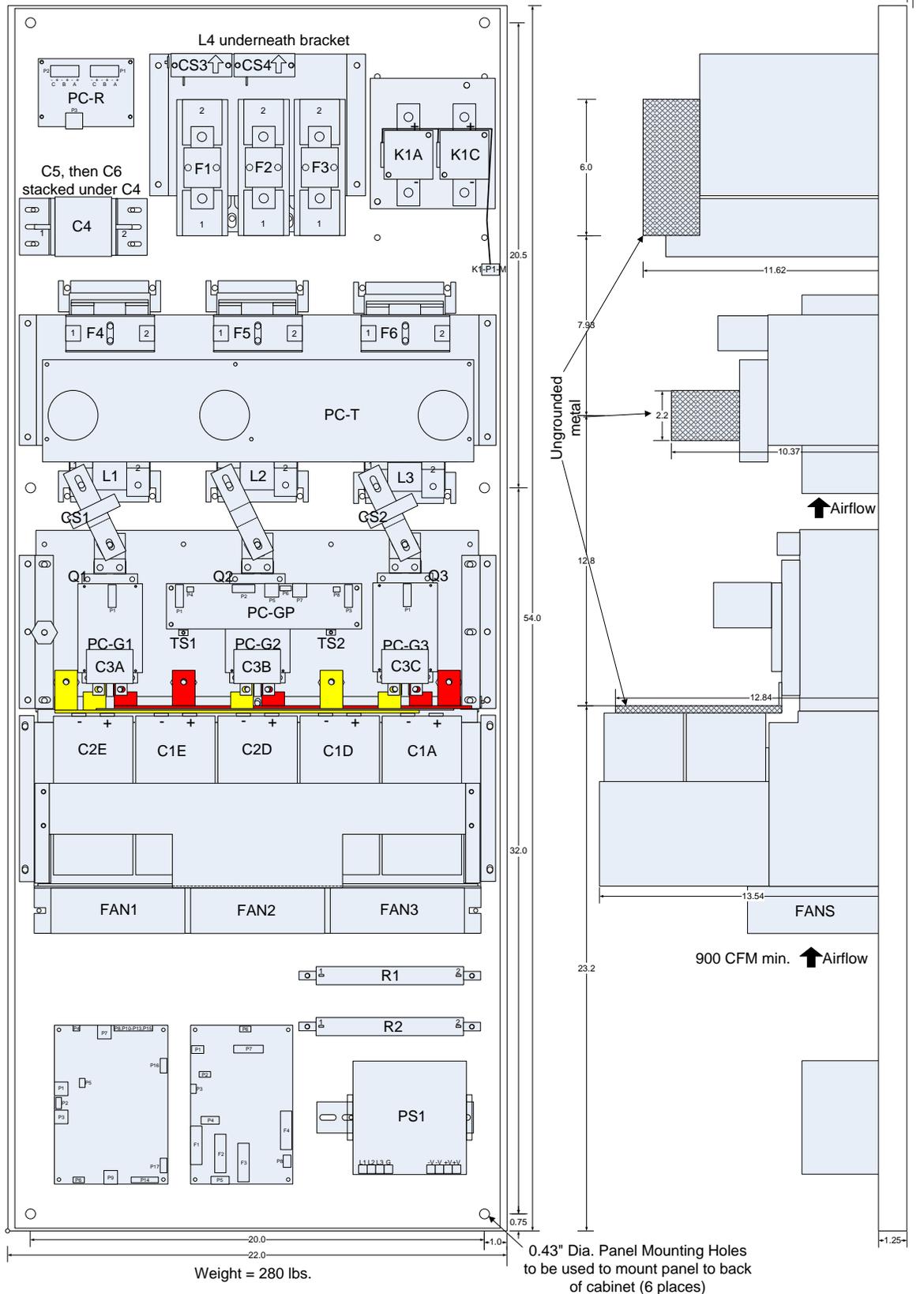
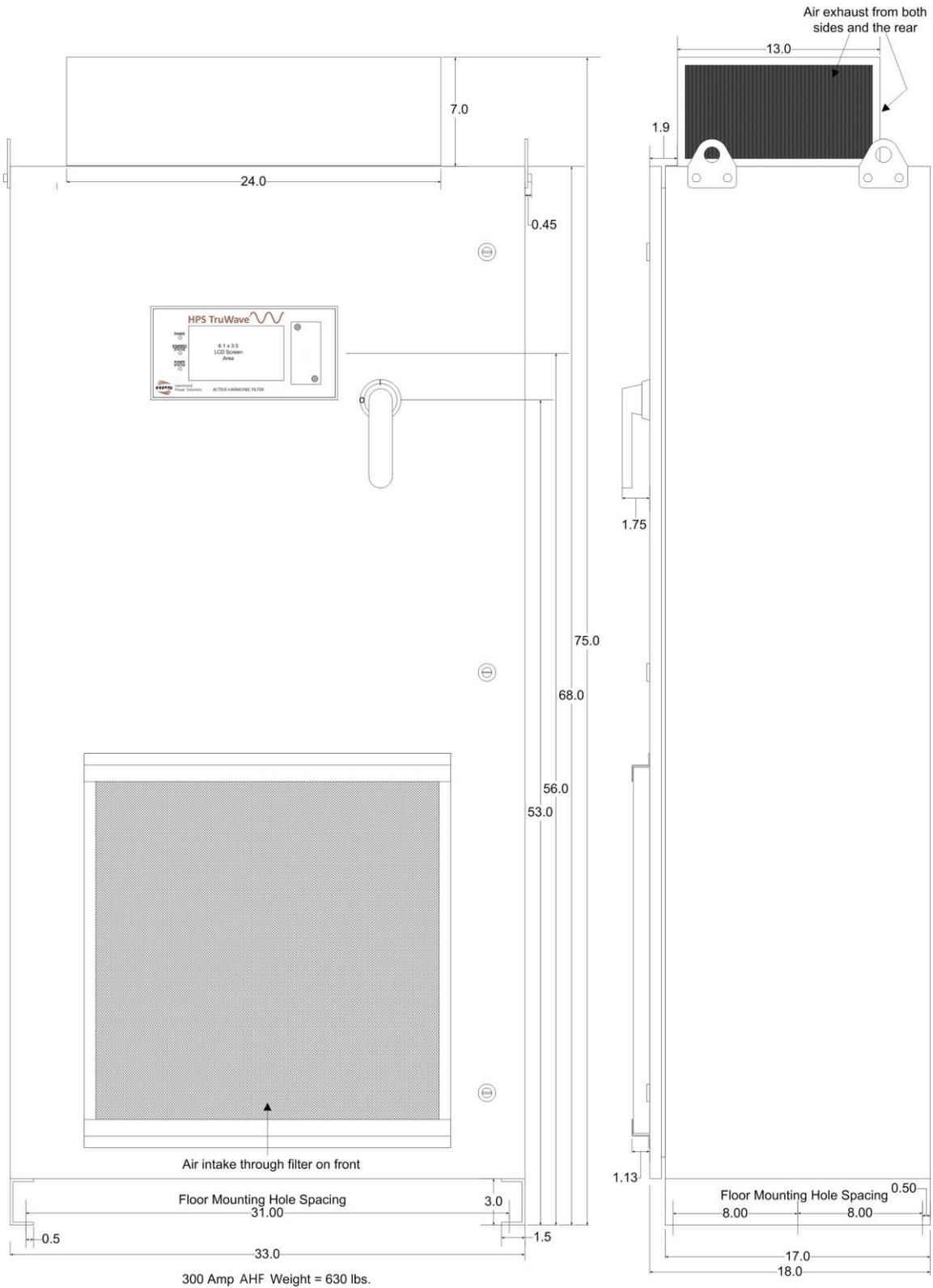


Figure 10.4: 200 Amp AHF Panel Layout Drawings









**Figure 10.8: 300 Amp Type 1 Enclosed AHF Drawings**

## **11. WARRANTY/SERVICE AND REPAIR**

### **◀LIMITED WARRANTY POLICY▶**

HPS warrants its Active Harmonic Filter (AHF) to be free from defects in materials and workmanship for a period of 18 months from the date of original shipment from the factory or 12 months from the verified date of startup, whichever comes first, provided the AHF has not been abused, misused, or used outside of the specified conditions. HPS will be the sole determiner as to whether the unit has been abused or misused. If found to be defective, the unit will be repaired or replaced at the discretion of HPS. Unless specified by contract, warranty service can only be obtained by returning the equipment to the HPS facility.

Before returning any unit, in or out of warranty, to HPS, purchaser must contact HPS's Customer Service Department. Any UNAUTHORIZED return of a unit to HPS for in-warranty or out-of-warranty repairs will be subject to an inspection and handling charge, in addition to all associated repair and transportation costs. HPS will be in no way responsible for any consequential damages of any kind or nature whatsoever resulting from the use of its unit in any manner whatsoever and/or from the breach of any warranty, express or implied.



Hammond  
Power Solutions

**CANADA**

595 Southgate Drive  
Guelph, Ontario N1G 3W6  
Tel: (519) 822-2441  
Fax: (519) 822-9701  
Toll Free: 1-888-798-8882  
[sales@hammondpowersolutions.com](mailto:sales@hammondpowersolutions.com)

**UNITED STATES**

1100 Lake Street  
Baraboo, Wisconsin 53913-2866  
Tel: (608) 356-3921  
Fax: (608) 355-7623  
Toll Free: 1-866-705-4684  
[sales@hammondpowersolutions.com](mailto:sales@hammondpowersolutions.com)

[www.hammondpowersolutions.com](http://www.hammondpowersolutions.com)