SAGE 1X50 Operation & Maintenance Manual

S1X50-AAA-00001 V1.1

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SAGE 1X50 Operation & Maintenance Manual

For Reference Only

Manual No. S1X50-AAA-00001

Document Approval

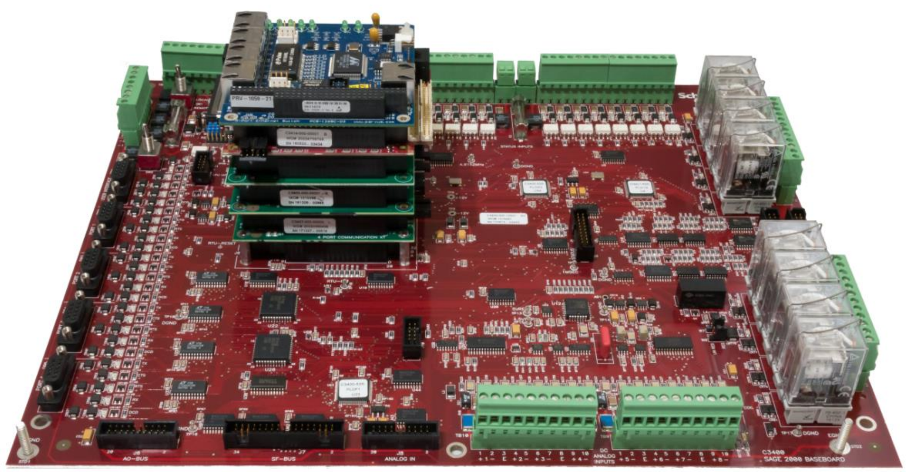
Rev	Date	Description	ECO #	Technical Review	Admin. Approval
0.0	09-19-11	Initial Release	N/A		
1.0	12-08-14	Schneider Electric Template		Chris Kerr	
1.1	08-10-18	Added California Prop 65 Warning		Chris Kerr	
					Chris Kerr Offer Manager - SAGE

SAGE RTU Product Line
California Proposition 65

Version : 1.0
Date : 09-Aug-2018

Identification

Product name:	SAGE RTU Product Line
References involved:	C3400 (SAGE 2400), C3800 (3030 M), C3700 (SAGE 1410), C3500 (SAGE 1430), C3600 (SAGE 1450), C3810 (LANDAC II), C3812 (SAGE 4400), C3414, C3132, C3133, C3140, C3230, C3231, C3232, C3233, C3235, C3241, C3243, C3244, C3247, C3248, C3263, C3320, C3321, C3322, C3330, C3360, C3429, C3430, C3432, C3437, C3438, C3476, C3831, C3835, C3861, C3439, C3442, C3443, C3444, C3445, C3446, C3447, C3448, C3449, C3450, C3451, C3452, C3453, C3454, C3455, C3456, C3457, C3459, C3460, C3462, C3464, C3465, C3466, C3467, C3468, C3469, C3470, C3471, C3472, C3473, C3474, C3475, C3477, C3478, C3479, C3480, C3481, C3482, C3484, C3485, C3486, C3487, C3488, C3489, C3490, C3491, C3492, C3493, C3494, C3495, C3530, C3532, C3534, C3550, C3551, C3552
Country - State	USA - California



California Proposition 65 Warning Statement for California Residents

WARNING: This product can expose you to chemicals including Lead, which is known to the State of California to cause cancer and birth defects or other reproductive harm. For more information go to www.P65Warnings.ca.gov

Details of the supplier:

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1 Introduction

Warning: The applications Energy Calculation, Timing, and the ACI function all use the same BB ram memory space; therefore only one of these applications may be run at any given time.

Throughout this manual, the term SAGE 1X50 refers to the SAGE 1250, the SAGE 1350 and the SAGE 1450 collectively.

This user manual describes the operation and maintenance of the SAGE 1X50 Remote Terminal Unit (RTU). It provides the detailed technical information necessary for installation, operation, setup, and maintenance of the SAGE 1X50.

The Theory of Operation chapter should be used in conjunction with the Drawings appendix which contains complete schematics and printed circuit assembly drawings. The drawings also include bills of material for those users wishing to perform component level repair of failed assemblies.

The SAGE 1X50 Remote Terminal Unit (RTU) is specifically designed to satisfy electric utility industry Distribution Automation project requirements for a compact, cost-effective RTU. The SAGE 1X50 RTU permits the integration of both Intelligent Electronic Devices and standard electric utility field devices into a real-time Supervisory Control And Data Acquisition (SCADA) system.

The SAGE 1X50 is a self-contained transducerless RTU. ACI inputs may be connected directly from CTs and PTs or Line Post sensors. This type of measurement maintains the phase relationship of the signals, allowing accurate phasor and power factor measurements, fault detection and direction.

The SAGE 1X50 contains a microprocessor, a Digital Signal Processor (DSP), and a high speed AC analog input subsystem that monitors current and voltage for all three phases simultaneously. In addition the SAGE 1X50 contains four Select Before Operate (SBO) control points, 8 status inputs and 2 dedicated DC analog inputs. Communications are handled by four RS-232C communications ports and one RS-232C User Interface port.

The unit may be expanded by including up to eight additional communications ports, a GPS receiver for 1 millisecond time-tag operation and an option for IRIG-B input.

1.1 Features

The SAGE 1X50 uses the latest electronic technology for reliability, speed and maintainability. The design includes several state-of-the-art functional capabilities. For example, the AC Input (ACI) option provides an advanced transducer-less AC analog input capability.

The SAGE 1X50 has the following new features:

- Easy-to-use Graphical User Interface (GUI) via Microsoft Internet Explorer or Chrome
- Embedded web server
- Built-in Ethernet with TCP/IP
- May be configured either locally or remotely
- Point naming (no more counting point numbers to find your point of interest!)
- Point mapping with simple click and drop
- Data concentration – adds data from multiple IEDs to one database for fast polling
- Protocol conversion – convert multiple protocols to a standard protocol
- Built on a widely adopted Real-Time Operating system (RTOS)
- Employs standard PC/104 bus interface for CPU and Communication upgrades
- Relay Ladder Logic capability that supports all five IEC 61131-3 Languages

- Provides Upgrade path for SAGE 1150 products

1.2 ACI Interface Options

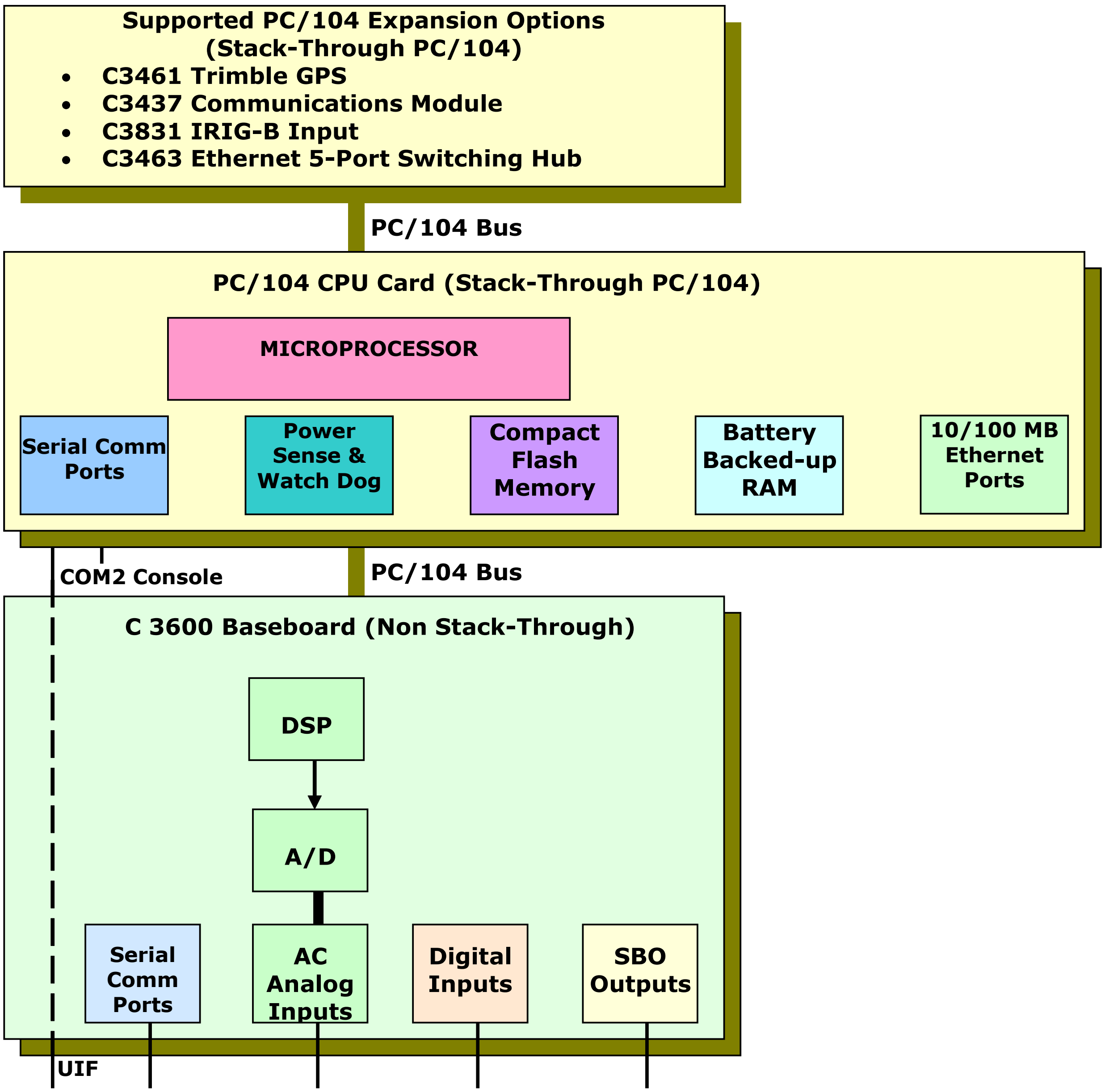
The SAGE 1X50 can be used for interfacing to conventional PTs and CTs as well as standard current/voltage linepost sensors such as the Square D LSCV Line Post Sensors or Lindsey CVMI linepost sensors. These terminations include custom instrument-grade transformers, designed for high linearity and ultra low phase shift, which provide the high impedance inputs required for the linepost sensor resistor divider voltage outputs.

1.3 Architecture

Figure 1-1 shows a simplified block diagram of the SAGE 1X50 Baseboard, which illustrates its general architecture and major components. The basic SAGE 1X50 consists of a Baseboard and a microprocessor daughter board. Terminal block connections are provided for all external I/O lines.

Additionally, the open architecture of the PC/104 interface provides for expanded functions. You may add a PC/104 GPS receiver and/or C3437/C3438 Communication cards that allow up to eight additional Communication ports.

Figure 1-1 SAGE 1X50 Simplified Block Diagram



1.4 Graphical User Interface (GUI)

The SAGE 1X50 is easily configured using the standard web browser, Internet Explorer version 6.0 or later, or Google Chrome. The physical connection may be made in one of four ways:

- Ethernet connection using an Ethernet crossover cable directly to the CPU card

- Ethernet connection to a network , locally or remotely
- PPP connection using a null-modem cable to the UIF port
- Console – this method commonly used to read and/or change IP address

See Appendix D and E in the config@WEB Software Users Guide for details on connections.

The GUI is designed around the classical client/server model. A web browser is all you need for your client (PC) and you can browse any RTU product or any version of that product that supports our web interface. All configuration data is stored on the RTU in the form of Extensible Markup Language (XML). XML data is served up to the browser within HTML pages or transformed into HTML via Extensible Stylesheet Language (XSL). In either case data is presented to the user in an intuitive format using common design elements like forms, Radio Buttons, Spin Boxes, Alert Boxes, etc. for much of the data entry.

The GUI supports the transfer of files to/from the RTU and the client. The file types include RTU applications, Web pages, Configuration files, and the operating system. In short, every file within one RTU can be transferred to another RTU or parts of the RTU file system can be upgraded as needed. This provides a powerful means of performing firmware upgrades or configuration changes. Please see the config@WEB Software Users Guide for details.

General Operational Considerations

Note: See the config@WEB Software Users Guide for initial IP address.

1.5 Point Mapping

The RTUs of today must interface to a wide Varity of I/O and industry standard IEDs. This creates within the RTU a large database of points that have been acquired by the RTU that must be transferred to one or more master stations.

The SAGE 1X50 GUI supports an intuitive drag and drop point mapping scheme. Each point within the RTU is named and scaled with user definable names and values. Scaling is used for local data display as well as protocol count scaling for conversion of data from one protocol to another.

1.6 Communications

The SAGE 1X50 supports a large suite of communication protocols over many different types of communications media. Ethernet and RS232 come as standard hardware. However, installation of media converters allow for just about any physical communications media to be supported.

The UIF is a dedicated RS-232 port that supports Point to Point Protocol (PPP). This port can be used for initial setup, local maintenance and configuration updates. However, it is commonly used only to configure the IP address of the Ethernet port. Once the Ethernet port is set up the UIF port will run concurrently on the RS-232 port and the Ethernet port.

All SAGE RTU products support multiple RTU and IED protocols. This allows for data to be mapped from IEDs to multiple masters via different RTU protocols. Example: If you were replacing your current master station software that talks Series V protocol with a system that supports DNP your RTU could talk to both the old master and the new master at the same time. This provides an excellent means of replacing legacy RTU/MTU equipment without interruption to data acquisition.

An emerging need for RTU products is SCADA protocols to communicate over Ethernet all the way down to the RTU. The SAGE 1X50 supports DNP3 and Modbus over Ethernet.

1.7 Relay Ladder Logic (RLL)

The SAGE 1X50 supports a RLL Runtime Target that accepts applications that can be developed using any one of the five IEC 61131-3 languages plus flow Charting. Programs are developed on an application workbench that runs only on the client. Fully developed/debugged programs can be downloaded into the SAGE 1X50 and activated for execution.

RLL applications have access to all the data within the RTU and make use of the powerful mapping capabilities of the GUI. Output data from RLL applications can be viewed in real time data displays.

1.8 Analog Subsystem

AC Analog Inputs

The AC analog subsystem provides six AC analog inputs which are typically configured as three voltage/current pairs for monitoring a 3-phase circuit. The DSP samples each analog input at 960 Hz and calculates the fundamental frequency phasors and true RMS quantities representing the fundamental and harmonic content to 480 Hz. These values are used to detect over-current and to compute real and reactive power.

DC Analog Inputs

Two analog inputs are configured as internal points reading the input voltage (10-35VDC) supplied to the RTU along with the RTU's Battery voltage.

1.8.1 Reported Values

The measured and calculated quantities provided by the AC analog subsystem include:

- Phase voltage, phase current, and neutral current (fundamental and true RMS)
- Fault current (up to 20x nominal full scale)
- VA, Watts, VARS, bidirectional WH and VARH both total and each phase
- Power factor
- Calculated harmonic components (2nd through 7th)
- Voltage quality data (Sag/Swell)
- Frequency

1.8.2 Accuracy

The AC analog subsystem was designed for a high degree of accuracy over the operating environmental range. This accuracy was achieved through an innovative subsystem design, the utilization of tight tolerance components, and instrument grade magnetics. The overall accuracy is:

Current Channels:

±0.25% FS, 0-150% nominal full scale input
±5.0% FS, 150-2000% nominal full scale input

Voltage Channels:

±0.25% FS, 0-125% nominal full scale input

1.9 Digital Inputs (DI)

The SAGE 1X50 accepts digital inputs representing either field status inputs or accumulator inputs. Status inputs can be monitored as ordinary on-off devices and can include 1 msec resolution Sequence Of Events (SOE) monitoring. Ordinary status inputs are monitored as contact closures. These inputs are optically isolated and debounced before being processed.

1.10 Select Before Operate Outputs (SBO)

As the name indicates, SBO outputs are activated by using a two step select/execute process. Only one SBO output may be active at a time. SBOs are utilized when it is necessary to provide sequential and/or critical control operations one step at a time. SBO outputs are activated by the Master Station using a two step select/execute process.

2 Specifications

2.1 User Computer Requirement

OPERATING SYSTEM	Windows XP and later with Internet Explorer Version 6 or above. Google Chrome can also be used. If using XML to Excel macro, Microsoft Office 2003 or above.

2.2 Environmental

TEMPERATURE	-40°C to +85°C
RELATIVE HUMIDITY	5% to 95% non condensing
TRANSIENT PROTECTION	All user field connections designed to pass IEEE 472 - 1974 ANSI C37.90 - 1979 (R1982) ANSI C37.90.1 - 1989

2.3 Digital Signal Processor (DSP)

DSP	Analog Devices Series 2185
ADC	80 Khz, 12 bit sampling
SAMPLING	Crystal controlled sampling clock 16 channels of solid state multiplexing

2.4 AC Analog Inputs

NUMBER OF 3Ø INPUTS	Designed to monitor all three phases of one feeder line with 3 built-in PTs & 3 built-in CTs
INPUT TYPES	Current/voltage Linepost Sensor or CT/ PT (transformer isolated)
INPUT RANGES	All popular Linepost Sensors supported CT: 0 - 5, 0 - 2.5, 0 - 1 A RMS PT: 0 - 69, 0 - 120 V RMS
FREQUENCY	50/60 Hz software selectable
RESOLUTION	12 bits (11 bits + sign)
OVERALL ACCURACY	CT or current sensor: ±0.25% FS, 0 - 150% nominal FS input ±5.0% FS, 150 - 2000% nominal FS input PT or voltage sensor: ±0.25% FS, 0 - 125% nominal FS input
BURDEN	CT: 0.0004 VA@ 5A PT: 0.012 VA@ 120VAC, 0.012 VA@ 69VAC
RESISTIVE IMPEDANCE	399Kohms for 69VAC, 1.2MegaOhm for 120VAC
CALCULATION RATE	all calculated values updated once per cycle; fault detection performed once per cycle.
CONVERSION RATE	Current and Voltage Inputs sampled 96 times per cycle, then filtered and down sampled to an effective sample rate of 16 times per cycle
INPUT RESISTANCE	CT: less than 0.1 VA burden PT: greater than 1000MegaOhm

	current sensor: greater than 1000MegaOhm voltage sensor: greater than 1000MegaOhm (Optional 1MegaOhm)

2.5 Terminations

BASEBOARD	Phoenix Removable Connectors
CT	Primary: unbroken wire loop through a toroidal transformer Secondary: Number 10 studs with nuts
PT	Number 10 studs with nuts

2.6 DC Analog Inputs

INPUT POINTS	6, internal fixed: Ground Reference +2.5V Reference -2.5V Reference Temperature (F or C) Battery Voltage DC Input Voltage

2.7 Digital Inputs

ISOLATION	Optically isolated, 1500VDC
LOOP VOLTAGES	12, 24, 48 and 129VDC
DEBOUNCE	20 msec nominal
CONFIGURATION	2 terminals per point (+ and -)
INPUT POINTS	8
TIMING	1 msec time tagged
POWER	Baseboard or external excitation
INDICATORS	One LED per point

2.8 SBO Control Outputs

DURATION	Software programmable in 5 msec increments
CONTACT FORM	1 Form A (one side common on each two relays)
CONTACT RATINGS	30 VDC @ 2A 120 VAC @ 0.6A 129 VDC @ 500 MA
CONTROL POINTS	4 (from 8 relays)

2.9 CPU/Memory

NOTE: Please refer to CPU Manual for CPU specifications.

2.10 Communications

NUMBER OF RS-232C PORTS	1 Console, 1 PPP User Interface, 4 Communications ports on baseboard, up to 8 additional ports with optional C3437 PC/104 cards and C3438 Comm Expansion card
SPEEDS	300-9600 bps
PROTOCOLS	Synchronous and asynchronous
ETHERNET	One built-in 10/100BASE-T (RJ45) auto-negotiate (will adjust to the speed and half/full duplex of the connecting device)

2.11 C3463 PCA Ethernet 10/100 5-Port Switching Hub (Optional)

ETHERNET	Five built-in 10/100BASE-T (RJ45) auto-negotiate (will adjust to the speed and half/full duplex of the connecting device)

2.12 Power Requirements

INPUT VOLTAGE	10 to 33VDC required by the Baseboard
OPTIONAL POWER SOURCES	120VAC, 240VAC, 48VDC, 129VDC with added supply
INPUT POWER	7.2W typ. for 10V to 33V for baseboard (excluding relays)
INPUT/ OUTPUT ISOLATION	500 VDC
BATTERY CHARGER	Built in constant current charger supporting low voltage disconnect

2.13 Visual Indicators

BASEBOARD LEDs	DC Power present LED Digital Input Power LED Battery Connected LED 5 LEDs per Comm port (DCD, RX, RTS, TX, CTS) Status Inputs LEDs (1 per input) Relays (1 per coil and the execute line)
PC/104 CPU LEDs	Please refer to the CPU Manual

3 Installation

This chapter describes the normal installation and operation procedures for the SAGE 1X50 RTU. The actual location of the various components of the RTU (i.e., the Baseboard assembly and any special hardware) will vary somewhat depending on a number of factors, including the types of enclosures selected, the particular mix and quantity of inputs/outputs, expansion requirements, etc.

Prior to moving the RTU assembly to the installation site, it is recommended that a preliminary functional test be performed to verify that the configuration is correct for the intended site and also to check for any undetected shipping damage. Preliminary testing should be performed after the RTU has been setup using the information in the Software Users Guide, Chapter 2.

The following discussions will be generally applicable to all SAGE 1X50s.

3.1 General Installation Procedure

Some site preparation may be necessary before the RTU can be installed. The majority of RTUs are housed in NEMA 4 wall mount enclosures. This common enclosure is rust resistant to specified environmental conditions, but is not rustproof. As a result, the NEMA 4 should not be selected for use in harsh salt or corrosive chemical environments.

The actual layout is subject to significant variation, depending on project requirements. Refer to your project assembly drawings for layout and input assignments. The procedures for connecting field wiring to the RTU are provided in the following sections.

In preparing the installation site, some consideration should be given to the supporting structures. As a guideline, a SAGE 1X50 in an aluminum 20.5-in. x 17.75-in. x 8.27-in. wall mount enclosure weighs approximately 45 lbs.

Mount the enclosure to the wall or pole where it is to be located. The four upper and lower flanges have 0.31-inch diameter holes (large enough for 1/4-inch bolts).

The next step in installation is the connection of the field wiring. Cutouts in the enclosures for field wiring are provided according to project requirements. Where a top or bottom cutout has been specified, cover plates with gaskets are provided. These can be unscrewed and prepared for conduit entries as required.

The exact termination points for the field wiring can be determined from the assembly drawings furnished with the RTU, but there are some general rules which apply to most assemblies. Figure 3-1 and Figure 3-2 show the standard enclosures for typical SAGE 1X50 Configurations (CT/PT and Line Post Sensors).

Figure 3-1 SAGE 1X50 with CT/PT Configuration in Standard Enclosure

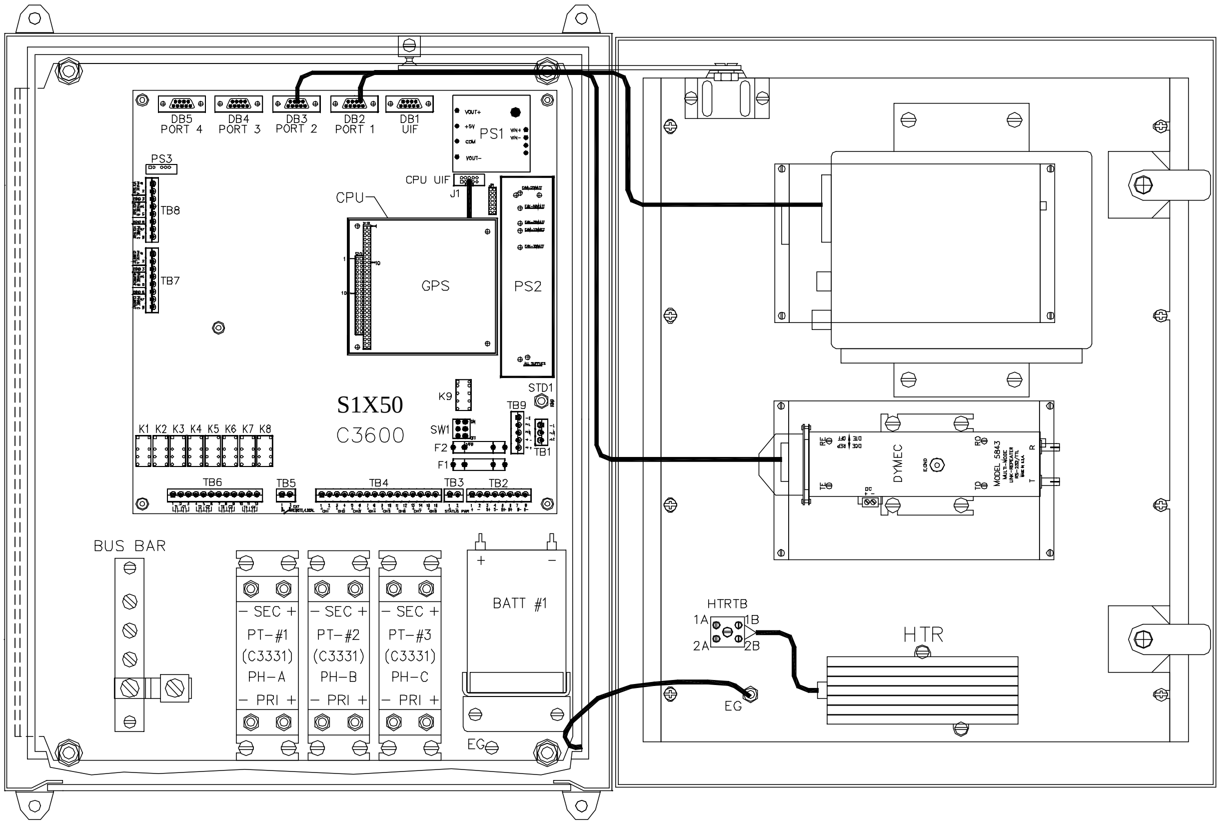
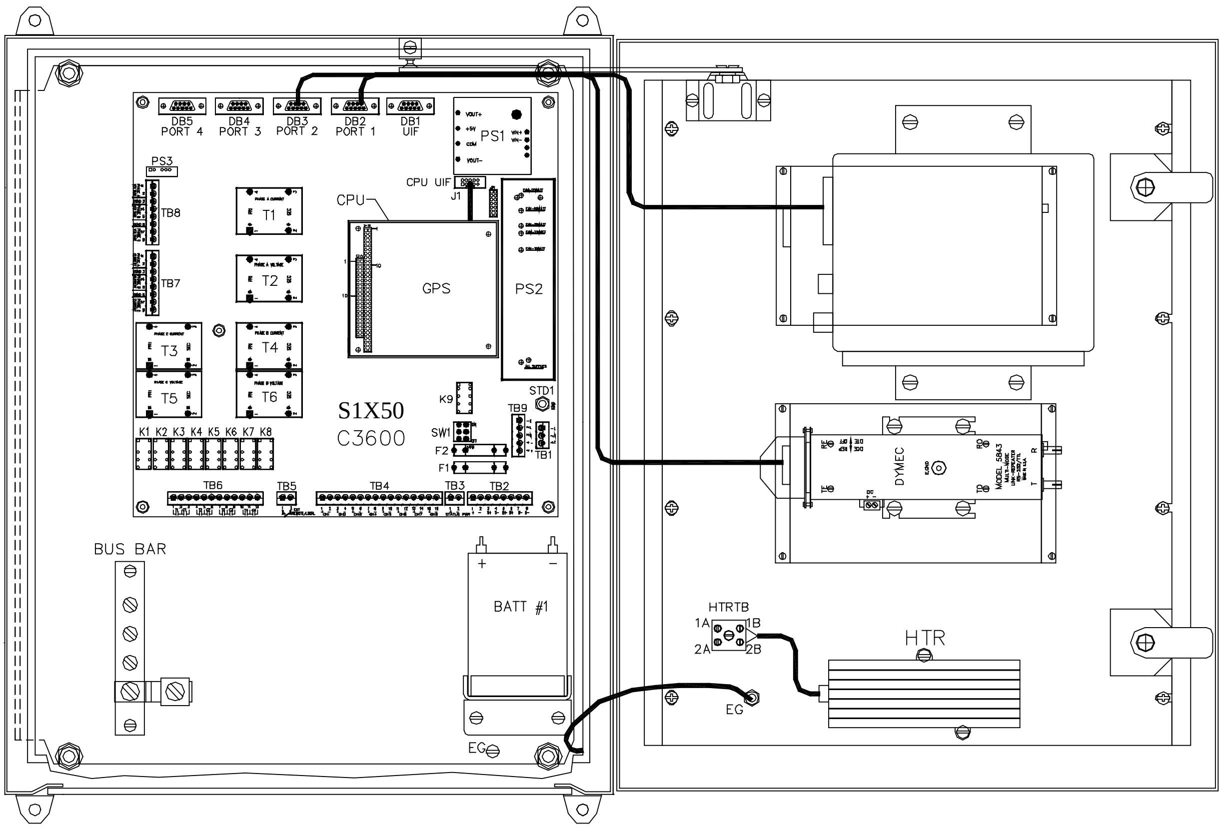


Figure 3-2 SAGE 1X50 with LPS Configuration in Standard Enclosure



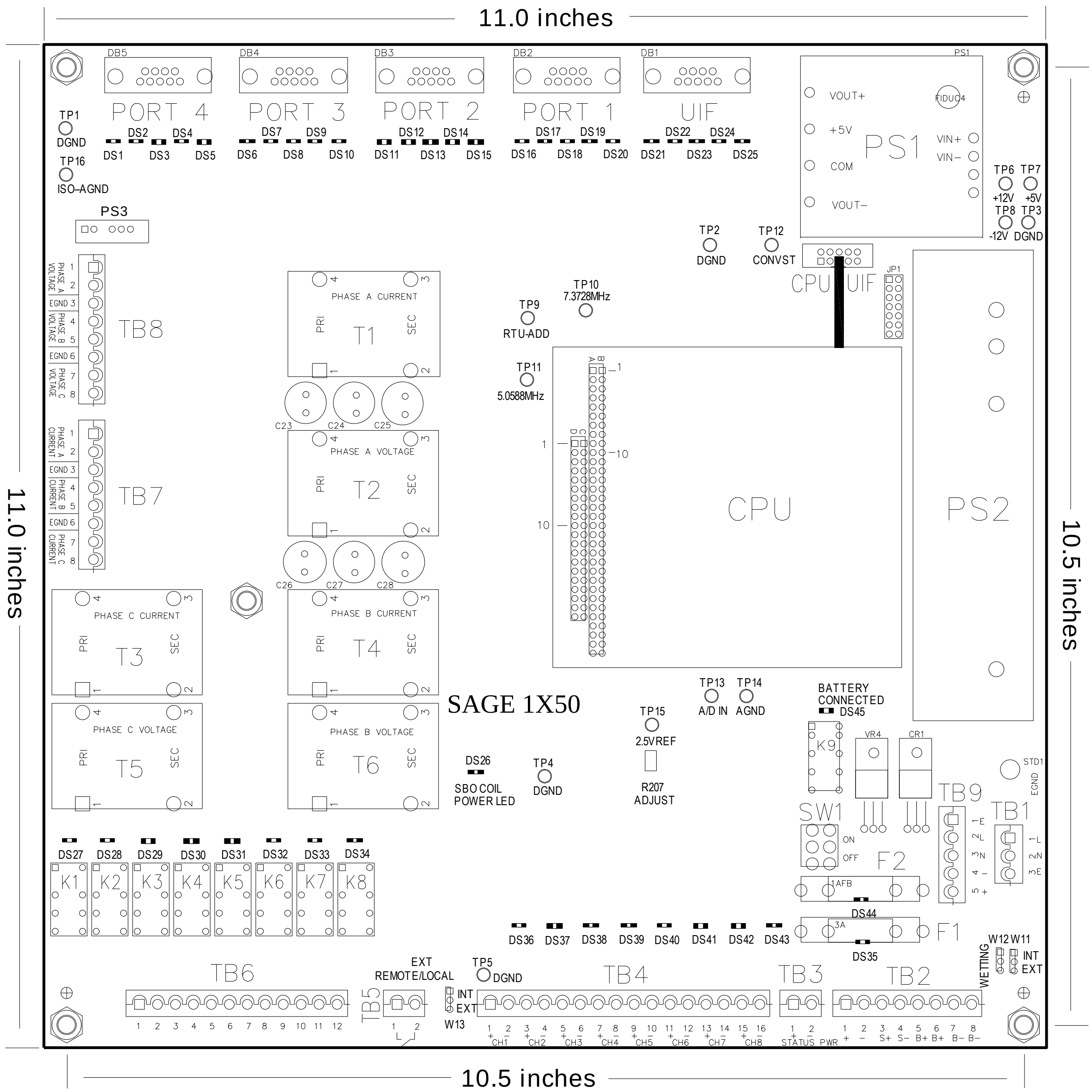
Typically a radio or modem may be mounted on the inside door of the enclosure. Batteries are typically mounted at the bottom of the box, with a DIN rail for barrier connectors running across the side. In this example, a heater is mounted across the bottom of the door.

The actual layout is subject to significant variation, depending on project requirements. Refer to your project assembly drawings for layout and input assignments. The procedures for connecting field wiring to the RTU are provided in the following sections.

Figure 3-3 shows the SAGE 1X50 board mounting dimensions.

Caution: The printed circuit assemblies contain CMOS devices and are sensitive to static discharge. Boards should be handled only at a grounded workstation. Avoid touching the electronic components, jumpers, connectors, or the exposed etches on the boards when connecting the field wiring.

Figure 3-3 SAGE 1X50 Baseboard



3.2 Power Terminations

Field input power will vary according to project requirements. The assembly also includes circuit protection devices for the field power. In most configurations, however, field power is connected directly to the Baseboard.

The Baseboard (Figure 3-3) runs on +10 to +33VDC. If the field input power is the AC line or a DC source other than +10 to +33VDC, the SAGE 1X50 baseboard can include, as an option, either a 120VAC, 240VAC, 48VDC, or 129VDC power supply. In this case, the optional power supply will be pre-wired and attached to the Baseboard. Refer to your RTU assembly drawing for the input power terminal assignments. It will be clear from the drawing where to hook up the hot and neutral or the field+ and field-, and chassis ground.

If the RTU is being directly powered from a +10 to +33VDC source with no switch or circuit protection device between the source and Baseboard, the input power must be connected to terminal strip TB2 on the Baseboard (see Figure 3-4). Make sure the input power is de-energized and then connect +10 to +33VDC to terminal 1 and the DC return to terminal 2.

Figure 3-4 Baseboard Power

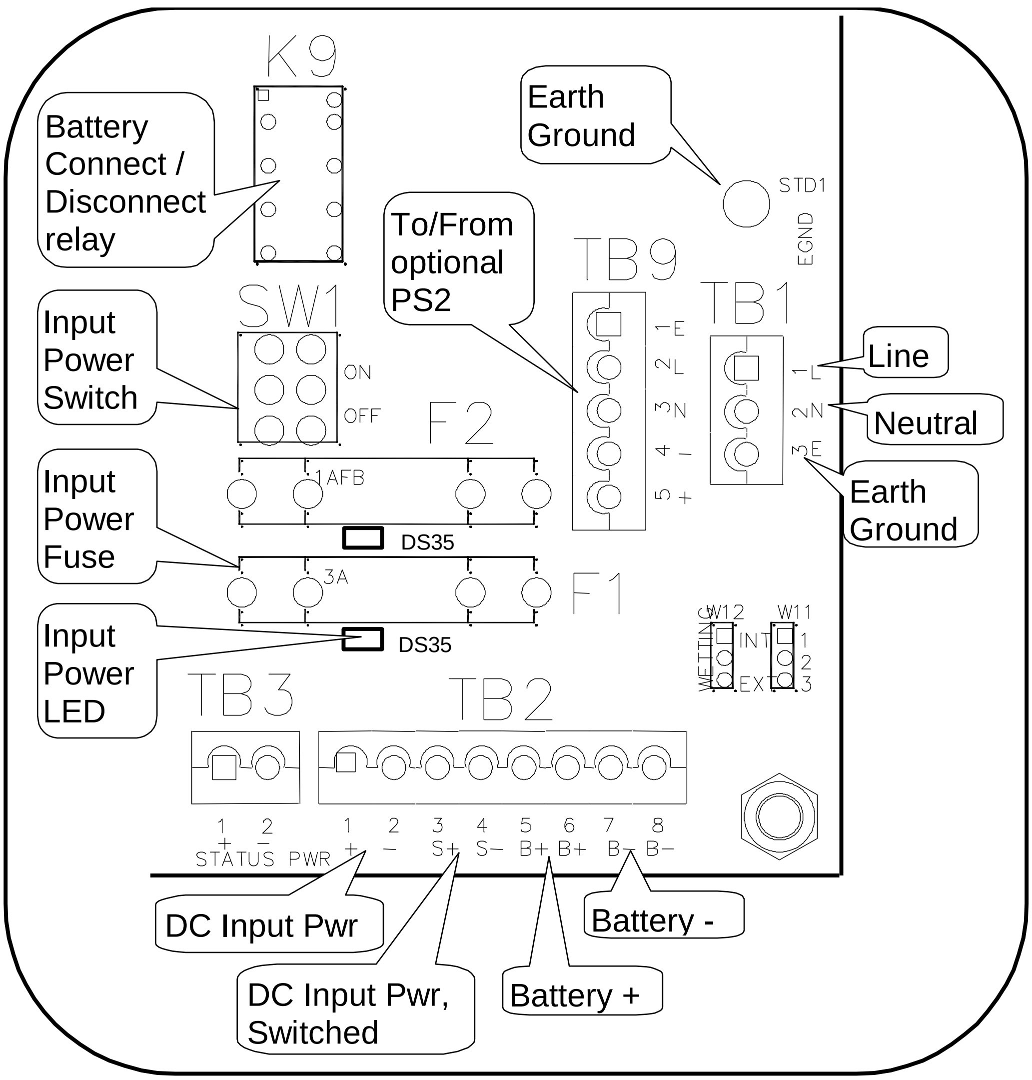


Figure 3-5 10-33 VDC (Any Variance)

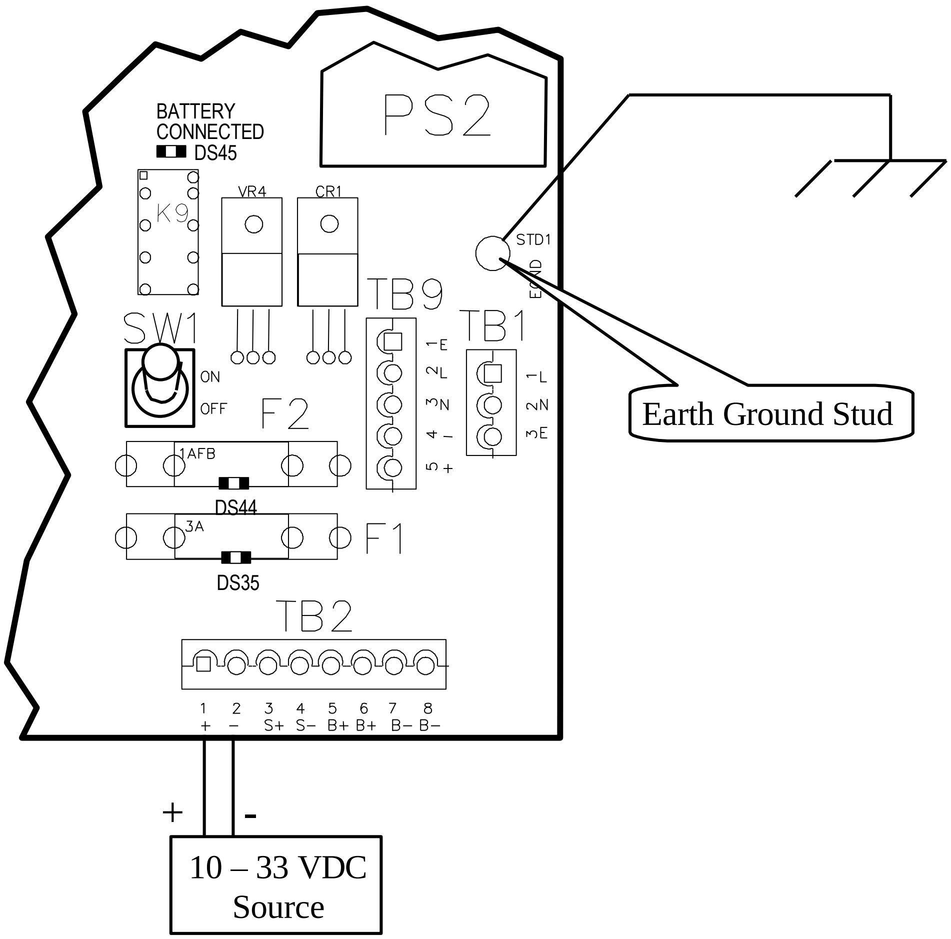


Figure 3-6 40-56 VDC (Variance: C3600-X6X)

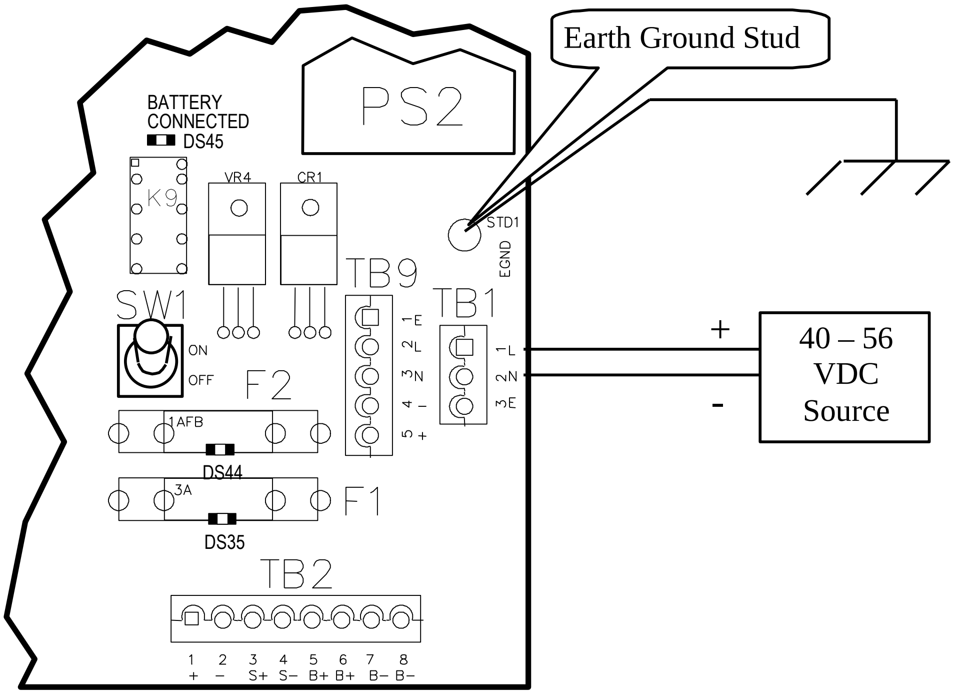


Figure 3-7 110-170 VDC (Variance: C3600- X1X, X2X, X3X)

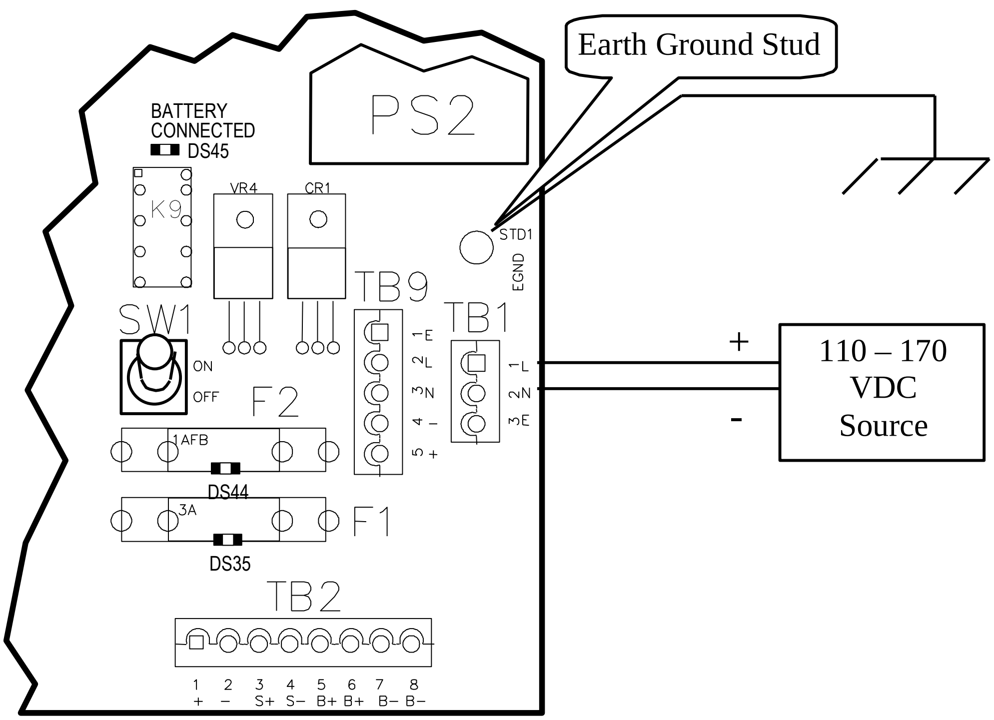


Figure 3-8 105-370 VDC (Variance: C3600- X4X, X5X)

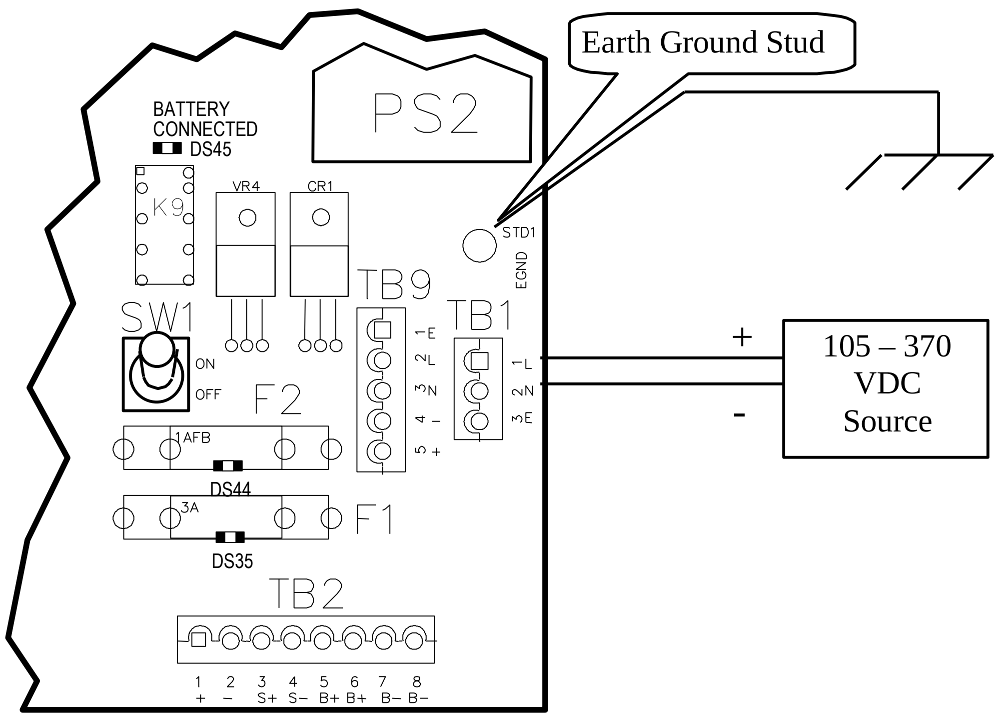


Figure 3-9 85-132 VAC (Variance: C3600- X1X, X2X, X3X) W/ Battery Backup

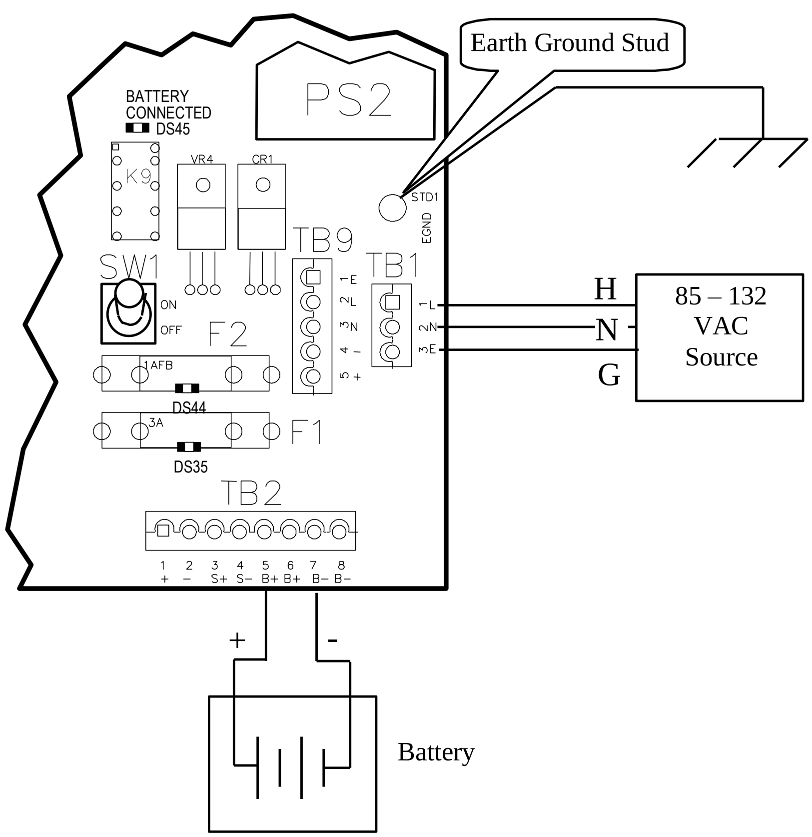
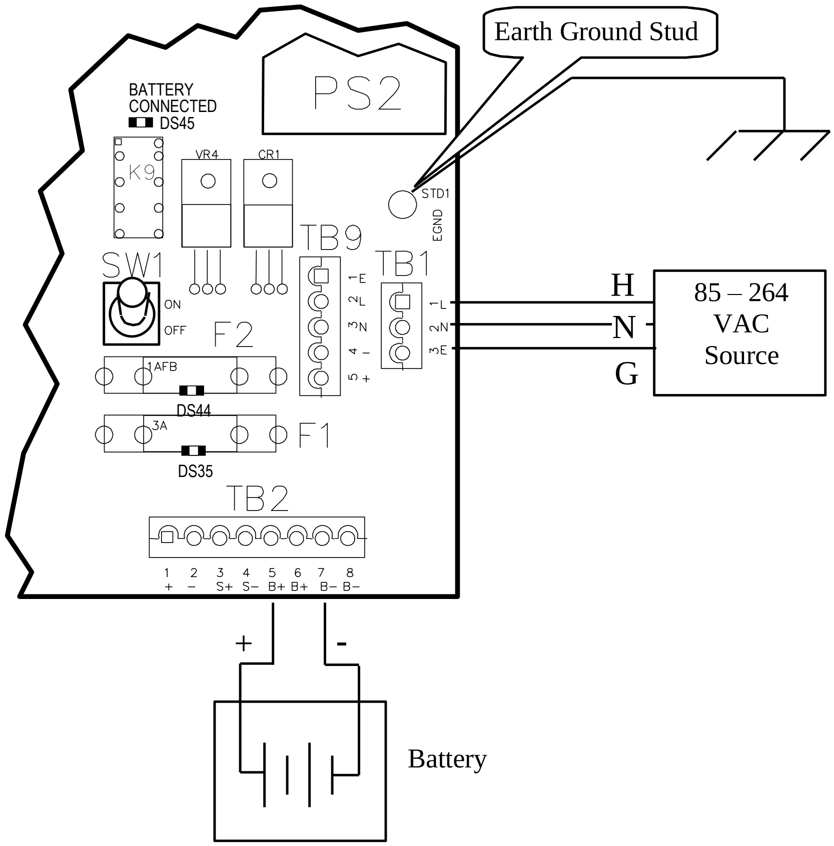


Figure 3-10 85-264 VAC (Variance: C3600- X4X, X5X) With Battery Backup



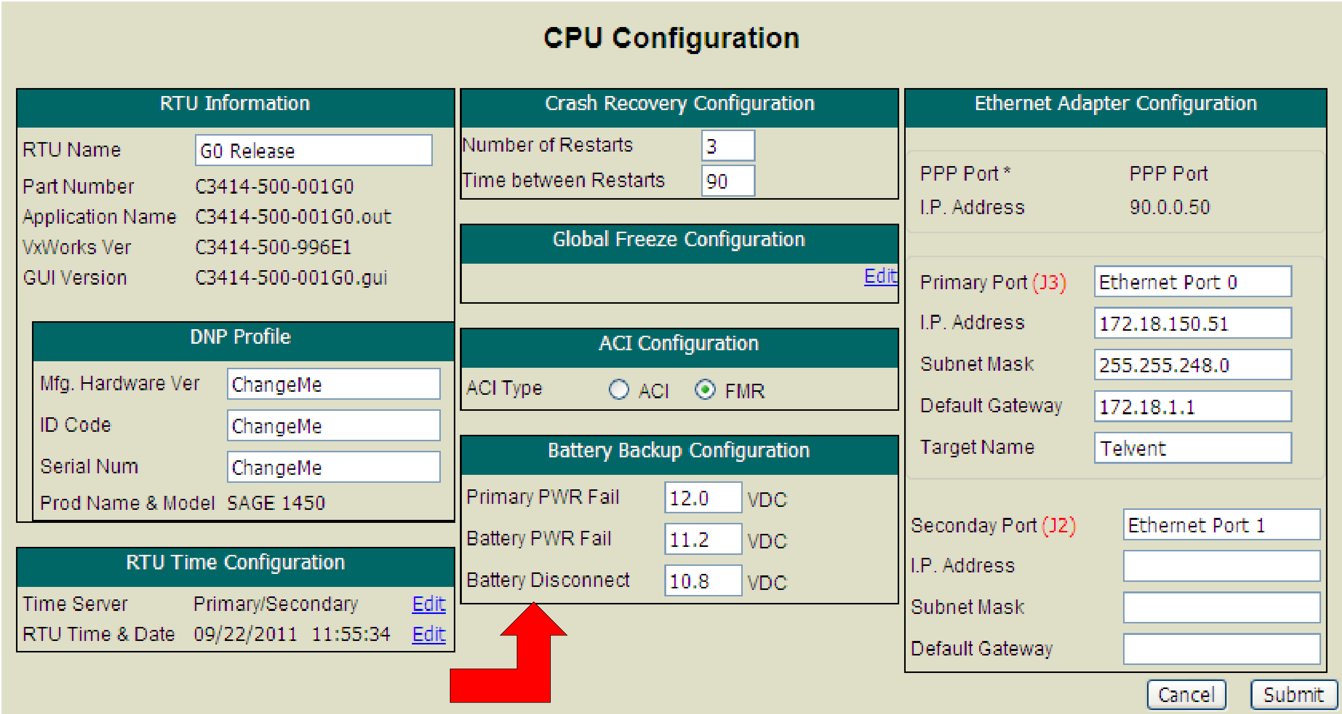
3.2.1 Battery Charging and Battery Disconnect

The battery charging and battery disconnect system was designed for a 12 volt battery. All variances of PS2 (see Figure 3-12) are designed to supply the baseboard with 15.8 VDC nominal. This voltage is enough to charge a 12 volt battery. If you do not use PS2 and you want a 12 volt battery charging system, you must supply at least 15.8 VDC to the baseboard at TB2-1 and TB2-2.

Note: The baseboard will run on as little as 10 VDC, but will not charge a 12 volt battery.

The logic of Primary Power/Battery setup is shown in Figure 3-11. The Battery Backup Configuration is available under the CPU Configuration.

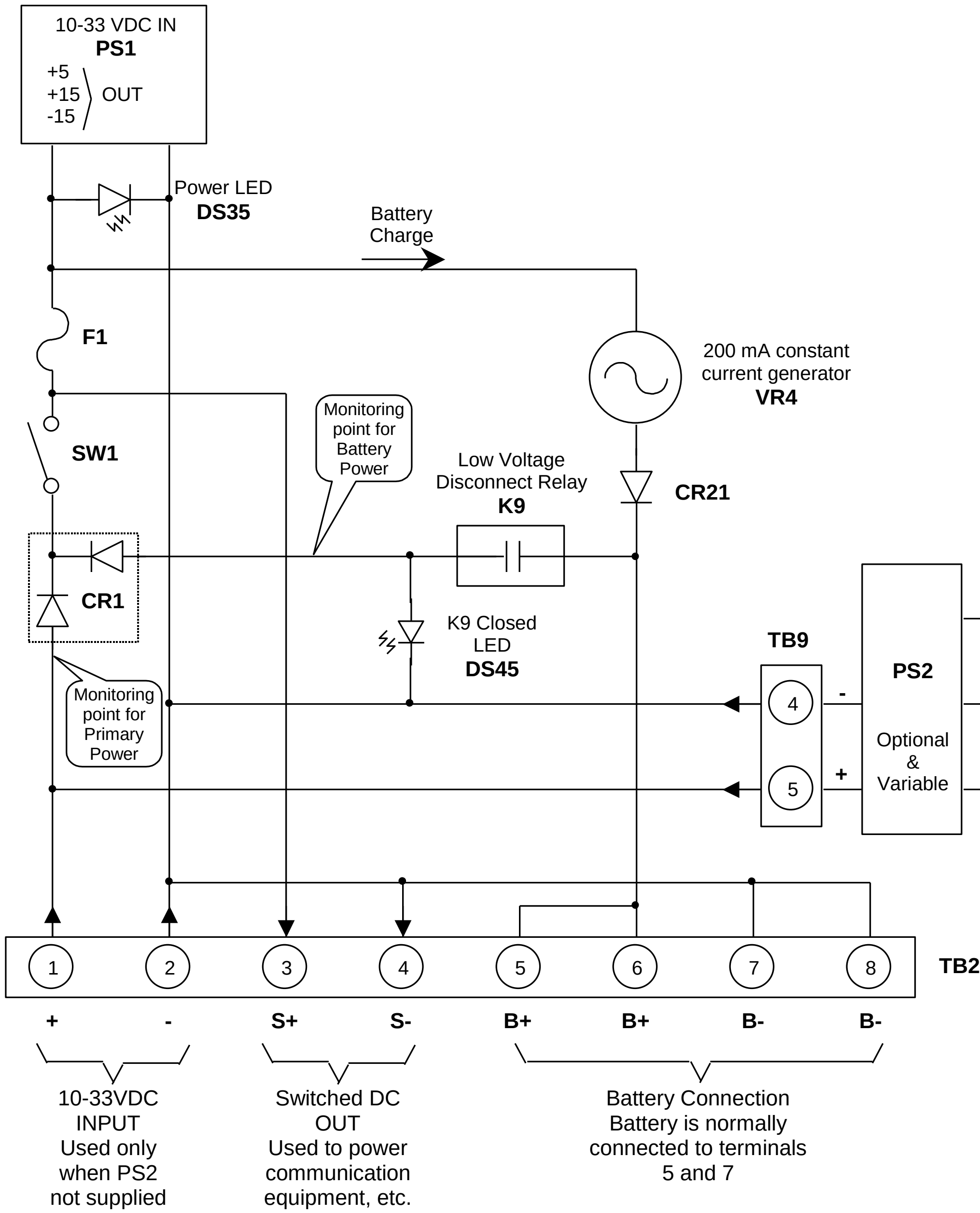
Figure 3-11 Primary Power/Battery Setup



Primary PWR Fail	The voltage at which the Primary Power is considered to be failed (12.0 volts is the default), forcing automatic switch-over to Battery. This event is available as a status Source Point (under AC Analog Inputs), which can be mapped to the Master.
Battery PWR Fail	The voltage at which the Battery will be considered failed (11.2 volts is the default). This event is available as a status Source Point (under AC Analog Inputs), which can be mapped to the Master.
Battery Disconnect	The voltage at which the Battery is disconnected (10.8 volts is the default). The disconnect prevents the battery from completely discharging.

Note: Once the battery is disconnected, the Primary Power must be restored before the RTU will reconnect the battery.

Figure 3-12 Simplified Circuit Diagram for Power Connections



3.3 Communication and Serial I/O Terminations

The SAGE 1X50 baseboard has 5 serial ports. One port is used for either Point-to-Point Protocol (PPP), or Console. The four other serial ports (1 through 4) use a dual Serial Communications Controller and may be used for communications with IEDs, MTUs, as a redundant channel to the primary master, or as a data concentrator for other RTUs. As an option, you may also configure two C3437 PC/104 cards and a C3438 card for an additional eight ports, as shown in Table 3-1.

The pinout of the DB-9 connectors is summarized in Table 3-1. For the simplest connection, only pins 2, 3, and 5 are actually required. The other pins are used for modem controls as well as synchronous connections. The input pins receive signals from external sources while the output pins supply signals from the RTU. Five signal lines for each channel are supplied with LEDs as indicated in the last column of the table.

Note: To conserve power, all communication LEDs except for UIF are deactivated if Primary Power is lost or disconnected. All other LEDs are unaffected.

Table 3-1 DB-9 Connector Pinouts

Baseboard						C3438	LEDs
SIGNAL	**PIN**	**DESCRIPTION**	**TYPE**	**UIF**	**Port 1-4**	**Port 5-12**	
RXCLK	1	Receive Clock	input		X	X	
RXD	2	Receive data	input	X	X	X	X
TXD	3	Transmit data	output	X	X	X	X
DTR	4	Data Terminal Ready	output	X	X	X	
GND	5	Ground	n/a	X	X	X	
DCD	6	Data Carrier Detect	input	X	X	X	X
RTS	7	Request to Send	output	X	X	X	X
CTS	8	Clear to Send	input	X	X	X	X
TXCLK	9	Transmit Clock	Input		X	X	

X = Active

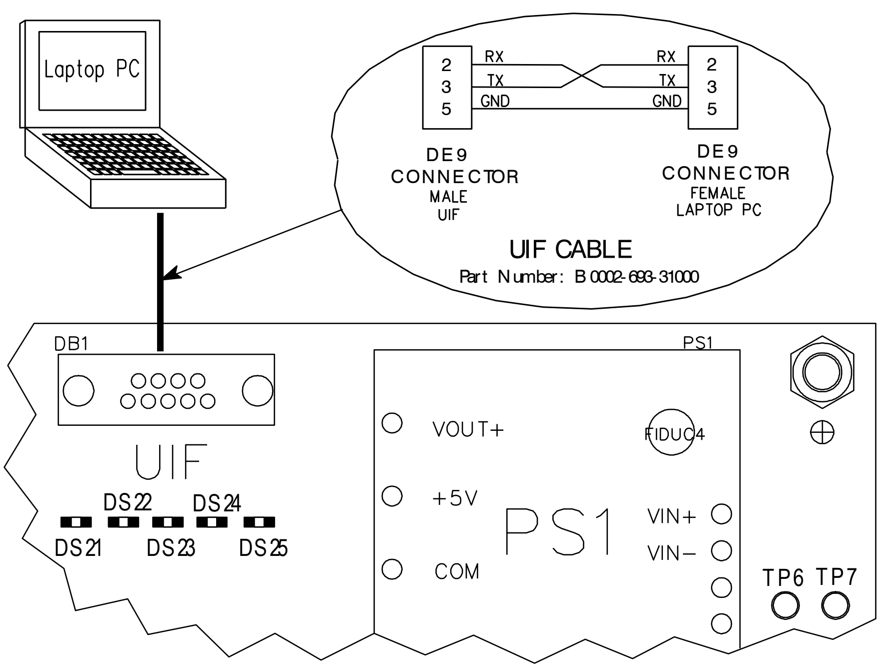
3.3.1 User Interface Port (UIF)

The UIF has been exclusively programmed for Console and PPP functions. The DB-9 connector provides the UIF RS-232 signals as denoted in Table 3-1. Chapter 3 of this manual provides information on the use of this communication port.

3.3.2 User Interface Cable

Figure 3-13 is a cable wiring diagram for connecting the SAGE 1X50 with a terminal or PC that has a 9-pin interface connector. The null-modem cable depicted is available from Schneider Electric.

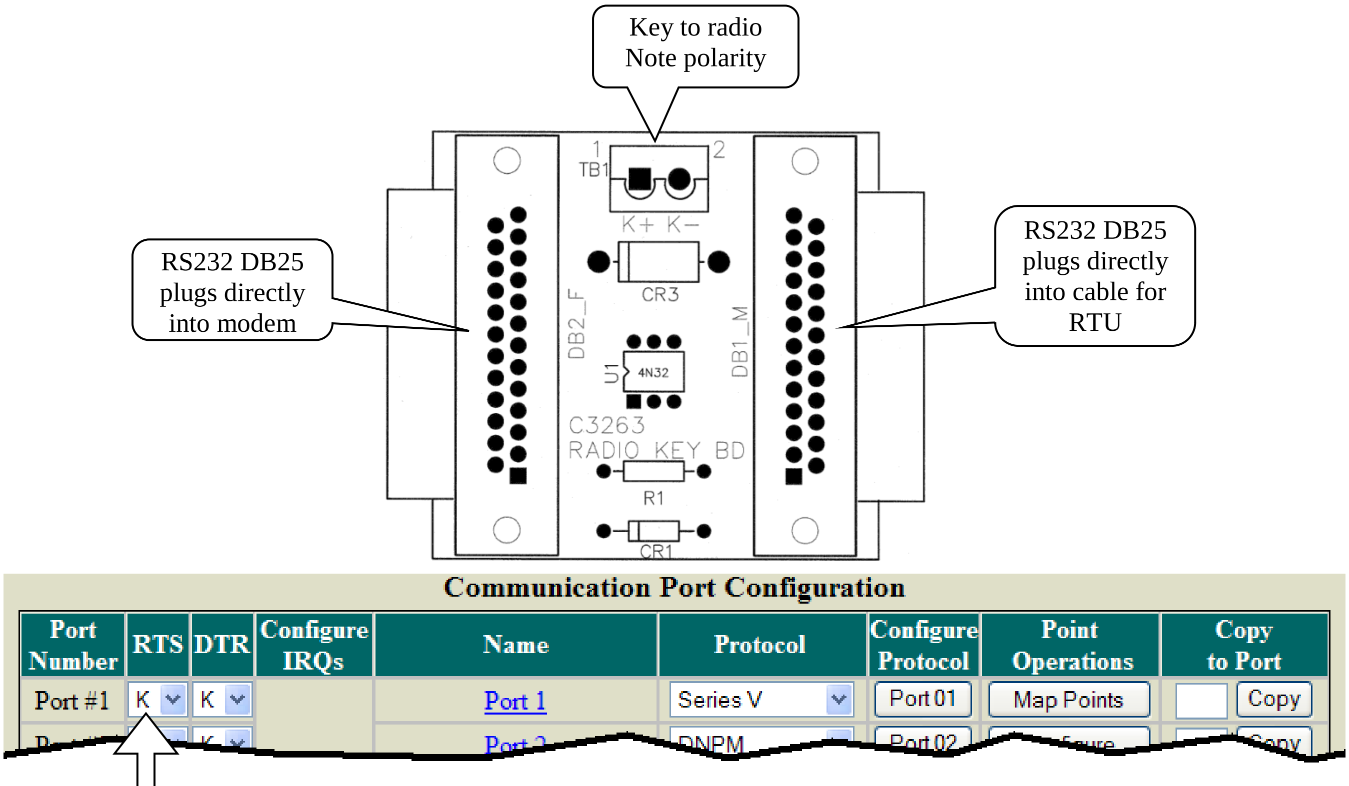
Figure 3-13 User Interface and Testset Cables



3.3.3 Radio Keying Option

Some communications devices require an open collector output to key the device for data transmission. The config@WEB RTUs do not have this output on their baseboards. The optional C3263 Radio Keying Module provides an optically isolated open collector output to perform this function. Configure the RTS (Request to Send) to K (for Keyed) in the Communications Port Configuration to control this output. The module is installed as shown in the figure below.

Figure 3-14 C3263 Radio Keying Board Installation



Note: RTS (Request to Send) in the Communications Port Configuration must be in the K (Keyed) position for the C3263 Radio Keying Board to work. The RTS time may be controlled with the CTS Delay (no RTU reset required after change) in the Communication Channel Configuration.

3.4 Digital Input Terminations

The SAGE 1X50 Baseboard is equipped with 8 digital inputs that are accessed at TB-4. The S1X50 uses the same digital input termination hardware for both status and low speed accumulator inputs. There are two terminals for each digital input. The terminal assignments are marked in the silk-screen on the board. The "+" sign indicates the terminal which connects to the wetting voltage. These terminals are all wired together on the board. The other terminals connect to the opto-coupler. All digital inputs include individual LEDs, which are illuminated when the corresponding contact is closed.

The Baseboard includes a fuse F2 to protect the loop power source against shorts in the field wiring and accepts only voltage-free contacts as inputs. Devices with voltage outputs can be connected. Tie the device output to the negative of the DI input and tie the common to the DI Status Excitation Input negative terminal. Jumpers W11 and W12 are in the Int. Wetting position. The device output voltage must match the design voltage for the DI point. A high voltage for the point asserts an active condition. See Figure 3-15.

Figure 3-15 Powered Status Point Connection

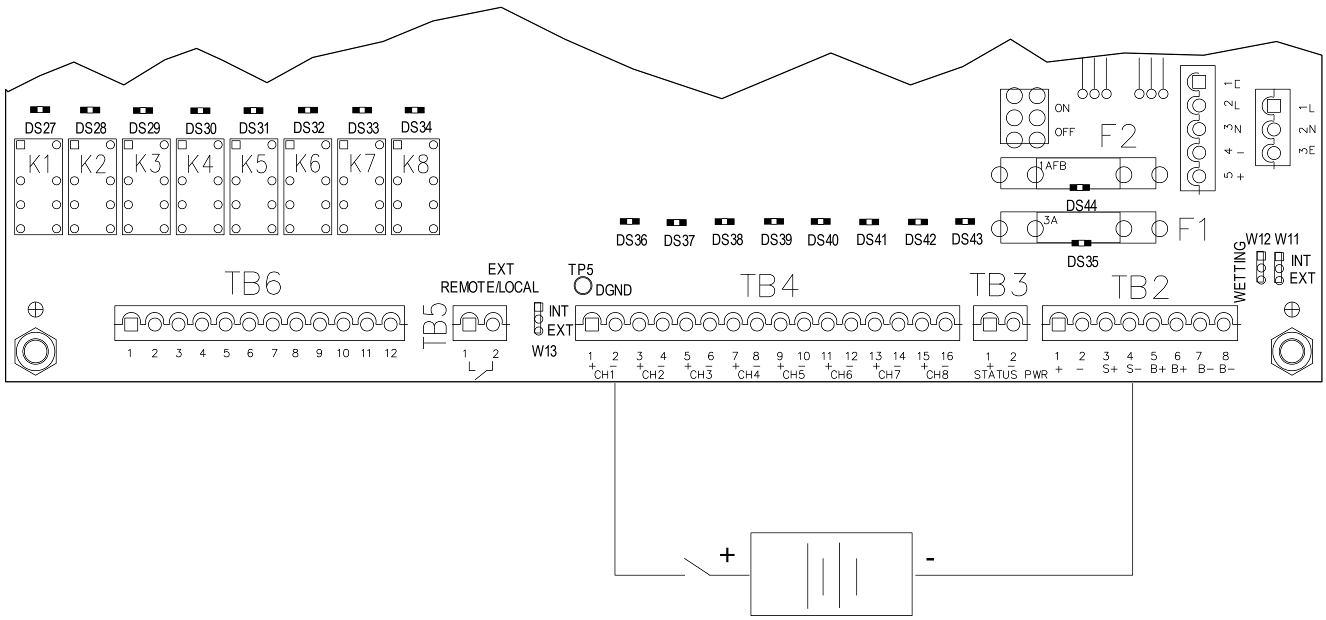
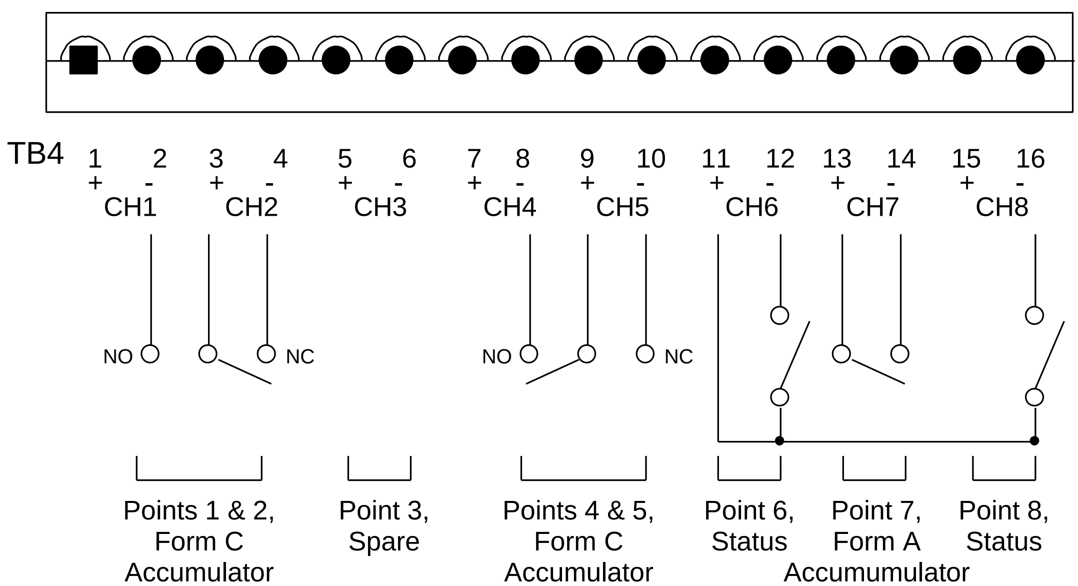


Figure 3-16 shows a mix of Status, Accumulators (Form A and Form C), and a spare. The sequential order of these points is arbitrary, but you must enter your choices into the Digital Input Configuration as directed in Chapter 3.

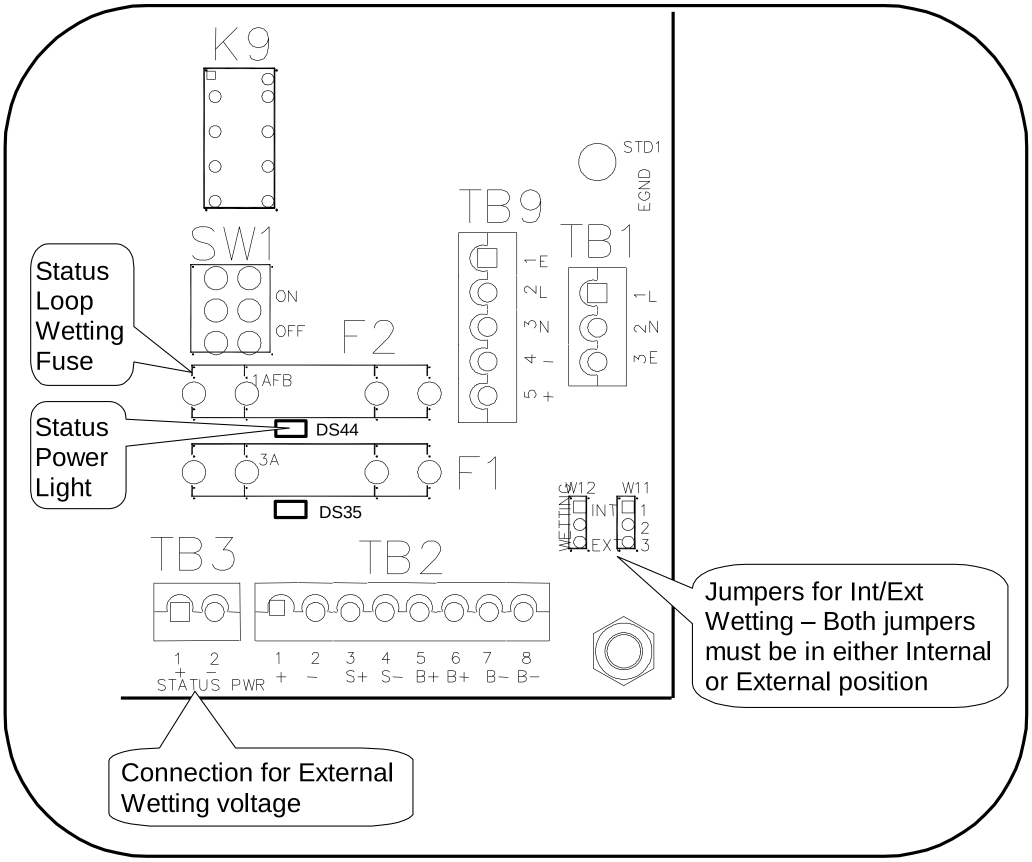
Form A accumulators require one digital input (two wires) each and are hooked up the same as status inputs. Form C accumulators require two digital inputs (three wires) each.

Figure 3-16 Accumulator, Status, & Spares Input Field Wiring



You may select the source of the wetting voltage from internal DC power or, by moving jumpers W11 and W12, external voltage which you provide at TB3. See Figure 3-17.

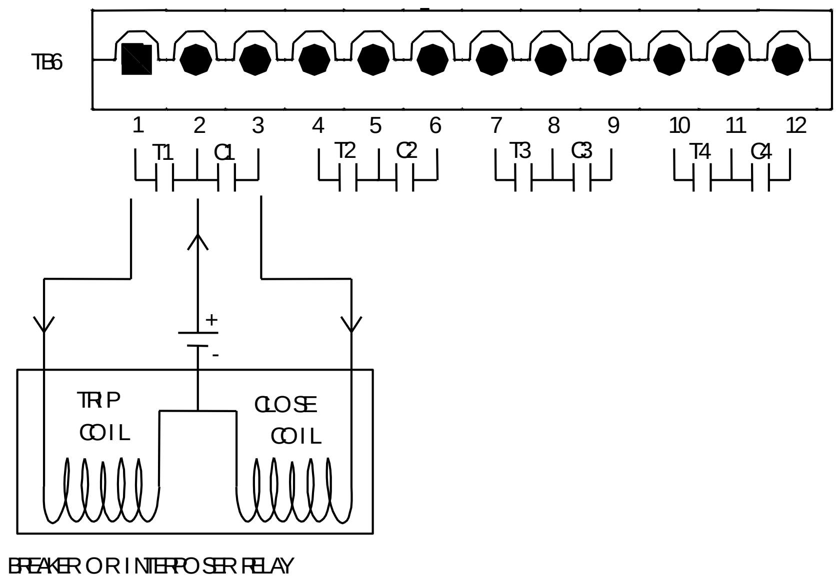
Figure 3-17 Baseboard Status Wetting



3.5 Control Output Terminations - Select Before Operate

The SAGE 1X50 Baseboard includes relays and terminations for four SBO (momentary) control points available at TB6. The termination assignments are marked in silk-screen on the Baseboard. Figure 3-18 illustrates the hookup procedure for the SBOs. The momentary functions shown (trip/close) are arbitrary; the actual functions are determined by the master station which commands the RTU. The firmware simply treats the SBOs as a group of 8 relay coils without regard to their assigned functions.

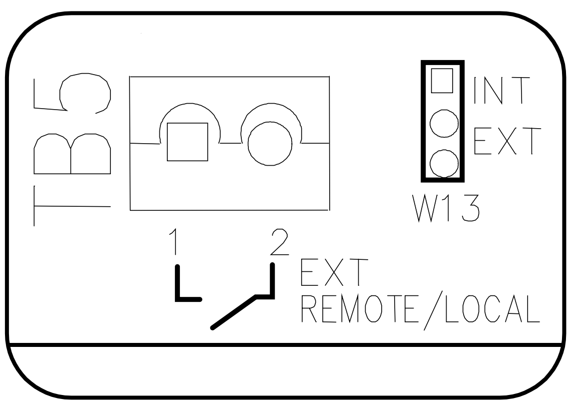
Figure 3-18 Example of SBO Field Wiring



Warning: The miniature momentary type relays should not be used to switch 125VDC devices, even if the current is significantly less than 2A. The contact rating of these relays is greatly reduced at such high DC voltages and the relay is subject to failure if the maximum current is exceeded. Consult the factory if you are unsure of the suitability of the relays installed on your RTU.

There is a provision at TB5 to connect an external Remote/Local switch to disable SBO power when the RTU is being serviced. If the external switch is to be used, jumper W13 must be in the EXT position. If no external Remote/Local switch is used, W13 must be in the INT position. See Figure 3-19.

Figure 3-19 Remote/Local Connection at TB5 and Jumper W13



3.6 AC Analog Input Terminations

The SAGE 1X50 Baseboard is equipped with six AC analog inputs; three current inputs and three voltage inputs. The two basic methods of connecting AC inputs are through CTs/PTs, and Line Post Sensors. Use shielded twisted pair cables for either type of input. Make sure that the cable drain wire is connected at the proper end as shown in the following series of Figures.

Line Post connections and CT-PT connections for 3-element, 2.5 -element, 2-element, and single voltage are shown in the following figures. The measured values for each type of connection are shown beneath each Figure.

Note: Remember, the voltages you enter in the ACI Configuration screens for 3-element and 2.5-element metering are measured from line to neutral. Voltages for 2-element metering are measured line to line.

Figure 3-20 Line Post Sensor Connection

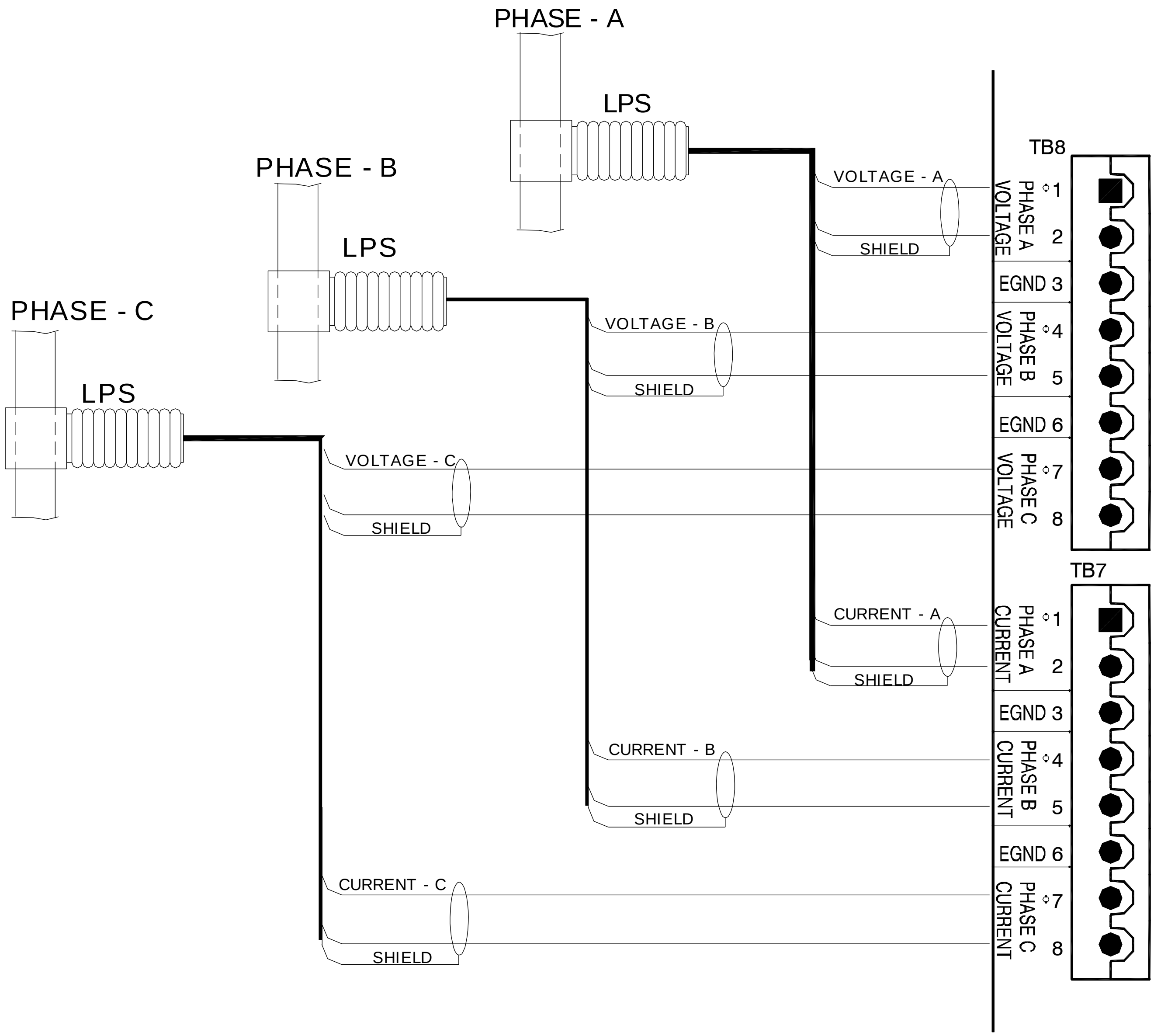


Figure 3-21 CT-PT 3-Element Connections

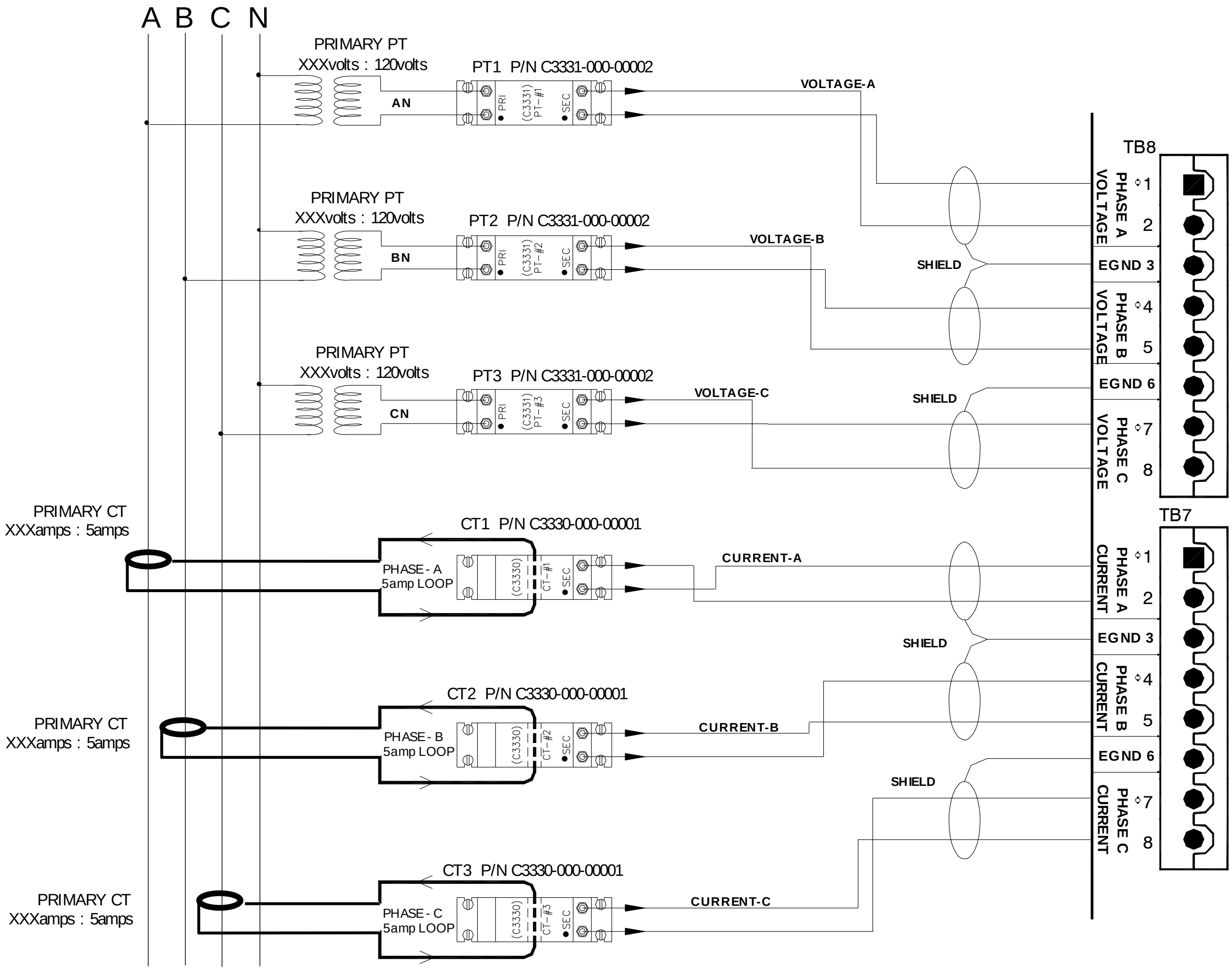


Table 3-2 Calculated Values for 3-Element Metering

Phase and Total Watts
Phase and Total VARs
Phase and Total PF
Phase and Total VA
Phase frequency, voltage derived
Phase RMS Current
Phase RMS Voltage
Harmonic content (2nd through 7th) of ABC voltage and ABC current
RMS Neutral current

Note: Remember, the voltages you enter in the ACI Configuration screens for 3-element and 2.5-element metering are measured from line to neutral. Voltages for 2-element metering are measured line to line.

Figure 3-22 CT-PT 2 1/2-Element Connections

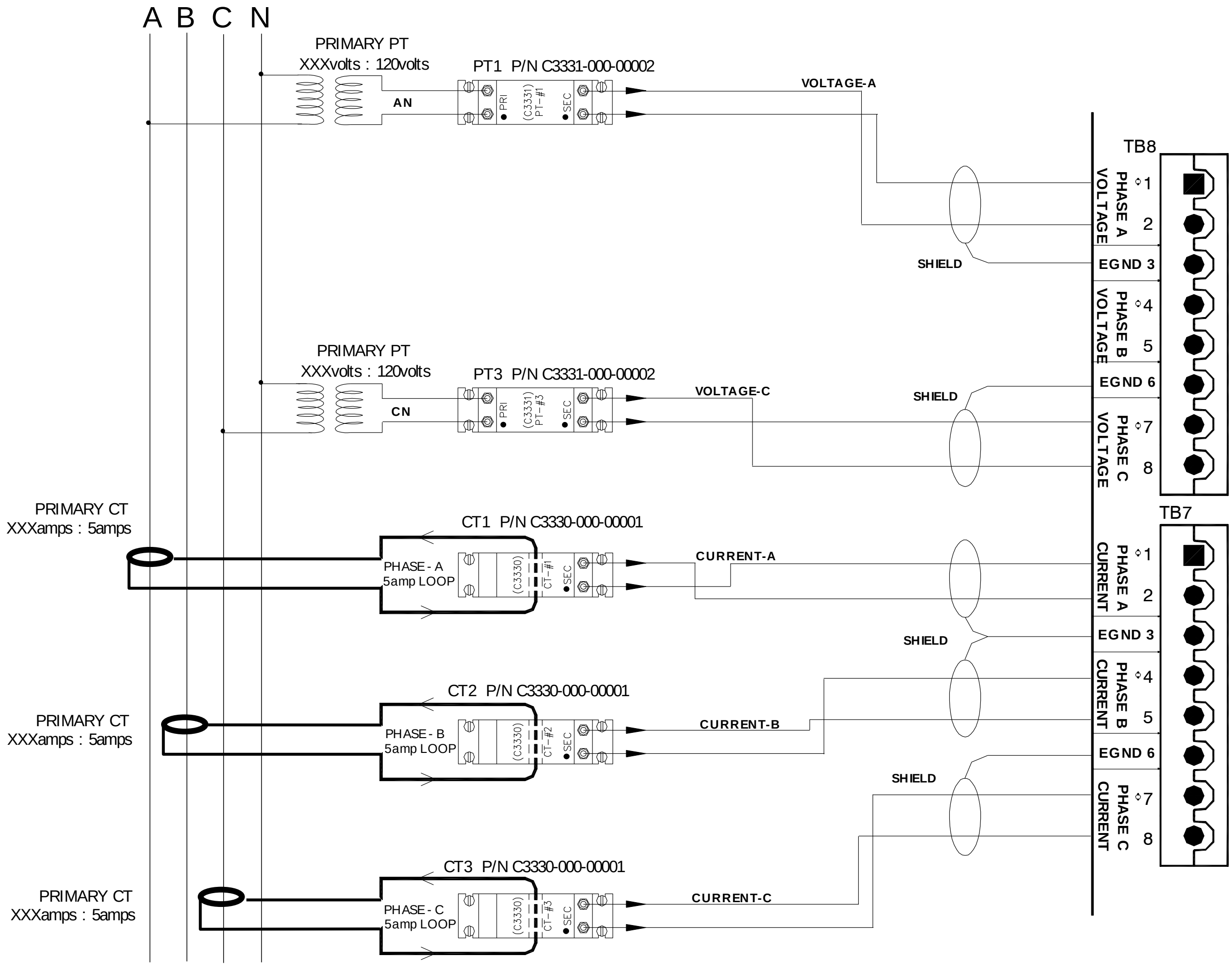


Table 3-3 Calculated Values for 2 1/2-Element Metering

Phase and Total Watts
Phase and Total VARs
Phase A & C and Total PF
Phase A & C and Total VA
Phase A and C frequency, voltage derived
Phase RMS current
Phase A and C RMS voltage
Harmonic Content (2nd through 7th) of A&C voltage and ABC current
RMS Neutral current

Note: Remember, the voltages you enter in the ACI Configuration screens for 3-element and 2.5-element metering are measured from line to neutral. Voltages for 2-element metering are measured line to line.

Figure 3-23 CT-PT 2-Element Connections

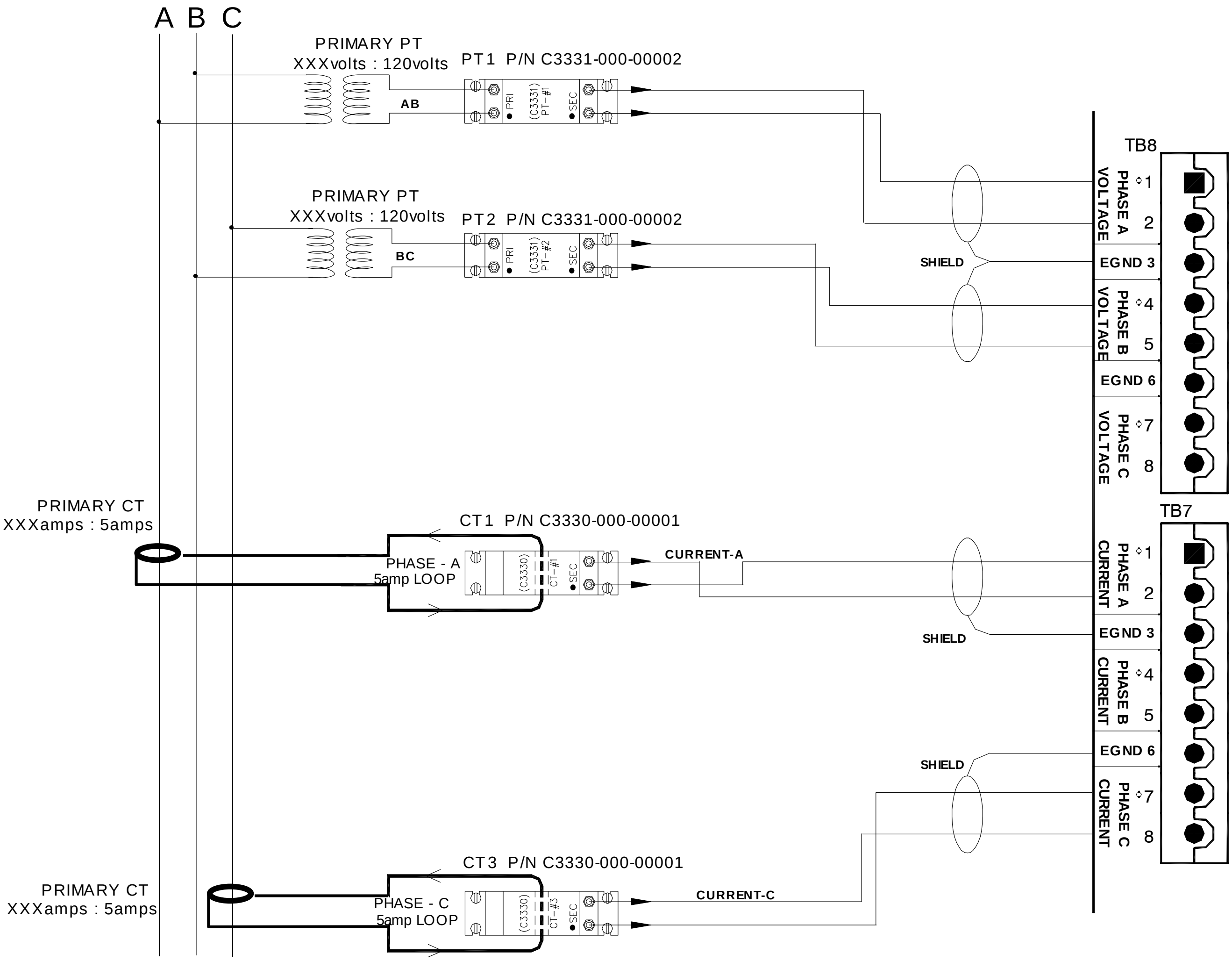
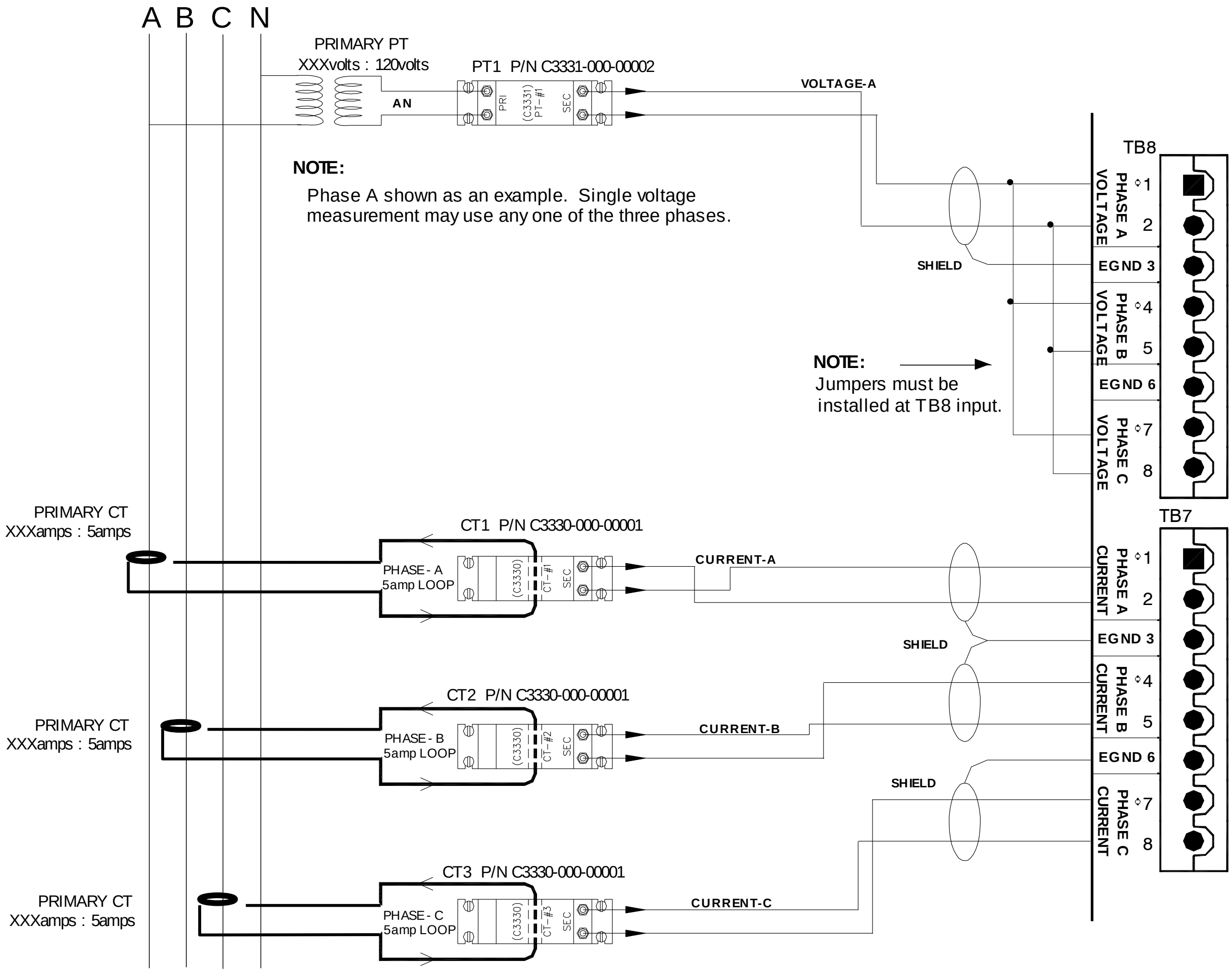


Table 3-4 Calculated Values for 2-Element Metering

Total Watts
Total VARs
Total PF
Total VA
Phase AB and BC frequency, voltage derived
Phase A and C RMS current
Harmonic Content (2nd through 7th) of AB & BC volts and A & C current

Note: Remember, the voltages you enter in the ACI Configuration screens for 3-element and 2.5-element metering are measured from line to neutral. Voltages for 2-element metering are measured line to line.

Figure 3-24 CT-PT Connections (Single Voltage)



When measuring from a single voltage, the phase angles must be corrected as shown in the following table. For instance, if you are using phase A for the single-voltage measurement, correct phase B to +120 degrees and phase C to –120 degrees.

Table 3-5 Voltage Phase Angle Correction

Voltage Sensor Phase Angle	**Voltage Phase Angle Correction**		
	A	**B**	**C**
A	0	+120	–120
B	–120	0	120
C	120	–120	0

Table 3-6 Calculated Values for 3-Element Metering

Phase and Total Watts
Phase and Total VARs
Phase and Total PF
Phase and Total VA
Phase frequency, voltage derived
Phase RMS Current
Phase RMS Voltage
Harmonic content (2nd through 7th) of ABC voltage and ABC current
RMS Neutral current

Note: Remember, the voltages you enter in the ACI Configuration screens for 3-element and 2.5-element metering are measured from line to neutral. Voltages for 2-element metering are measured line to line.

3.7 Analog References

The SAGE 1X50 has six internal reference. For scaling purposes at the MTU, the EGU Min & EGU Max are shown in Table 3-7.

Table 3-7 SAGE 1X50 Analog References

Ref #	Reference	Reference Name	Type	EGU Min	EGU Max	EGU
1	Ground	bb_gnd_ref	Bipolar	-3	+3	VDC
2	Positive 2.5	bb_+2.5V_ref	Bipolar	-3	+3	VDC
3	Negative 2.5	bb_-2.5V_ref	Bipolar	-3	+3	VDC
4	Temperature	bb_temp_ref	Bipolar	-58	+185	DEG F
4	Temperature	bb_temp_ref	Bipolar	-50	+85	DEG C
5	Battery Power	bb_bat_in_ref	Bipolar	-33	+33	VDC
6	Primary Power	bb_pwr_in_ref	Bipolar	-33	+33	VDC

3.8 Jumpers

All jumper designations and functions for the Baseboard are found in Section 4.6 of this document. It is important that the jumper configurations are properly set to prevent the RTU from malfunctioning. Please check the jumper settings whenever an addition or change is made to the RTU configuration.

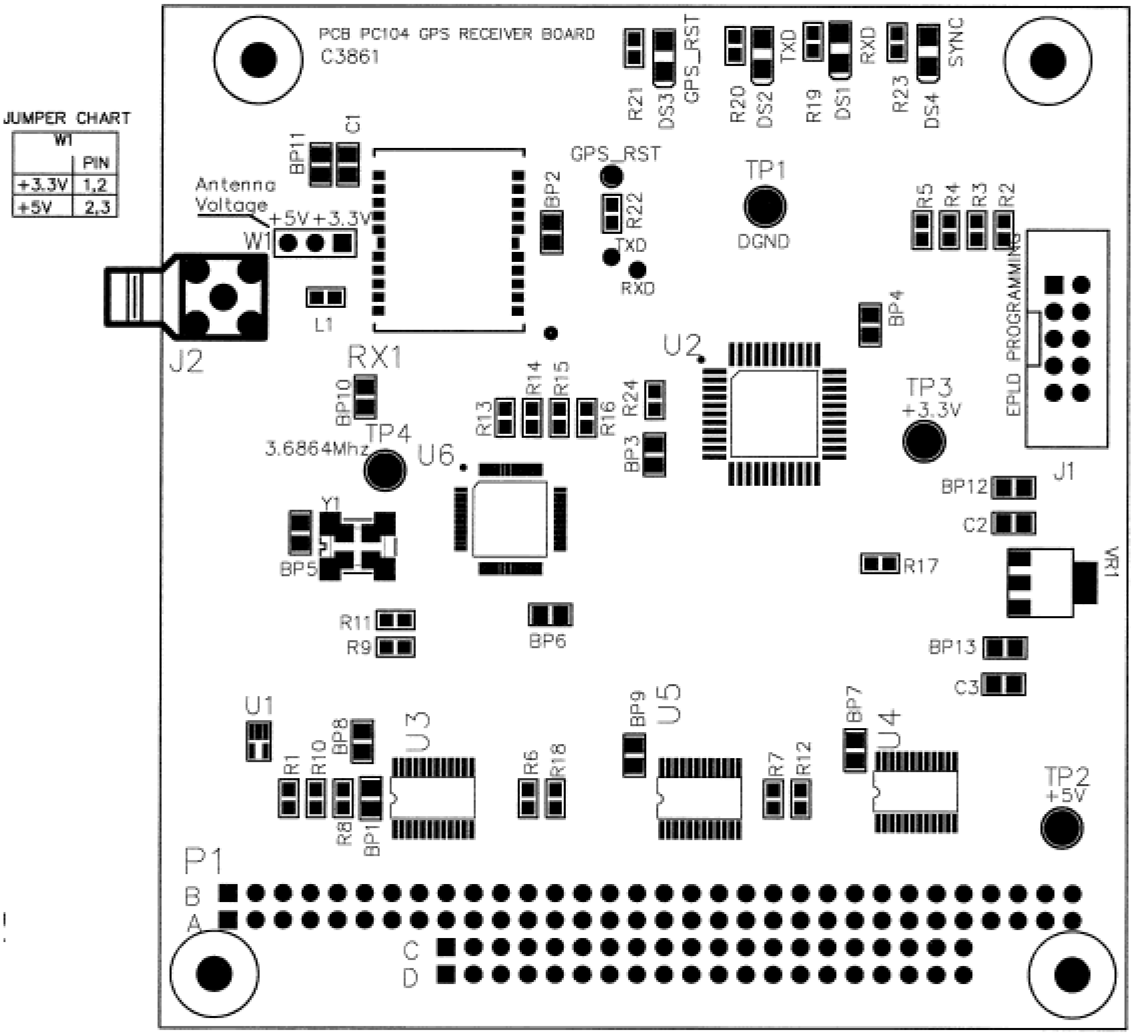
3.9 PC/104 Expansion Installation

The PC/104 interface provides for expanded functionality. Presently, there are three PC/104 functions as described in the following sections. PC/104 expansion cards are optional.

3.10 C3861 Lynx GPS In

This connector on the rear panel is for a GPS antenna, if the variance supports the GPS option.

Figure 3-25: C3861 PC104 GPS Module



3.10.1 C3461 PC/104 Trimble GPS Receiver (Optional)

The C3461 PC/104 Trimble GPS Receiver consists of the SATPAK Carrier Board and the Trimble GPS Receiver Board riding piggy-back.

Caution: The SATPAK Carrier Board and the Trimble GPS Receiver Board are permanently joined. Do NOT attempt to separate the two. Also take care to avoid bending any pins on the C3461 or the PC/104 assembly on which it is mounted.

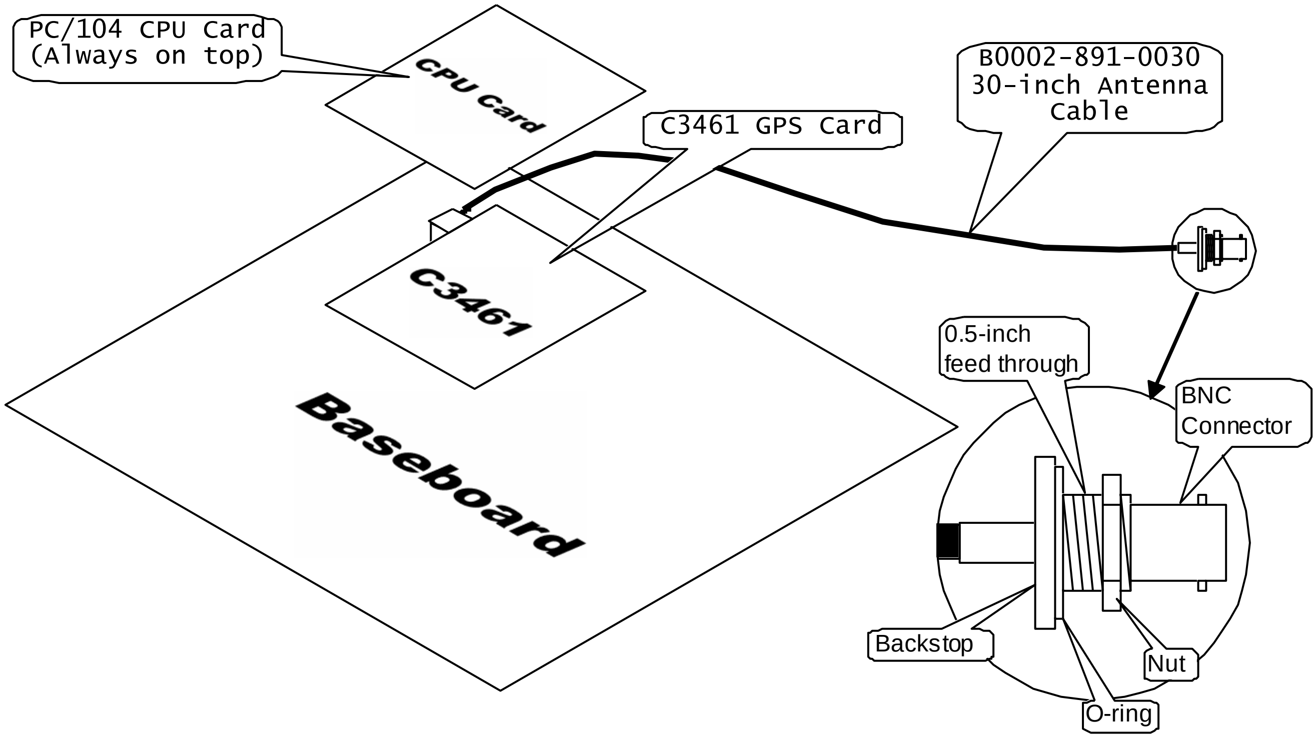
As shown below, the C3461 requires only a few steps for physical installation:

1. Unplug the CPU card.
2. Plug the C3461 into the baseboard.
3. Plug the CPU card into the top of the C3461. The CPU card must always be on top.
4. There is a 30-inch thin coax cable that attaches to the C3461 card. The BNC end may be mounted through a 0.5-inch hole in the cabinet or other barrier. The assembly comes with a built-in O-ring to afford some weather protection.
5. Mount the GPS antenna in an elevated, clear area outside the building.

6. Connect a suitable length of BNC cable* from the antenna to the cabinet-mounted BNC connector.

Note: Schneider Electric supports a maximum length of 50 foot of RG-58 coaxial cable.

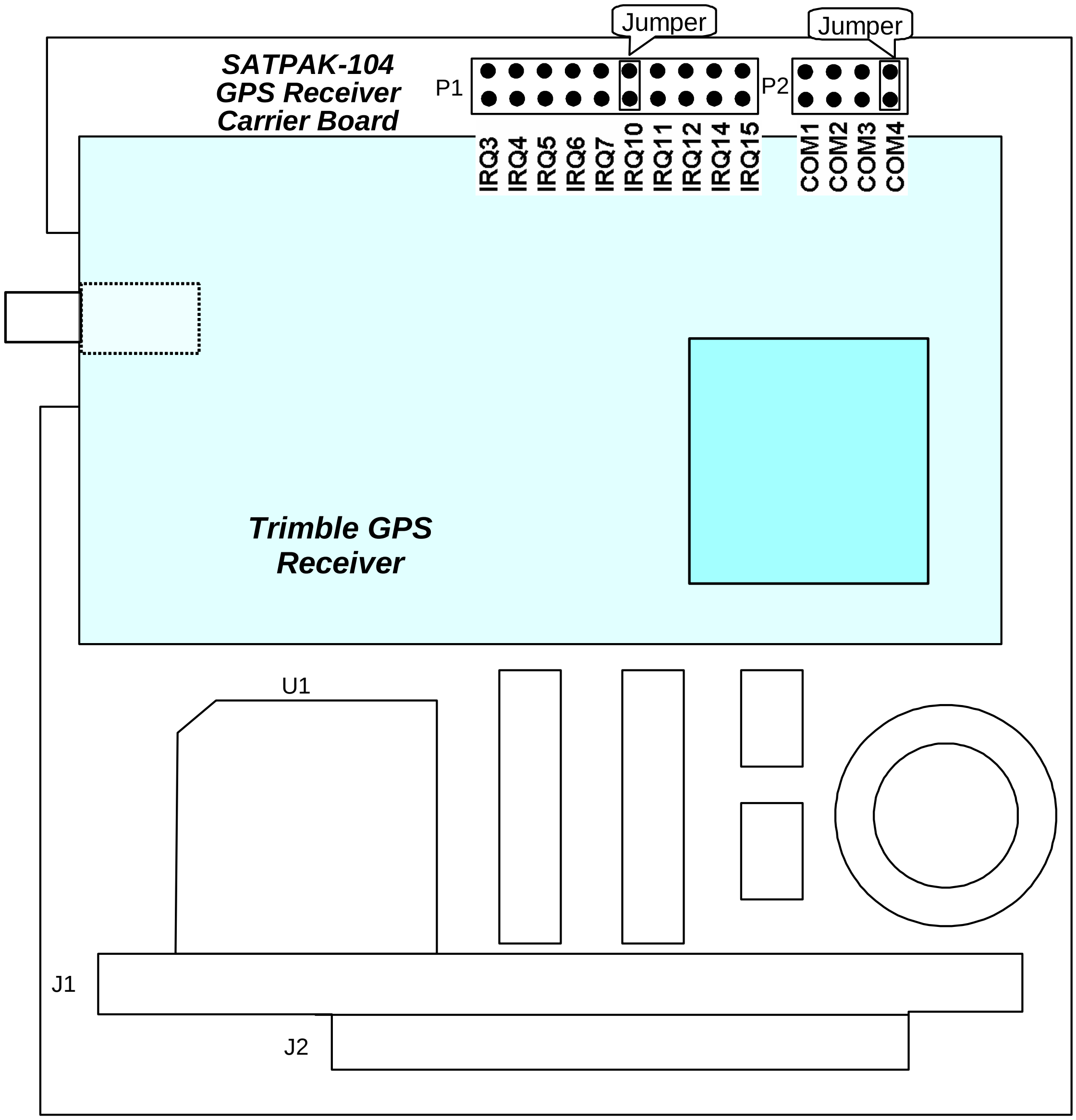
Figure 3-26 C3461 PC/104 Trimble GPS Receiver



3.10.1.1 C3461 GPS PC/104 Jumper Configuration for P1 & P2

P1 and P2 should have the jumpers and wire connection as shown below.

Figure 3-27 C3461 Board Layout

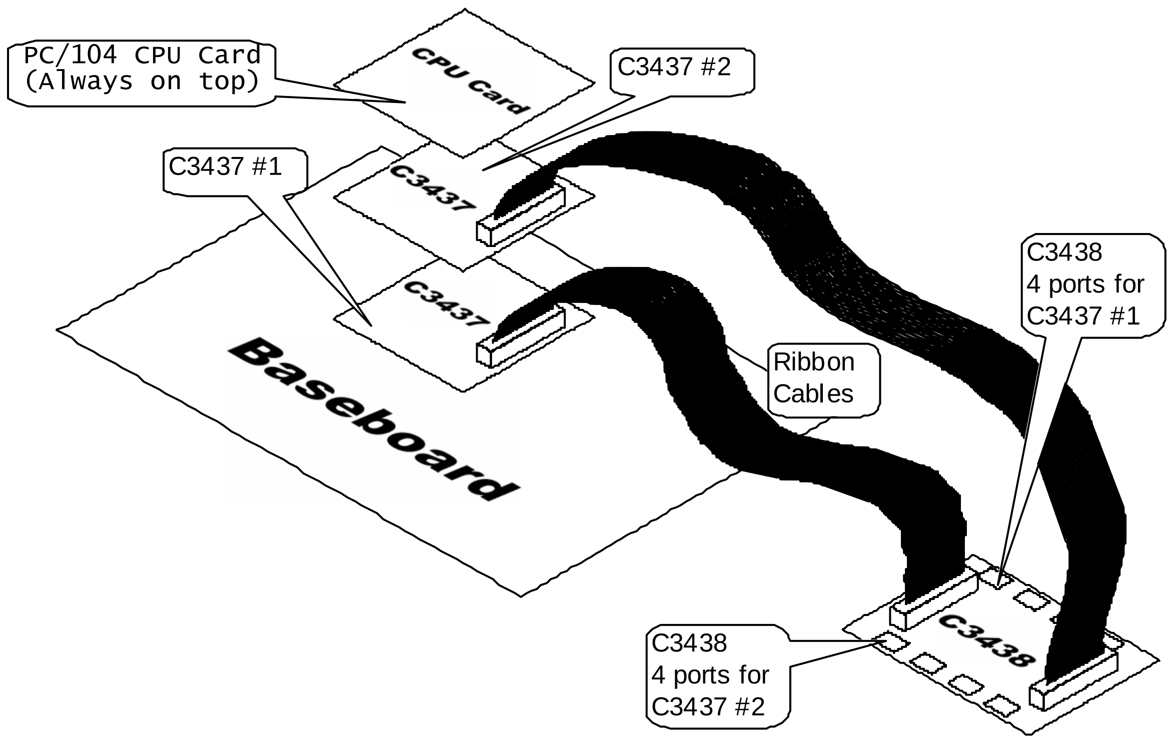


3.10.2 C3437 PC/104 Comm Expansion & C3438 RS-232 Port Card (Optional)

3.10.2.1 Introduction

The C3437 is a PC/104 card which must be plugged into the top of any existing PC/104 cards. One C3437 will service four ports on a C3438 (see Figure 3-28). Another C3437 is required to service the remaining four ports on the C3438.

Figure 3-28 Installing the C3437/C3438 Communications Expansion Cards



3.10.2.2 C3437 IRQ (Interrupt) Selection

The C3437 must be version B or above.

	Board 1	Board 2
IRQ9	OUT	OUT
IRQ3	OUT	OUT
IRQ6	IN	IN
IRQ7	OUT	OUT
PD (Pull Down)	OUT	OUT
BOARD1	IN	OUT

3.10.2.3 C3438-002-REV-X, XT Board

The XT board is used to provide 8 DB-9F terminations for two C3437 4 channel communications boards. All signals in the DB-9F connector are RS-232 levels and are configured as DTE (Data Terminal Equipment).

Two ribbon cable connectors are provided to accept signals from the C3437 boards.

Connect the C3437 board(s) to the XT as follows:

C3438 Connector	C3437
J1	Board 1
J2	Board 2

The DB-9F connectors are configured as follows:

C3437	C3437Channel	C3438 Port	RTU Channel
Board 1	1	1	5
Board 1	2	2	6
Board 1	3	3	7
Board 1	4	4	8
Board 2	1	5	9
Board 2	2	6	10
Board 2	3	7	11
Board 2	4	8	12

The pins in the DB-9F are used as follows:

Pin	Signal	Direction
1	RXCLK	Input
2	RX#	Input
3	TX#	Output
4	DTR	Output
5	DGND	
6	DCD	Input
7	RTS	Output
8	CTS	Input
9	TXCLK	Input

3.10.3 C3463 PCA Ethernet 10/100 5-Port Switching Hub (Optional)

The optional C3463 5-Port Ethernet switching hub expands the number of Ethernet port to five. There is no special software needed, but because of clearance restrictions, the card must be installed on top.

Figure 3-29 C3463 5-Port Ethernet Switching Hub

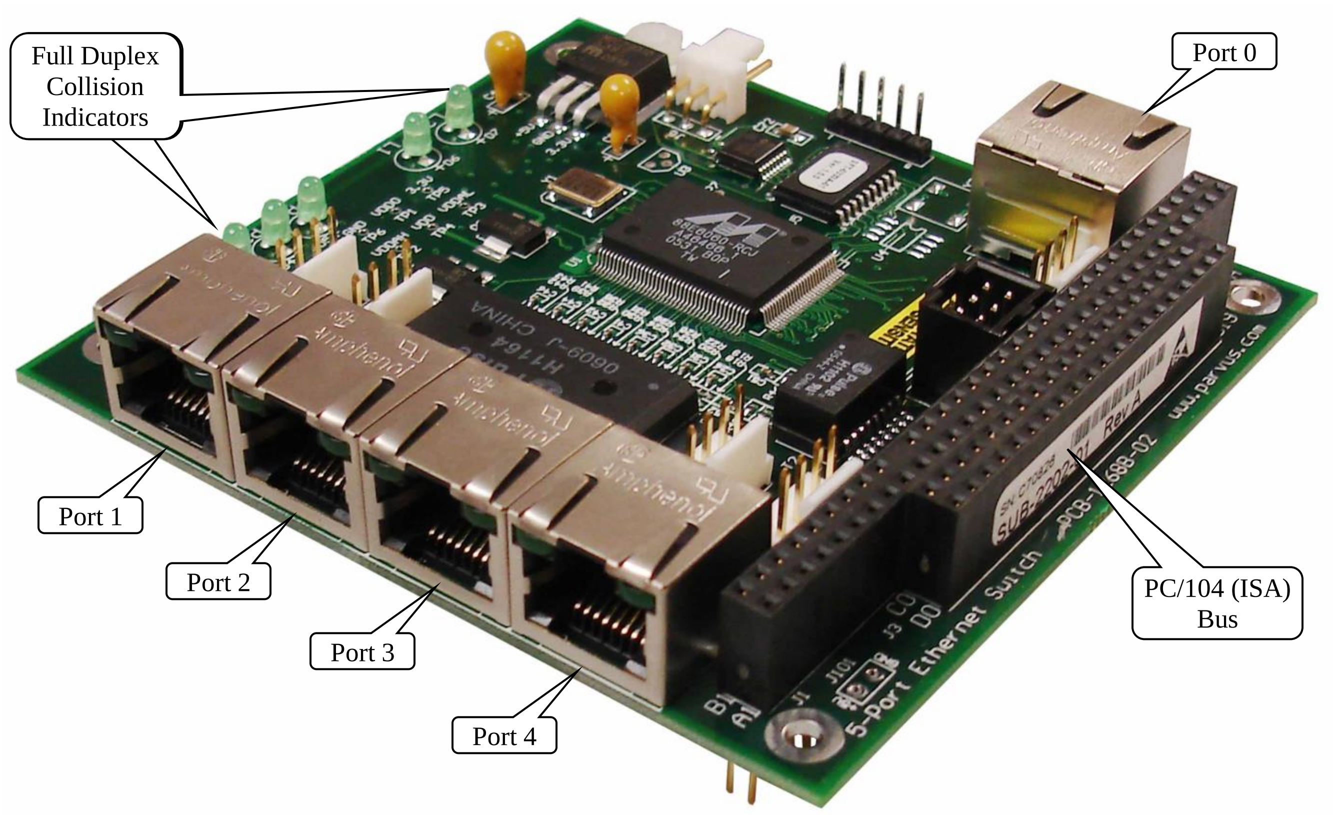
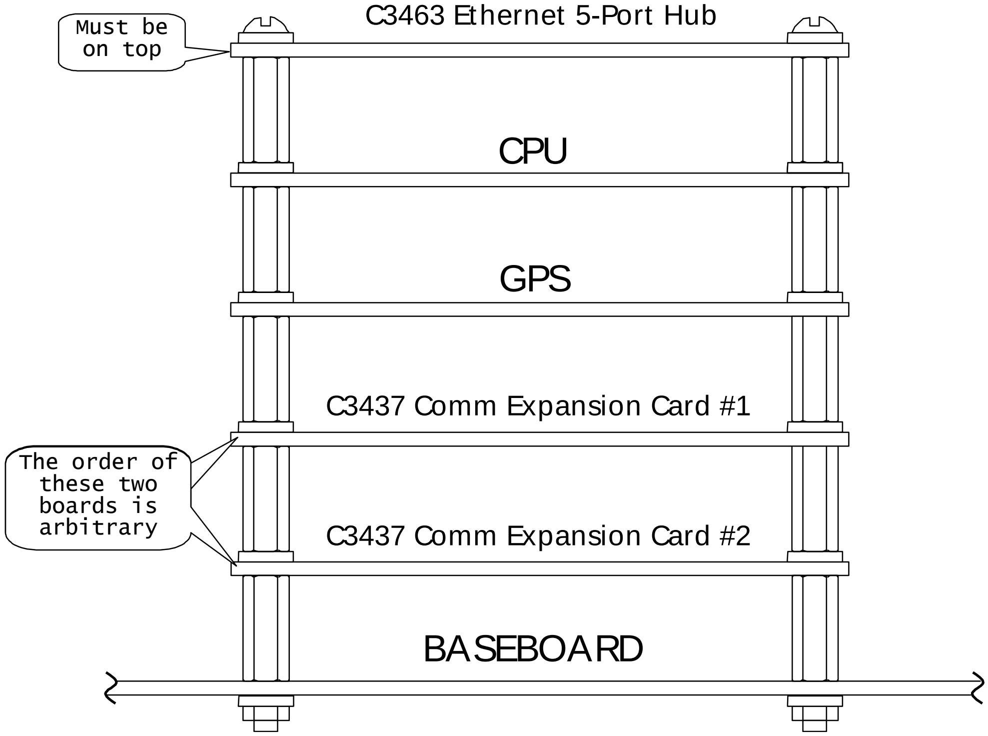


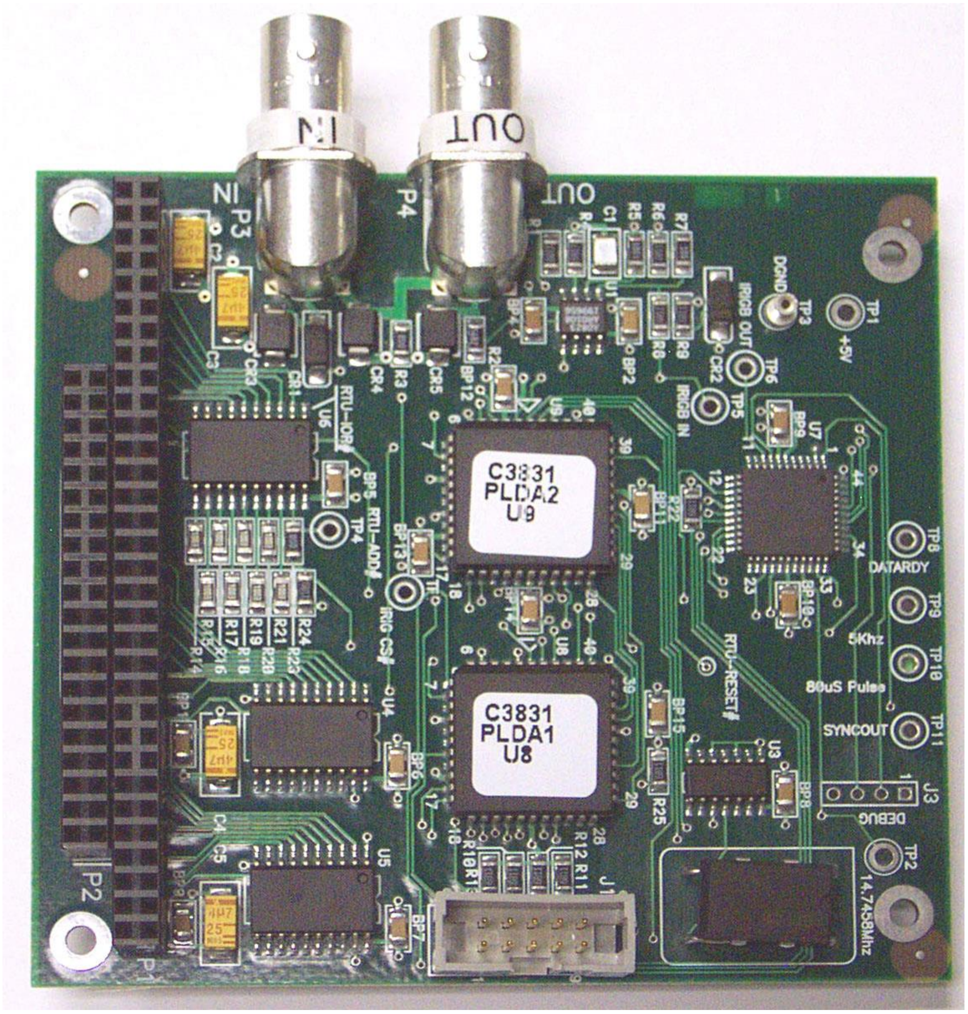
Figure 3-30 PC/104 Card Stacking



3.10.4 C3831 PC/104 IRIG-B Card (Optional)

The IRIG-B card pictured below is available for all SAGE RTUs except the S3030, which has built-in IRIG-B.

Figure 3-31 C3831 PC/104 IRIG-B Card



3.10.4.1 IRIG-B signal as a Input to the RTU

If the RTU IRIG-B system is connected to an IRIG-B source, it must provide a B 0 2 X or B 1 2 X Time Code Format signal to the RTU.

Modulation/Frequency (First Digit of IRIG-B Time Code Format)

0 - Pulse Width Code

1 - Sine Wave, Amplitude Modulated

Frequency/Resolution (Second Digit of IRIG-B Time Code Format)

2 - 1kHz/1ms

Coded Expressions (Third Digit of IRIG-B Time Code Format)

0 through 7 is acceptable. The RTU IRIG-B system uses only the BCDtoy (Binary-Coded-Decimal time-of-year) Coded Expressions part of the IRIG-B data stream. The BCDtoy is included in Coded Expressions 0 to 7 of the IRIG-B data stream.

3.10.4.2 IRIG-B signal output from the RTU

If the RTU IRIG-B system is driven by a time source in the RTU, the Time Code Format is B 0 2 2.

Modulation/Frequency (First Digit of IRIG-B Time Code Format)

0 - Pulse Width Code

Frequency/Resolution (Second Digit of IRIG-B Time Code Format)

2 - 1kHz/1ms.

Coded Expressions (Third Digit of IRIG-B Time Code Format)

2 - BCDtoy

3.10.4.3 IRIG-B Reference

The following is a link to the IRIG Standard 200-04 document for IRIG Serial Time Code Formats.

https://wsmrc2vger.wsmr.army.mil/rcc/manuals/200-04/TT-45.pdf

4 Maintenance

This chapter describes the various calibration procedures for maintaining the SAGE 1X50. Those users who desire a more thorough technical understanding of the SAGE 1X50 should refer to Chapter 5, Theory of Operation, which contains detailed descriptions of each module, and to the back of this manual, which contains complete schematics, bills of materials, and printed circuit board assembly drawings.

The following equipment is recommended for performing routine maintenance and repair on SAGE 1X50 RTUs:

- Precision 4-1/2 digit DMM, (±.01% accuracy)

The SAGE 1X50 requires very little routine adjustments, with the exception of analog input calibration. All adjustments, including calibration, are preset at the factory, and should not require calibration at startup.

4.1 Analog Input Calibration

The analog input section of the SAGE 1X50 has a simple calibration technique that is intended for use while the RTU is operating on-site. The RTU has a dedicated internal point that provides a 2.5V reference, and is used as the local voltage standard. All other points are a ratio of this local voltage standard. Since the RTU is generating this reference, only a precision voltmeter and a small screwdriver are required to perform the calibration. See Figure 4-7 to locate adjustments and test points.

1. Connect the voltmeter between TP14 (analog ground) and TP15 (2.5V reference)
2. Adjust potentiometer R207 until the meter indicates 2.500 Volts ±.001V.

At this point, the field calibration is complete.

4.2 Temperature Calibration

The References Configuration screen allows you to set the temperature units (°F or °C) and correct the temperature reading. This step should not be done remotely because you must enter the current correct temperature at the RTU. See Figure 4-1. Click Submit when you are satisfied with the configuration, or Cancel to back out of the function without saving.

Figure 4-1 References Configuration

References Configuration

Point	Point Name	Units	Temperature
1	bb_gnd_ref		
2	bb_+2.5V_ref		
3	bb_-2.5V_ref		
4	bb_temp_ref	°F	74
5	bb_bat_in_ref		
6	bb_pwr_in_ref		

Cancel Submit

4.3 Comm Port Testing

The RTU includes a built-in test routine that allows limited testing of the communication ports. Click the Command tab, then click Serial Comm. You will see a screen similar to Figure 4-2.

Note: The channel under test must be assigned a protocol before this test will work.

Figure 4-2 Command Communications Port Data

Command Communication Port Data

Port Number	RTS	DTR	Name	Protocol	Command Port Data	Test Mode
Port #1	K	K	Series V to Master	Series V	Port Data	Normal
Port #2	K	K	Port 2	DNPM	Port Data	Normal
Port #3	K	K	Port 3	Series V	Port Data	Normal
Port #4	K	K	Port 4	None	Port Data	Normal
Port #5	K	K	Port 5	None	Port Data	Normal
Port #6	K	K	Port 6	None	Port Data	Normal
Port #7	K	K	Port 7	None	Port Data	Normal
Port #8	K	K	Port 8	None	Port Data	Normal
Port #9	K	K	Port 9	None	Port Data	Normal
Port #10	K	K	Port 10	None	Port Data	Normal
Port #11	K	K	Port 11	None	Port Data	Normal
Port #12	K	K	Port 12	None	Port Data	Normal

Back

Under the Test Mode heading, select the type of test you wish from the pull-down menu for the port of interest. The choices and the meaning of each type of test is listed below. See Figure 4-4 for the expected results for each test.

Normal

In the normal mode, the selected comm channel functions normally. Each channel will be in this mode when the display is called up. Each channel is automatically restored to this mode when you exit from the display or the RTU is reset.

Mark

In the mark mode, the selected comm channel outputs a continuous stream of ones. Marks for the RS-232 channel are low (negative) voltage pulses, and low frequency (1,200Hz) for any attached 202 modem.

Space

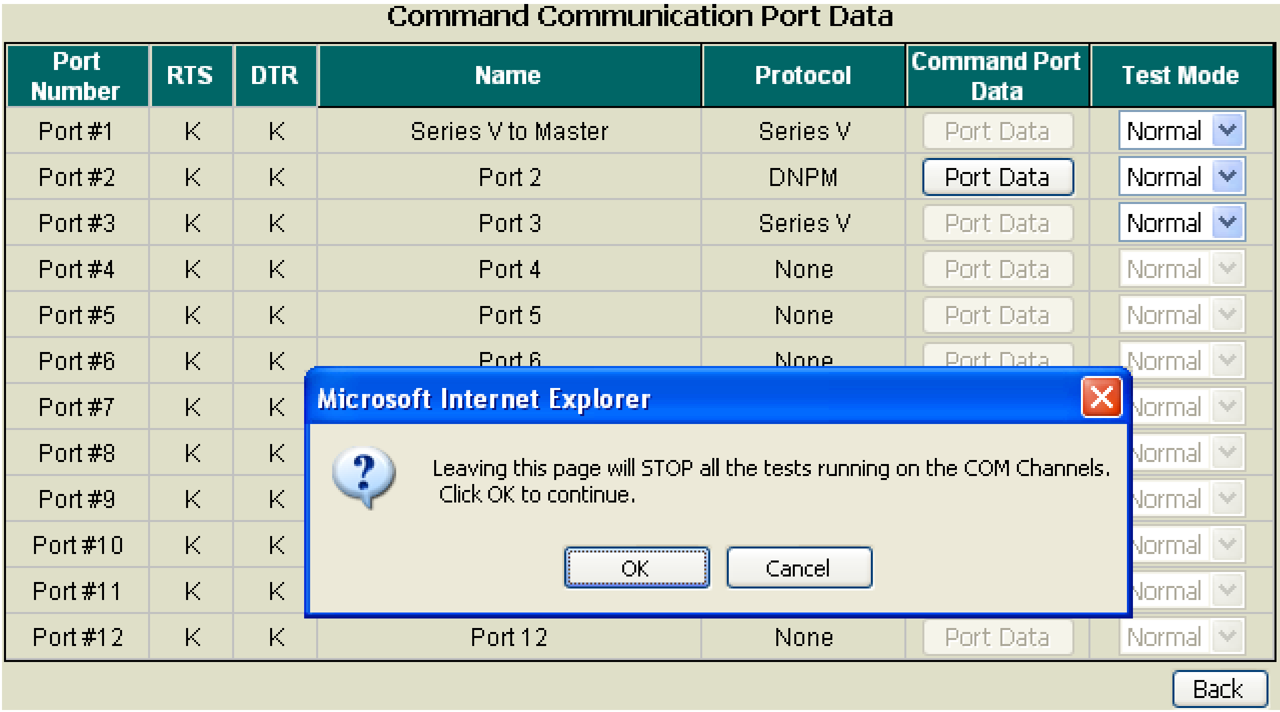
In the space mode, the selected comm channel outputs a continuous stream of zeros. Spaces for the RS-232 channel are high (positive) voltage pulses, and high frequency (2,200Hz) for any attached 202 modem.

Alt

In the Alt mode, the selected comm channel outputs a continuous stream of alternating ones and zeros at the baud rate originally selected for the channel.

You may use a scope to see the outputs on the ports under test as shown in Figure 4-4. Notice that the test mode will terminate and return to Normal mode if you leave this screen with the pull-down menus in anything other than Normal, as shown in Figure 4-3.

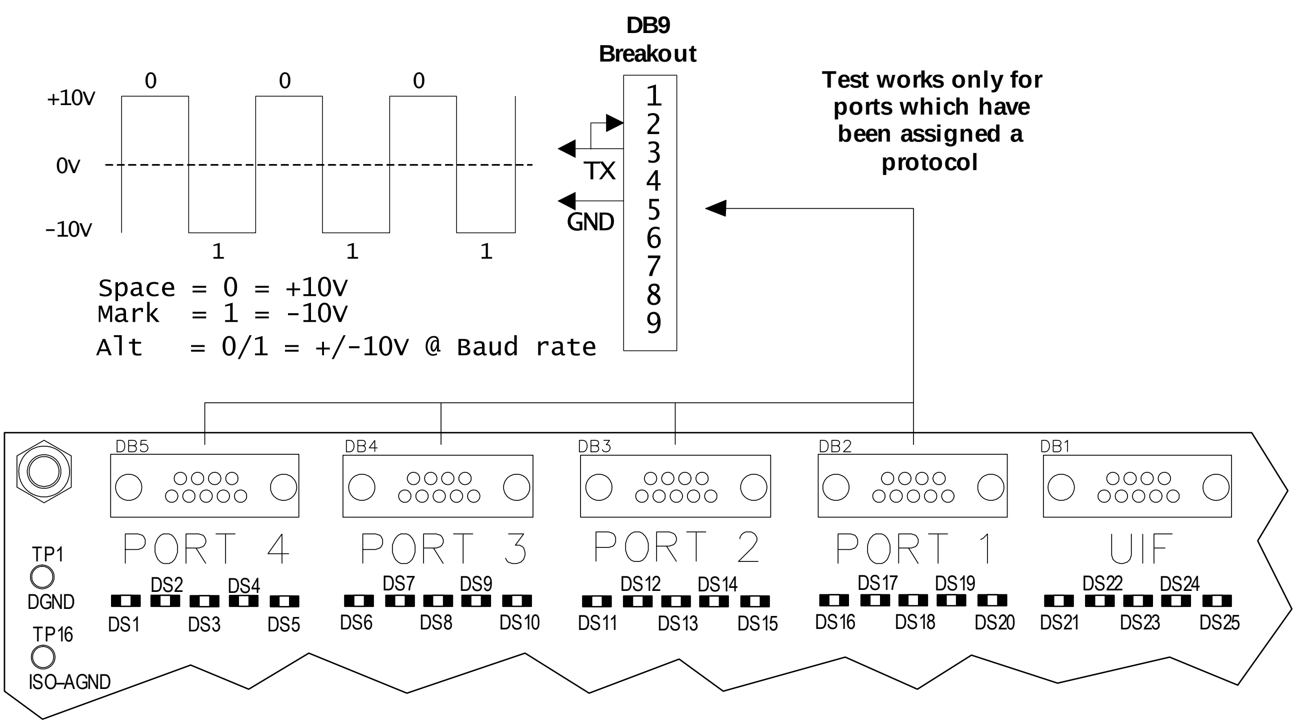
Figure 4-3 Clicking the Back Button While in Test



Command Communication Port Data

Port Number	RTS	DTR	Name	Protocol	Command Port Data	Test Mode
Port #1	K	K	Series V to Master	Series V	Port Data	Normal
Port #2	K	K	Port 2	DNPM	Port Data	Normal
Port #3	K	K	Port 3	Series V	Port Data	Normal
Port #4	K	K	Port 4	None	Port Data	Normal
Port #5	K	K	Port 5	None	Port Data	Normal
Port #6	K	K	Port 6	None	Port Data	Normal
Port #7	K	K				Normal
Port #8	K	K				Normal
Port #9	K	K				Normal
Port #10	K	K				Normal
Port #11	K	K				Normal
Port #12	K	K	Port 12	None	Port Data	Normal

Figure 4-4 Comm Port Test



4.4 Troubleshooting

This section includes a brief guide to troubleshooting some of the more common problems that could occur in the SAGE 1X50. If you are troubleshooting to the component level, the use of Chapter 5, Theory of Operation and the drawings located in the back of this manual will be helpful.

4.4.1 Removing PC/104 CPU Card or Compact Flash

Please refer to the CPU Manual.

4.4.2 Visual Inspection

A visual inspection of the equipment is often a good place to start the troubleshooting process. Look for frayed or loose connections, blown fuses, and any indications of damage or excessive wear. Check that switches and jumpers are in the right position and that input power is being supplied to the RTU. Verify that the LEDs are providing expected indications compared to the present status conditions.

4.4.3 Data Display

You can use the Data Display Menu to monitor the operation of input and output devices. The Data Display can be compared to the LEDs as a means of status verification.

4.4.4 LED Indicators on Baseboard

Refer to Figure 4-7 for the location of LEDs, Jumpers, Test Points, and adjustments on the Baseboard, and to Figure 4-5 for the location of LEDs on the C3438 Communications Expansion Card. The SAGE 1X50 has been designed with an ample number of LEDs to provide the operator an indication of the activities being performed by the RTU.

Power LED

The power LED (DS35) is illuminated and Baseboard power is provided when SW1 is on. Fuse F1 (directly above DS35) would be a prime suspect if DS35 is not lighted when SW1 is on. Fuse F1 is a 3AG 3 Amp 250 Volt slow blow fuse.

Battery Connected LED

The Battery Connected LED (DS45) is illuminated when power is applied to the RTU and the K9 relay (low voltage disconnect relay) is in the battery connected state. The battery need not be present for this LED to be illuminated.

Communication LEDs

Each of the RS-232 communications ports, both on the baseboard and on the C3438, are annunciated by 5 LEDs as noted in Table 4-1

Note: To conserve power, all communication LEDs except for UIF are deactivated if Primary Power is lost or disconnected. All other LEDs are unaffected.

Table 4-1 Communication LEDs

Signal	Baseboard					C3438 Communications Expansion Card							
	UIF	**CH-1**	**CH-2**	**CH-3**	**CH-4**	**CH-1**	**CH-2**	**CH-3**	**CH-4**	**CH-5**	**CH-6**	**CH-7**	**CH-8**
Tx	DS25	DS20	DS15	DS10	DS5	DS5	DS10	DS15	DS20	DS25	DS30	DS35	DS40
CTS	DS24	DS19	DS14	DS9	DS4	DS4	DS9	DS14	DS19	DS24	DS29	DS34	DS39
RTS	DS23	DS18	DS13	DS8	DS3	DS3	DS8	DS13	DS18	DS23	DS28	DS33	DS38
Rx	DS22	DS17	DS12	DS7	DS2	DS2	DS7	DS12	DS17	DS22	DS27	DS32	DS37
DCD	DS21	DS16	DS11	DS6	DS1	DS1	DS6	DS11	DS16	DS21	DS26	DS31	DS36

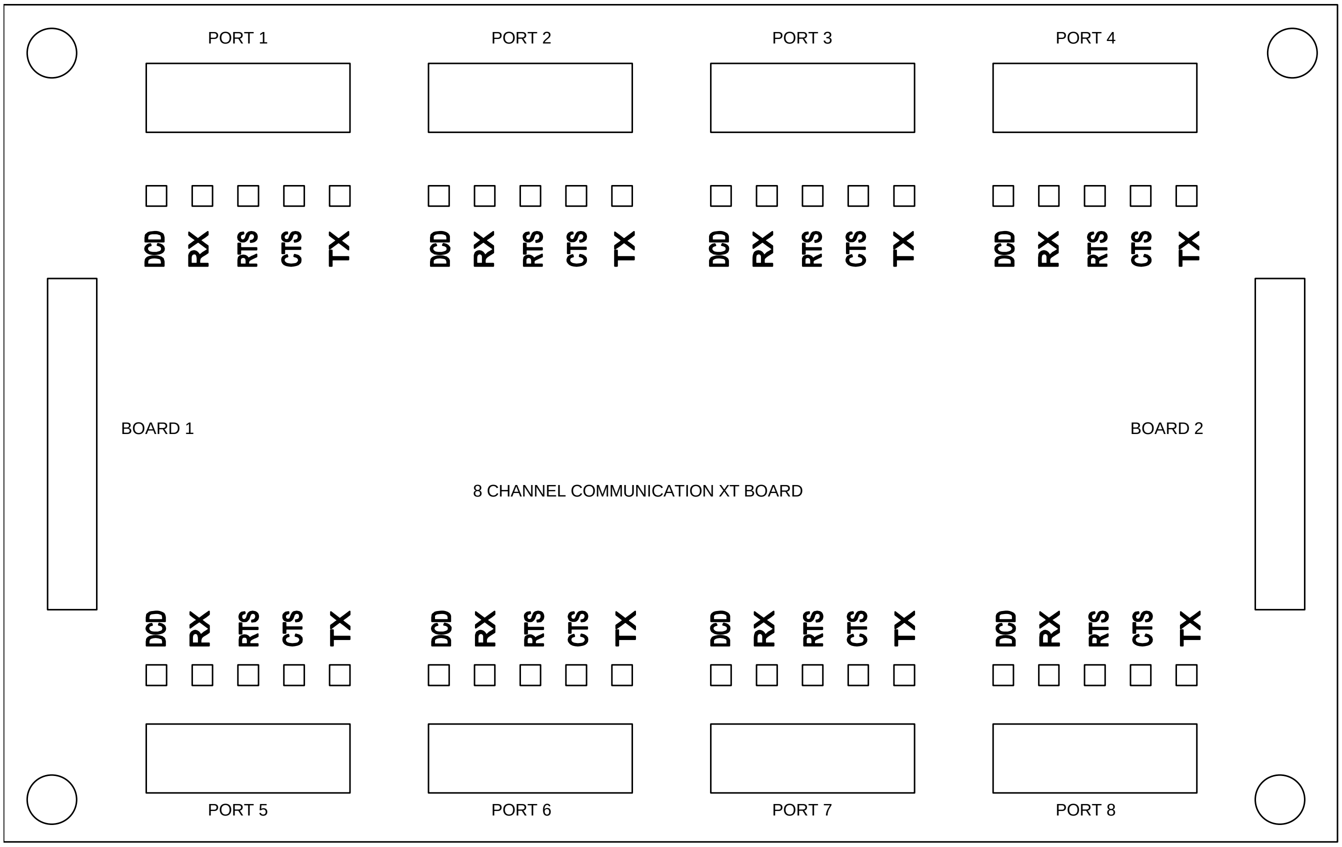
SBO LEDs

Nine LEDs (DS26 through DS34) illuminate when each of the SBO relays have been energized. DS26 illuminates for any SBO activation. DS27 through DS34 illuminate for each individual SBO.

Status LEDs

LEDs DS36 through DS43 indicate activity on the 8 Baseboard status input points. LED DS44 indicates wetting voltage for the status points. Fuse F2 (directly above DS44) would be a prime suspect if wetting voltage is present (either internally or externally, depending on the position of Jumpers W11 and W12) and DS44 is not lighted. Fuse F2 is a 3AG 1 Amp 250 Volt slow blow fuse.

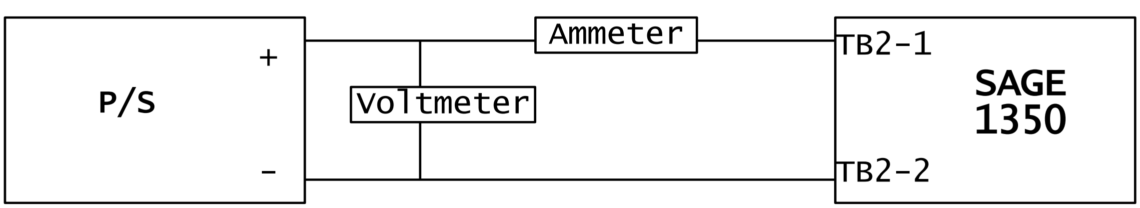
Figure 4-5 C3438 Board Layout



4.4.5 Power Consumption Test

If you suspect that the internal power supply is not performing properly, or that the board is drawing more power than it should, then check the power consumption of the RTU baseboard (unloaded; no I/O). If a power supply is installed at PS2, make sure that no power lines are connected at TB1. Also, disconnect the Phoenix connector from TB9.

Connect a variable external power supply as follows:



The test should yield the following results (approximately):

With PC/104 CPU Card installed

@ 10v = 691mA = 6.9 Watts
@ 15v = 466mA = 7.0 Watts
@ 33v = 445mA = 14.7 Watts

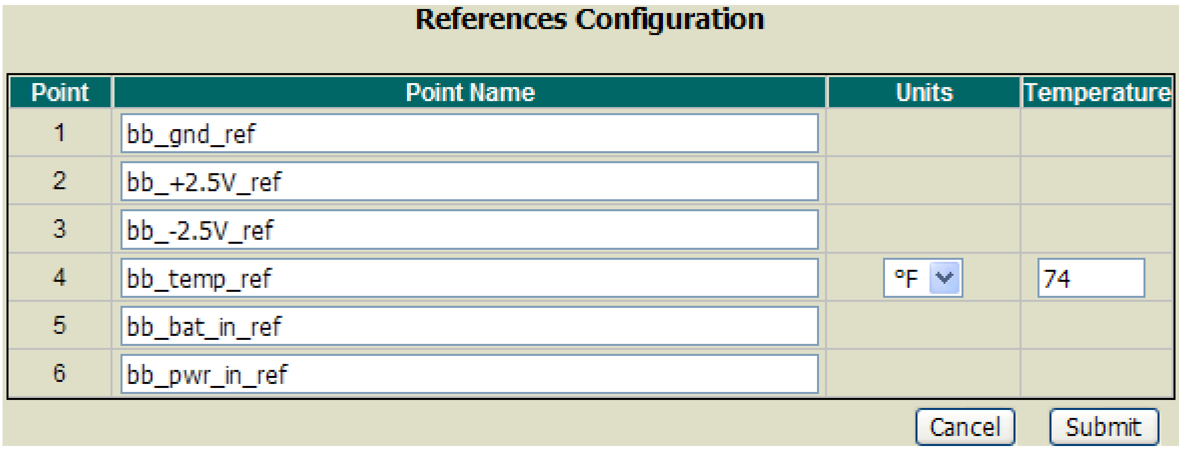
Without PC/104 CPU Card installed

@ 10v = 191mA = 1.91 Watts
@ 15v = 131mA = 1.965 Watts
@ 33v = 83mA = 2.739 Watts

4.5 Temperature Calibration

The References Configuration screen allows you to set the temperature units (°F or °C) and correct the temperature reading. This step should not be done remotely because you must enter the current correct temperature at the RTU. See below. Click Submit when you are satisfied with the configuration, or Cancel to back out of the function without saving.

Figure 4-6 References Configuration



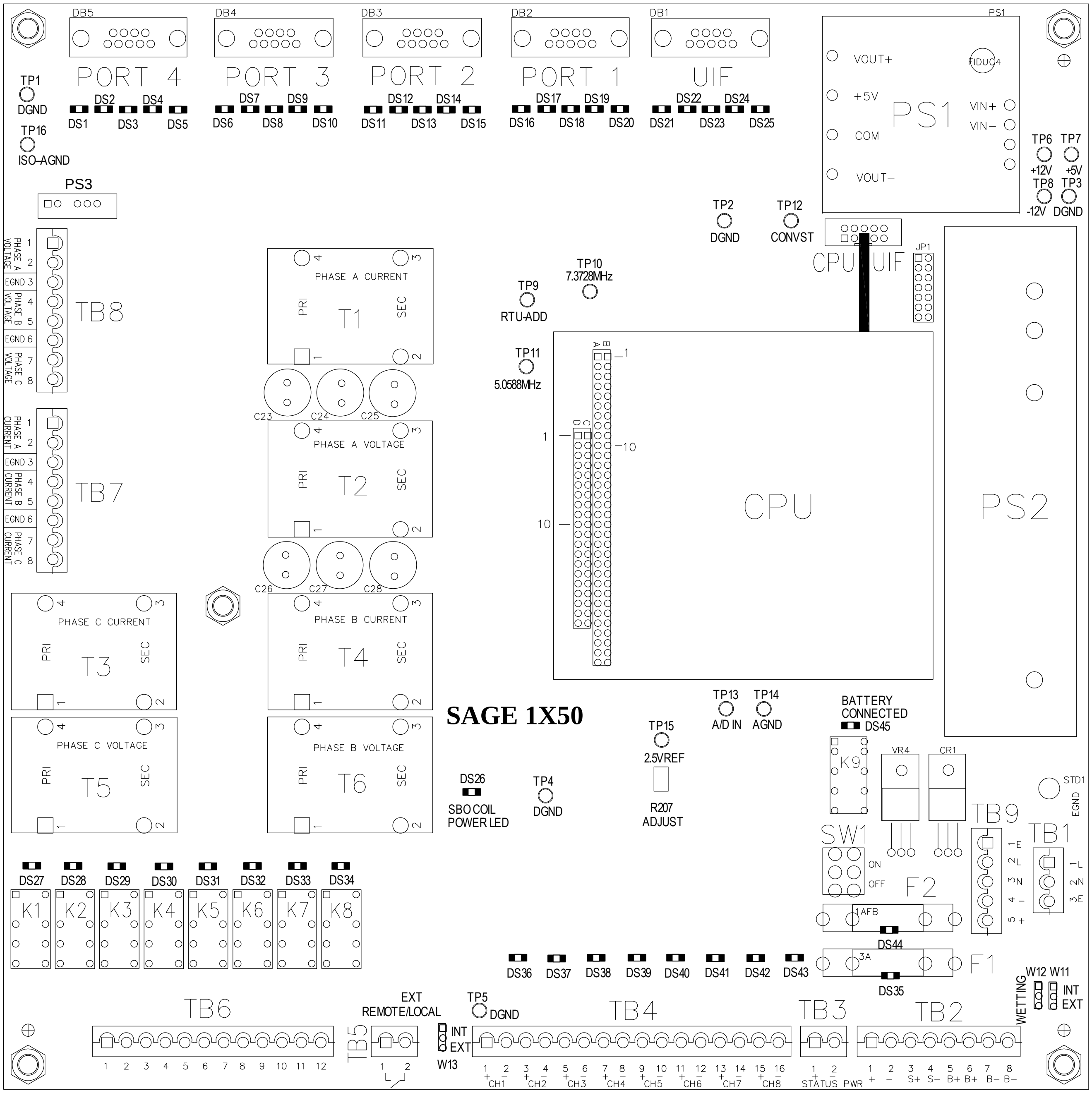
4.5.1 Test Points

The following test points are included on the SAGE 1X50 baseboard:

Table 4-2 Test Points

Testpoint	Signal	Schematic Page	Used For	Allowable Range
TP1	DGND	8 of 8		N/A
TP2	DGND	4 of 8		N/A
TP3	DGND	8 of 8		N/A
TP4	DGND	8 of 8		N/A
TP5	DGND	8 of 8		N/A
	+15 Volts	8 of 8		14.5 to 15.5
	-15 Volts	8 of 8		-15.5 to -14.5
TP6	+12 Volts	8 of 8		11.4 to 12.6
TP7	+5 Volts	8 of 8		4.95 to 5.05
TP8	-12 Volts	8 of 8		-12.6 to -11.4
TP9	RTU-ADD	1 of 8	Goes low when any I/O is accessed; useful as sync for looking at data and addresses.	N/A
	1,000.00Hz	8 of 8		999.95 to 1,000.05
TP10	7.3728MHz	8 of 8		7.3724 to 7.3732
TP11	5.0688MHz	8 of 8		5.0685 to 5.0691
TP12	CONVST	4 of 8		N/A
TP13	A/D IN	4 of 8		N/A
TP14	AGND	3 of 8	Return for A/D IN, 2.5VREF, F+S, F-S, F+15, F-15	N/A
TP15	2.5VREF	4 of 8		2.4995 to 2.5005
TP16	ISO-AGND	4 of 8	Return for ISO +15 and ISO -15	N/A
	ISO +15	4 of 8		13.5 to 16.5
	ISO -15	4 of 8		-16.5 to -13.5
	F +5	8 of 8		4.75 to 5.25
	F -5	8 of 8		-5.25 to -4.75
	F +15	8 of 8		14.5 to 15.5
	F -15	8 of 8		-15.5 to -14.5

Figure 4-7 Baseboard LED, Jumper, Test Point, & Adjustment Map



4.6 Jumper Positions, Baseboard

The factory test Baseboard jumpers are positioned as noted in Table 4-3. This may not agree with the configuration required for proper operation of your RTU. Determine the setup for your RTU by checking the function column in the table. For a detailed view of the SAGE 1X50 baseboard, please look in the back of this manual.

Table 4-3 Jumper Positions, Baseboard

Jumper	Name	Pins or Positions	Normal	Function	Circuit Diagram Sheet
W1	None	1-2	Out	Customer-specific for ACI sensor gain	5 of 8
		2-3	Out		
W2	None	1-2	Out	Customer-specific for ACI sensor gain	5 of 8
		2-3	Out		
W3	None	1-2	Out	Customer-specific for ACI sensor gain	5 of 8
		2-3	Out		
W4	None	1-2	Out	Customer-specific for ACI sensor gain	4 of 8
		2-3	Out		
W5	None	1-2	Out	Customer-specific for ACI sensor gain	4 of 8
		2-3	Out		
W6	None	1-2	Out	Customer-specific for ACI sensor gain	4 of 8
		2-3	Out		
W7	Debug	In/Out	Out	* Debugging - Schneider Electric internal use only	1 of 8
W11	Wetting	Int/Ext	Either	Wetting for Status inputs (both W11 & W12 must be in either Int or Ext)	6 of 8
W12					
W13	Remote/Local	Int/Ext	Either	If an external Remote/Local switch is connected at TB5, set to External. Otherwise, set to Internal	7 of 8

* Normally not used by customer, so this jumper is not shown on Figure 4-7.

4.7 Jumper Positions & Test Points, C3437 PC/104 Communications Card

Please see the Installation chapter to set jumpers correctly.

Figure 4-8 Jumper Positions & Test Points, C3437 PC/104 Communications Card

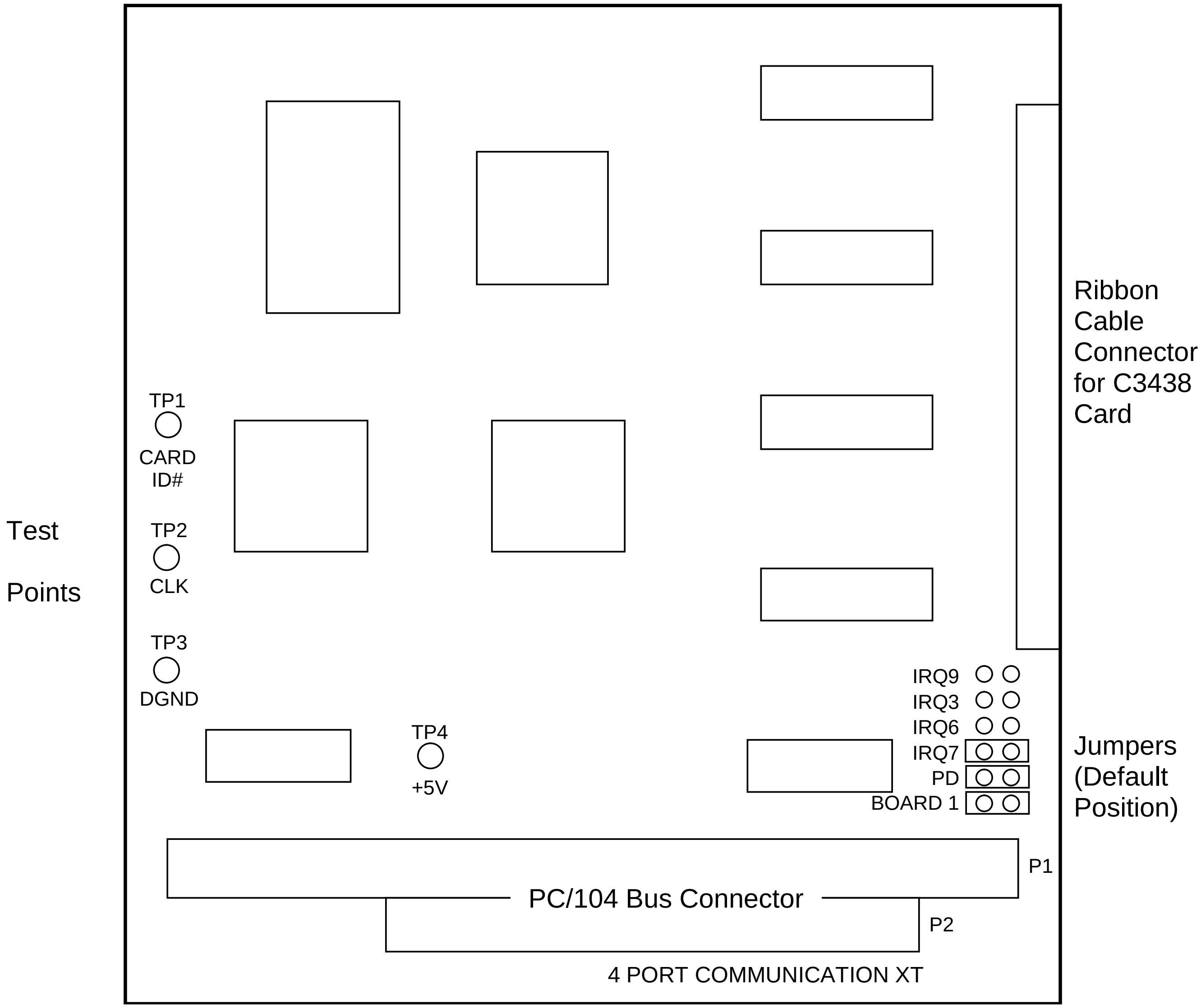
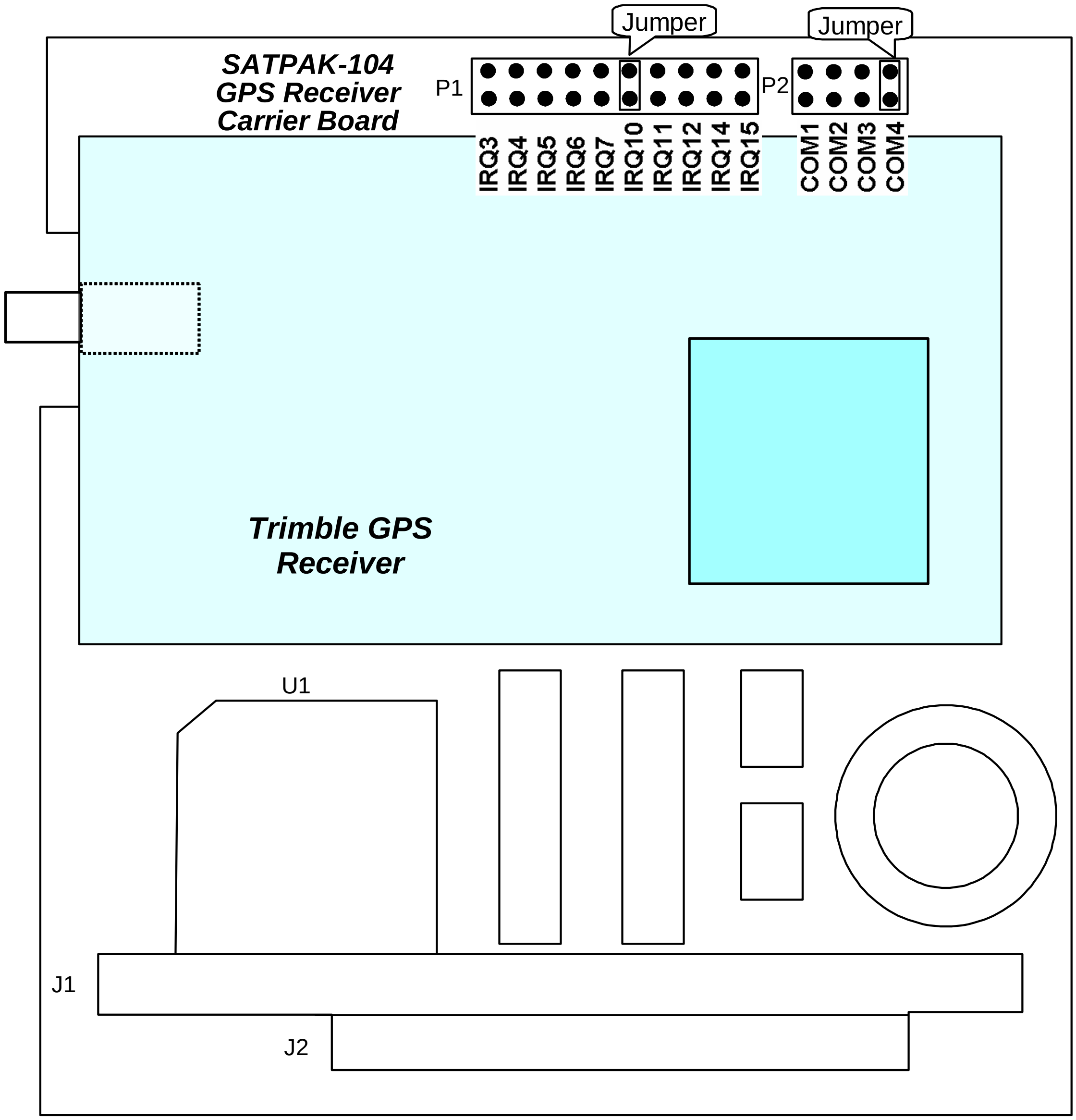


Table 4-4 Jumper Chart

JUMPER	SECTION	PIN	DEFAULT INSTALL	DESCRIPTION
W2	IRQ9	1–2		INTERRUPT 9
	IRQ3	3–4		INTERRUPT 3
	IRQ6	5–6		SHARED INTERRUPT 6
	IRQ7	7–8	IN	INTERRUPT 7
	PD	9–10	IN	PULLDOWN RESISTOR
	BOARD 1	11–12	IN	BOARD 1 SELECT

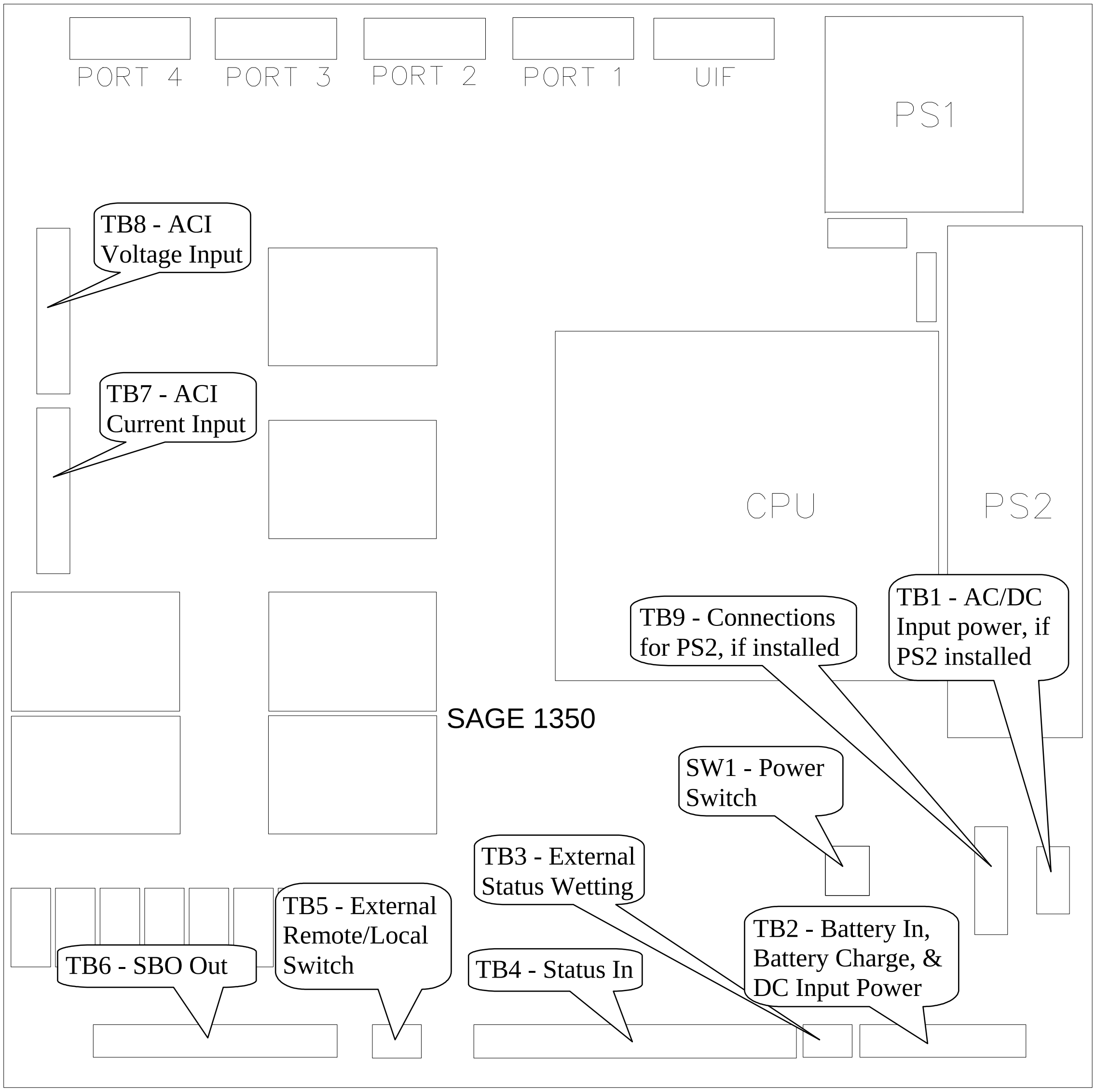
4.8 Jumper Positions, C3461 PC/104 GPS Card

Figure 4-9 Jumper Positions, C3461 PC/104 GPS Card



4.9 I/O Locations & Functions

Figure 4-10 I/O Locations & Functions



5 Theory of Operation

This section provides detailed technical design information on the SAGE 1X50, including design of the firmware and hardware. It is intended for use by those who wish to perform component-level troubleshooting and repair. This section is based on the simplified block diagrams included with the text. The schematic drawings and printed circuit assembly drawings at the back of this manual can be used for a more detailed study.

5.1 Basic Architecture

The SAGE 1X50 is composed of a Baseboard and a Daughter board microprocessor. Each unit performs a specific part of the functions necessary for operation as an intelligent remote terminal unit in a SCADA system. The Baseboard gathers data from the I/O and handles all communications with the Master Station(s). It maintains a central database containing all of the input/output data, and issues various types of commands as they are received from the Master Station(s).

Wiring is brought into the Baseboard through the use of terminal blocks. The Baseboard printed circuit assembly contains user terminations, transient protection, and any required input signal conditioning devices.

5.1.1 PC/104 Architecture

The open architecture of the PC/104 interface provides for expanded functions. You may add a PC/104 GPS receiver and/or C3437/C3438 Communication cards which allow up to eight additional Comm ports and/or a 3831 IRIG-B input as an option.

The PC/104 architecture is a compact version of the IEEE P996 (PC and PC/AT) bus, optimized for the unique requirements of embedded systems applications. The PC/104 derives its name from the 104 signal contacts on the two bus connectors (64 pins on P1, plus 40 pins on P2). The main differences from the IEEE P996 are:

1. Reduced form-factor (3.550 x 3.775 inches)
2. Self-stacking, eliminating need for backplanes or card cages
3. Minimized component count and power consumption (typically 1-2 watts per module) and reduced bus drive requirement (typically 4 mA)

5.2 SAGE 1X50 Microprocessor Overview

See CPU Manual for processor overview.

5.3 Hardware Design

5.3.1 C3437 PC/104 4-Port Communication XT

Each C3437 supports four external ports on a C3438 card. Up to eight ports are supported by using two C3437 PC/104 cards and one C3438 Port XT. The C3437 is connected by ribbon cable to the C3438.

P1 acts as the PC/104 interface. The C3437 acts as an 8-bit slave ISA card and as such only decodes the first nine addresses from the bus. Addresses SD15 - LA23 are in the connector but not brought out to the RTU.

The communication controller is a Zilog 85230. These devices have 4 byte TX FIFOs and 8-byte RX FIFOs.

Figure 5-1 C3437 Board Layout

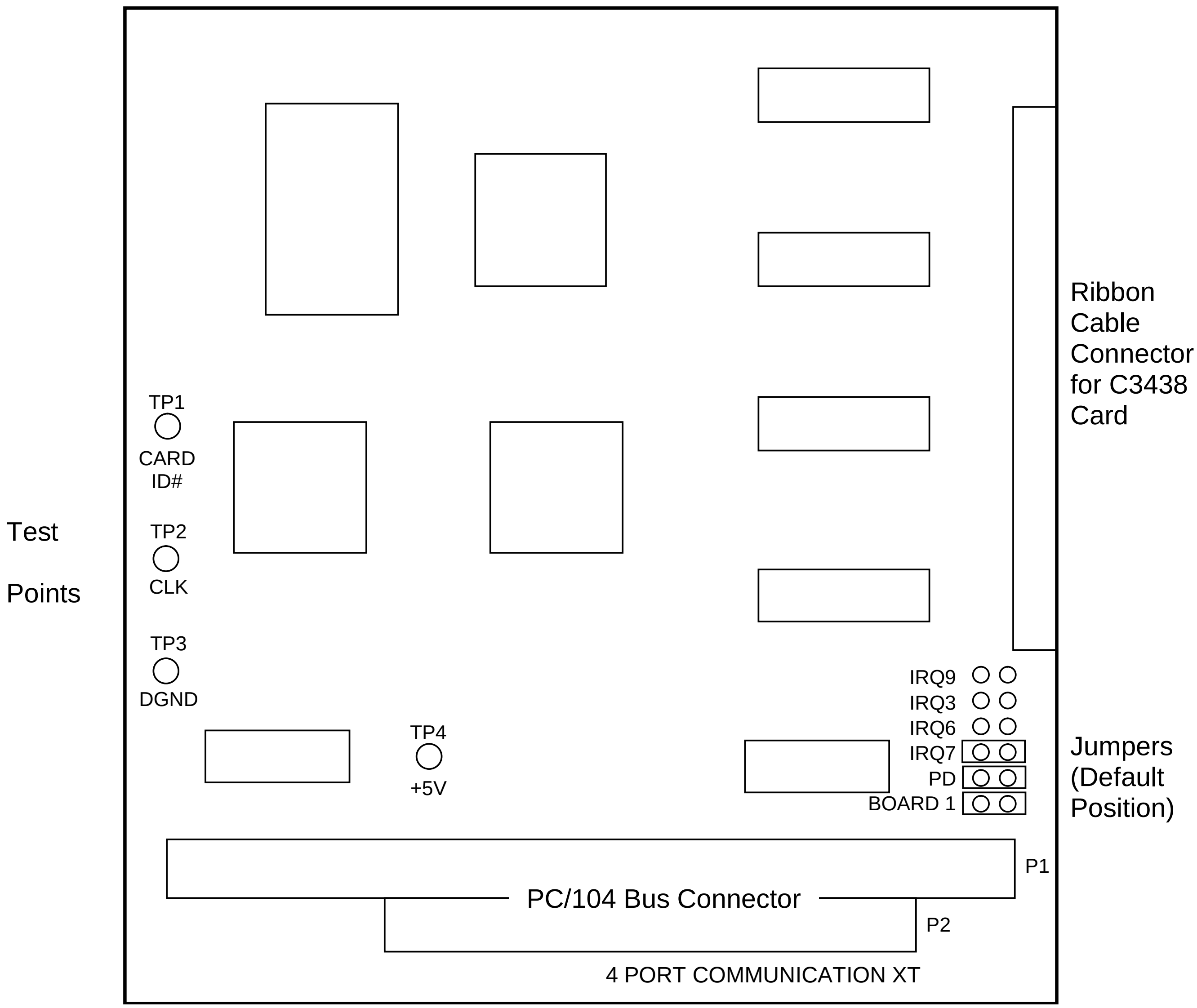


Table 5-1 Jumper Chart

JUMPER	SECTION	PIN	DEFAULT INSTALL	DESCRIPTION
W2	IRQ9	1–2		INTERRUPT 9
	IRQ3	3–4		INTERRUPT 3
	IRQ6	5–6		SHARED INTERRUPT 6
	IRQ7	7–8	IN	INTERRUPT 7
	PD	9–10	IN	PULLDOWN RESISTOR
	BOARD 1	11–12	IN	BOARD 1 SELECT

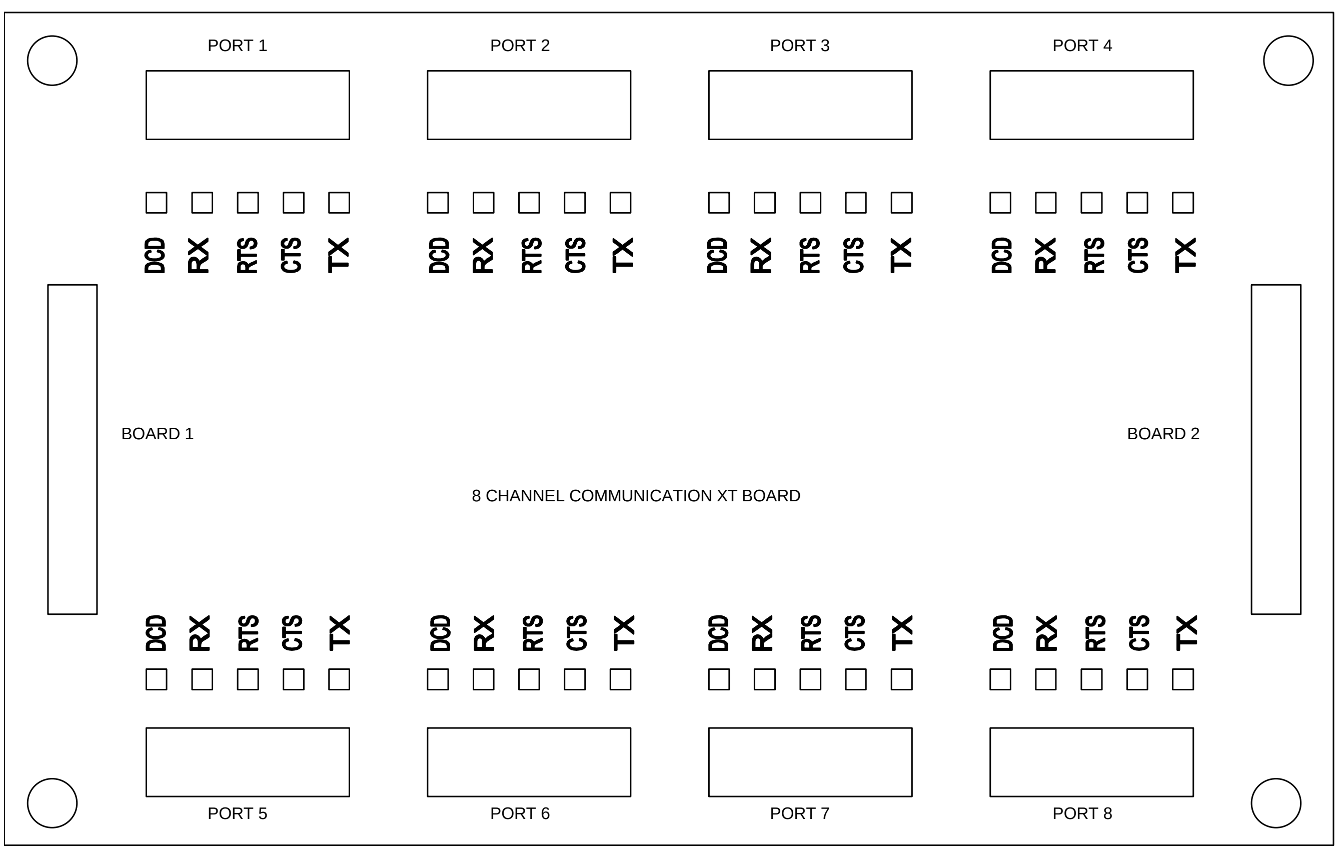
Table 5-2 I/O Port Addresses for the 4-Channel C3437 Communications Card

Port (hex)	ACRONYM	DEFINITON	READ/WRITE
180-183	CS-COM1&2	85230 Ports	READ & WRITE
184-187	CS-COM3&4	85230 Ports	READ & WRITE
188-18B	CS-COM5&6	85230 Ports	READ & WRITE
18C-18F	CS-COM7&8	85230 Ports	READ & WRITE

5.3.2 C3438 8-Channel Communication XT

Each port on the C3438 has its own RS232 driver. Each of the eight ports are identical and each can receive both transmit and receive clocks.

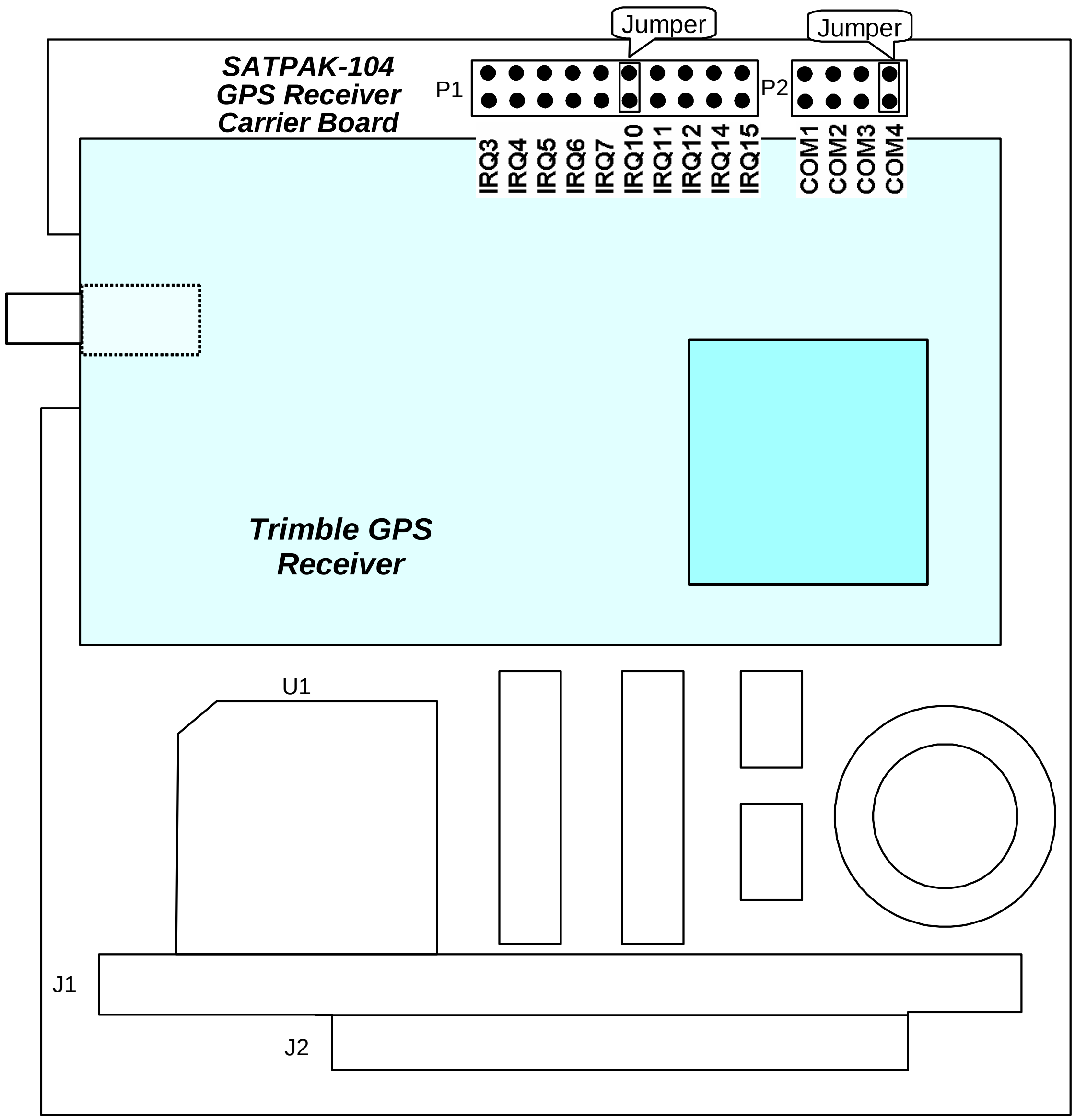
Figure 5-2 C3438 Board Layout



5.3.3 C3461 PC/104 Trimble GPS Receiver

The C3461 PC/104 Trimble GPS receiver consists of two boards; a PC/104 carrier card (SATPAK-104), with a Trimble GPS receiver riding piggy-back. See Figure 5-3.

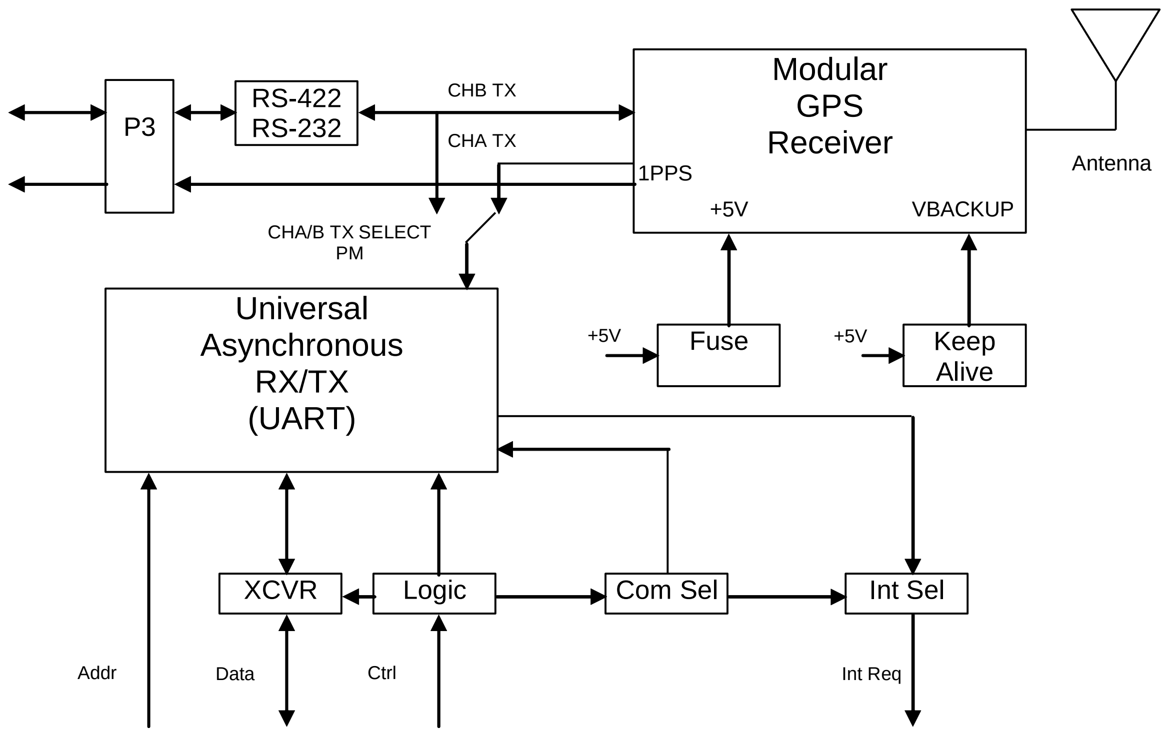
Figure 5-3 C3461 Board Layout



The SATPAK-104 communicates with the GPS receiver through a 16550 universal asynchronous receiver/transmitter (UART). The UART converts the serial TTL data required by the GPS receiver to parallel data required by the PC/l04 protocol. Simple push-on jumpers are used to configure the SATPAK-104 for standard input/output base addresses (COMI, COM2, COM3, COM4) and any of the available bus interrupt lines (IRQ3-IRQ7, IRQl0-1RQl2, IRQ14, or IRQ15). The J2 pass-through connector option must be installed to access interrupt request signals IRQ10-IRQ12, IRQl4, and IRQl5. Custom programmable logic is available if the user must decode base addresses other than those supported by the standard serial communication addresses. The SATPAK-104 also provides signal level conditioning for RTCM-104 serial differential correction signals (RS232 or RS422), and a large value l Farad capacitor to maintain the almanac, ephemeris, and real-time clock of the GPS receiver after power is removed. The GPS receiver is protected with a thermally resettable fuse in line with the +5V power to the GPS receiver. The IPPS signal from the GPS receiver is available on connector P3 located on the SATPAK-104.

The overall block diagram for the PC/104-Trimble receiver combination is shown in Figure 5-4.

Figure 5-4 GPS Receiver Block Diagram



5.3.4 Power Input

The SAGE 1X50 Baseboard has an internal AC/DC (optional) power supply. The output of the AC/DC supply connects to the DC power input to the C3600 baseboard. This DC input can accept DC power from +10VDC to +33VDC. The AC/DC supply has two standard outputs. These being 24VDC and 15VDC. These are configured for 24V and 12V battery applications respectively.

Terminal Block input TB1-1, TB1-2, & TB1-3 are used for AC input and are Line, Neutral and Earth Ground respectively. RV29 and RV30 provide input surge protection and TB9 provides the AC supply (PS2) with its AC input and DC output wiring.

SW1 provides a means of disconnect of DC power for the RTU. Note AC power once connected to TB1 will remain hot. The DC input fuse for RTU is F1 and fuses power just up stream of the DC/DC converter PS1 that provides +5VDC & +/- 15VDC for baseboard use.
VR1, VR2 and VR3 provide the power sources of F-5V, +12V and -12V respectively.

An internal battery charger is provided. This charger will float charge either 12VDC or 24VDC batteries (depending on options) by means of VR4. Low voltage disconnect functionality is provided by K9 and is controlled by software functions.

CR1 acts as a hot fail-over component. In the event of loss of AC power CR1 will pull power from the battery instead of the AC source.

5.3.5 Local/Remote Switch

The SAGE 1X50 can provide the function of an external Local/Remote switch by use of W13 jumper configured in the EXT position. In this case TB5 acts as the input termination for the external switch. When the external switch is in the off position no DC power is provided to the baseboard relays.

5.4 Communication Ports

The SAGE 1X50 baseboard has four RS-232 serial communication ports plus one RS-232 port that can be used for either Point-to-Point Protocol (PPP), or Console. The ports are accessed through 9 pin female connectors. Each pin has electrical surge protection. The combined data rate for all four ports is 100K baud. Baud rates are individually selected by port for rates between 300 and 9600 baud. The UIF is dedicated at 9600 baud.

5.5 AC Analog Inputs

The SAGE 1X50 is composed of a PC/104 board acting as the CPU and a Baseboard containing the digital signal processor (DSP), I/O AC and DC power function. The DSP and A/D converter along with the interface logic act together to measure and calculate AC quantities for a single circuit (one feeder). Two types of interface devices exist to connect the SAGE 1X50 to the AC circuit depending on the users interface type:

1. CT/PT interfaces
2. Linepost sensor interface

The firmware then downloads the user configuration into the DSP to set up the database required by the DSP to read and calculate the analog values for the circuit. The CPU then periodically reads the analog values from the DSP, scales the data, and writes the result into the databases for the Master Terminal Unit (MTU) protocols.

The CPU reads information from the DSP and the hardware digital inputs to maintain the RTU database. It also performs select before operate controls and all communications with the MTU, IEDs and the User Interface.

5.5.1 DSP Overview

The SAGE 1X50 digital signal processor (DSP), which is responsible for all analog measurement on the SAGE 1X50, uses an Analog Devices ADSP-2185 chip. The DSP runs at a 2 times the 7.3728 MHz clock speed, resulting in an 67ns instruction time. The DSP contains 80K bytes of On-Chip RAM configured as 16K words of Program Memory and 16K Words of Data Memory.

The communications between the DSP and the CPU is facilitated over the PC/104 interface. The DSP receives its program via the Internal Direct Memory Interface port (IDMA) and connects (16-bit mode) to the CPU via the PC/104 interface..

5.5.2 Sampling Scheme

The three phase current signals are split into six actual channels, with three normal range inputs (0-150%) and three high range inputs (150%-2000%). The normal range inputs are used for measuring the phase currents during normal operations and the high range inputs are used for fault detection and peak fault current measurements. The phase voltage inputs have a range of 0-125%.

The ACI subsystem uses a 6x oversampling scheme to achieve a more effective anti-aliasing filter without the need for elaborate hardware front end filters which can introduce phase errors between channels. For 60 Hz inputs, each channel is sampled at 96 samples per cycle and then down sampled to an effective sampling rate of 16 samples per cycle, or 960 Hz (for 60 Hz inputs). This implies that the 1st through 8th harmonics are to be included in the sampled signal and all higher harmonics must be suppressed or else they will alias into the lower harmonics.

The DSP samples all field inputs and a pair of DC inputs 96 times per cycle, resulting in a total of 63,360 channels digitized each second (for 60 Hz inputs). A precise, stable sample clock is obtained from a dedicated crystal-controlled oscillator to prevent the introduction of sample jitter due to software latencies in the DSP. This sample rate results in a Nyquist frequency of 2880 Hz such that only frequencies at or above 5280 Hz will alias into the first 8 harmonics (i.e., 5280 aliases to 480, 5340 aliases to 420,..., 5700 aliases to 60). All of these will be very small components of the original signal, and the input filter attenuates them another 30 dB, so the distortion of these desired harmonics is negligible at this stage. The hardware anti-alias filter also attenuates any high frequency noise components.

The over-sampled data is passed through a 4-pole Butterworth low pass digital filter run each time the channel is sampled (i.e., every 174 usec per channel). The corner frequency of this digital filter is set to 480 Hz, representing a trade-off between attenuating passband frequencies and passing unwanted components above the required 480 Hz Nyquist frequency. Its magnitude response characteristics are shown in Figure 5-6, along with the combined effect of the two filters. Note that it also passes the 50 and 60 Hz components with negligible attenuation.

Every 6th output sample of the digital filter is stored as an input sample and the other 5 are discarded. The effective sampling rate after this filtering and decimation operation is the desired 16 samples per cycle, but the data has now been subjected to the equivalent of a 6-pole anti-alias input filter. The combined filtering scheme allows some aliasing from the 10th harmonics and above into the 5th-8th harmonics, but the magnitude of these components will be small so the error in the true RMS calculation will be correspondingly small. The lowest harmonic which can alias back to the fundamental, is attenuated by more than 24 dB.

5.5.2.1 Hardware Anti-Alias Filter

All channels have the same type of filter: critically damped with the 3-dB corner frequency set to 960 Hz. This filter is implemented with ±0.5% low temperature coefficient (10 ppm/° C) resistors and ±5.0% film capacitors. These low tolerances give the needed stability and channel-to-channel phase matching needed for accurate power measurements. Gain resistors are matched to 0.02%.

Figure 5-5 Hardware Anti-alias Filter Frequency Response

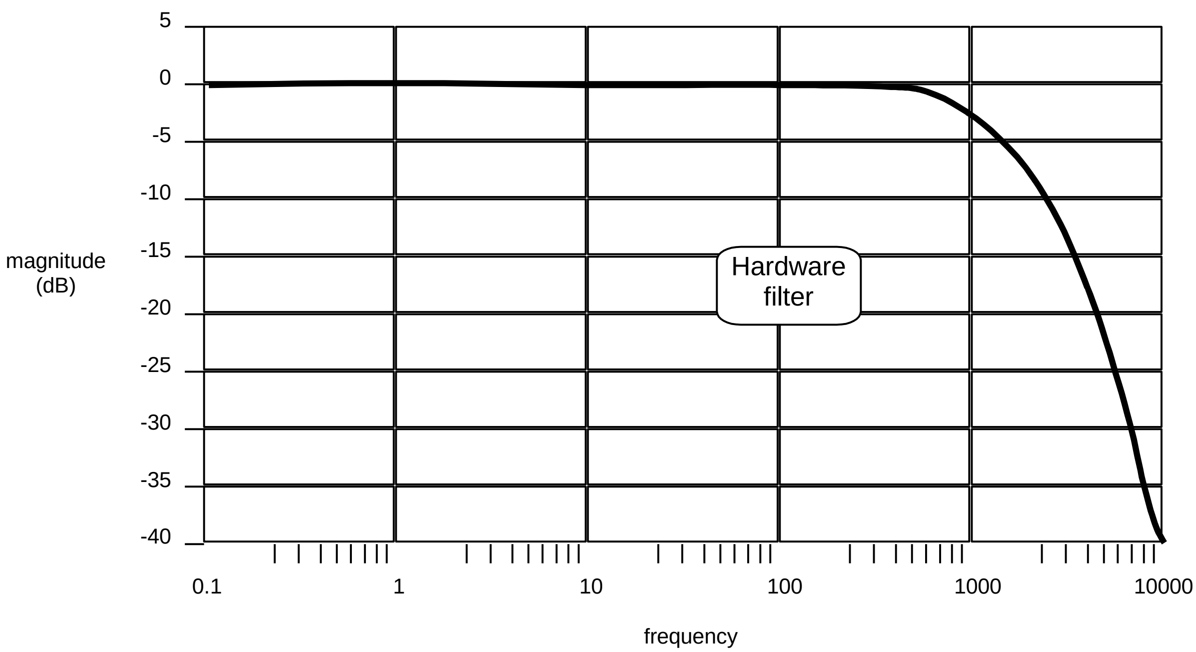
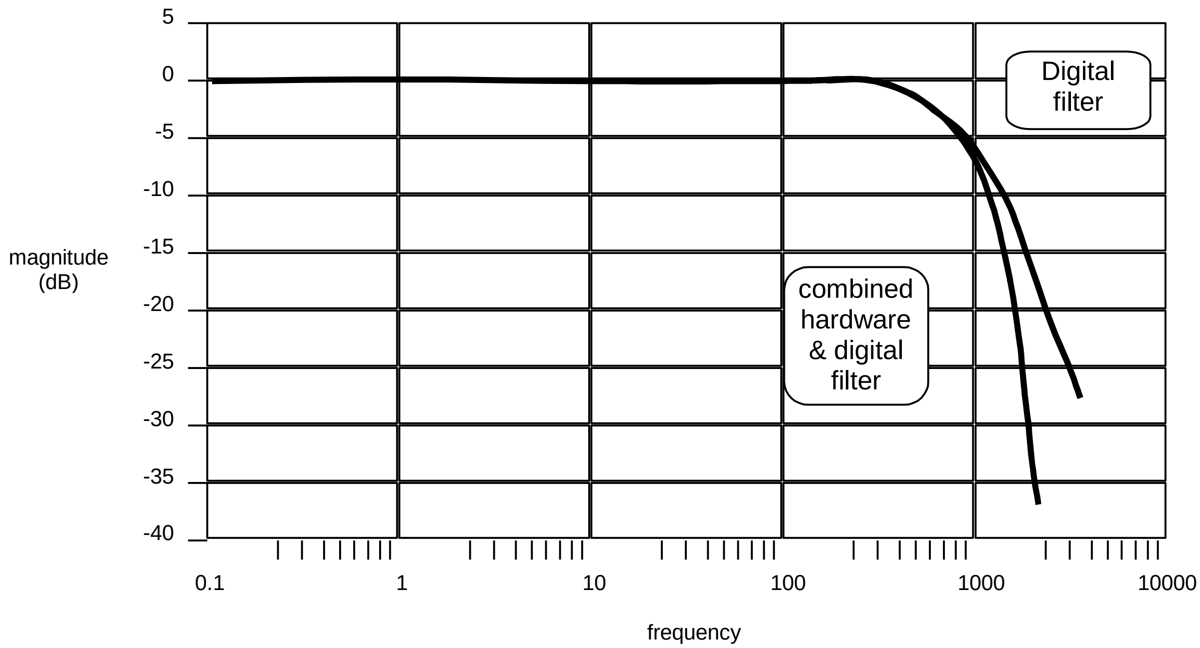


Figure 5-6 Hardware/Software Anti-alias Filter Frequency Response, 60Hz Operation



The hardware filters suppress high frequency noise and filter the incoming data for the 6th oversampling rate. It passes frequencies up to 480 Hz with little attenuation or phase shift, and in particular, it passes the 50 and 60 Hz component essentially untouched. It causes appreciable attenuation only above its 960 Hz corner frequency, as seen in Figure 5-5.

5.5.3 Basic Periodic Calculations

The raw data from the A/D converter is in 12-bit signed integer format. The filtering operation described in the preceding section is performed on this data in 16-bit format, resulting in 16-bit signed fractional format samples. Beyond this, however, all subsequent calculations are performed in full 32-bit signed fractional integer format, thus avoiding the introduction of resolution errors.

The periodic calculation load is distributed between the ACI subsystem and the microprocessor. The ACI subsystem samples the high range current inputs, the normal range current inputs, and the voltage inputs 16 times a cycle. At the end of each cycle, it uses this data to compute AC and RMS values, real and reactive power, and to perform fault detection and power quality monitoring functions.

The values obtained from the high and normal range current inputs will ordinarily be essentially the same except that the normal range readings will exhibit less resolution error and so are used for measuring the current under normal conditions and computing power. The high range readings are ignored in this case. The high range inputs serve as a means for monitoring the current during a fault, when the normal range channel can easily overscale.

All results are computed in the ACI subsystem's native fractional integer format. These are periodically scanned by the processor which converts them to floating point, scales them to engineering units and, in some cases, uses them to calculate additional quantities. The firmware also converts the data into a format suitable for the SCADA communication protocol being used.

5.5.4 ACI Calculations

The basic quantities computed by the ACI are described in the following sections.

5.5.4.1 Phasors

Phasors representing the high range phase currents, the normal range phase currents, the phase voltages, and the high and normal range neutral currents are computed. The phasors are automatically corrected (rotated) to compensate for the phase error due to sampling skew. At the resulting sample rate, the equivalent skew is approximately 0.3 degree per channel at 60 Hz. The DSP corrects their phase to that which would be measured had they all been sampled at exactly the same instant. These are complex numbers representing the instantaneous magnitude and phase of the inputs. These values represent the 60 Hz or 50Hz component only, but in the absence of any DC or significant harmonic content they will be identical to the calculated RMS values. Each phasor is computed in rectangular format (i.e., real and imaginary parts) using a formula based on the standard Discrete Fourier Transform (DFT):

$$Real\ Part = \frac{1}{8}\sum_{n=0}^{15} x_n cos\left(2\pi \frac{n}{16}\right)$$

$$Imag\ Part = \left(-\frac{1}{8}\right)\sum_{n=0}^{15} x_n sin\left(2\pi \frac{n}{16}\right)$$

Where the x_n are the 16 filtered samples of the phase voltages or currents acquired in the preceding cycle. The method for computing the neutral current phasors is described below in this section. The ACI subsystem computes the magnitudes of the phasors according to the following formula and these are periodically scanned by the baseboard.

$$magnitude = \sqrt{(real\ part)^2 + (imag\ part)^2}$$

The relative angle between voltage and current pairs is calculated from the apparent power, described below in Section "5.5.5 Power Calculations."

5.5.4.2 RMS Value

RMS readings are computed for the high and normal range current inputs, the voltage inputs, and the high and normal range neutral current inputs. The RMS value is computed as the square root of the average of the 16 samples squared. Since taking a square root is somewhat time-consuming for the DSP, the ACI subsystem computes these values as mean squared values (MSV) which is simply the average of the squared values. The baseboard converts them to actual RMS by taking their square root and then converts them to the appropriate engineering units. Note that the RMS quantities, unlike the phasors, will include the effects of any DC or harmonic components up through the 8th harmonic. The formula for computing the true RMS of a voltage or current is:

$$RMS\ Value = \sqrt{\frac{1}{16}\sum_{n=0}^{15} x_n^2}$$

As mentioned earlier, the RMS value will be the same as the phasor in the absence of any DC or harmonic components.

5.5.4.3 Neutral Current

The ACI subsystem also computes a set of high and normal range neutral currents, including both phasor and RMS representations. The phasor values are simply the vector sum of the corresponding set of current phasors and like those quantities, only represent the 50 Hz or 60 Hz content of the neutral current. Since this may not give an accurate measurement of the neutral current during a fault, an RMS value is also computed by summing the 16 samples from each phase to obtain samples of the neutral current. These samples are then used to compute the RMS values in the same manner as the RMS values of the phase currents. The RMS estimate is approximate because the raw samples of the phase currents are not corrected for sampling skew. However, in the ACI, this is only about 32 microseconds, and the error in the RMS estimate of the neutral current will typically be less than ± 1%

5.5.5 Power Calculations

Each cycle, the ACI subsystem computes the instantaneous real and apparent power for each phase, computed as the product of the voltage phasor and the conjugate of the current phasor:

$$S = VI^*$$

The result is a complex number whose real and imaginary parts are the real and reactive power respectively. Note that these are signed quantities, and thus they include power flow direction information.

The baseboard periodically uploads these complex numbers from the ACI and converts them to engineering units (watts and vars, respectively). The algebraic signs of the real and reactive power values are preserved to indicate the direction of flow. Positive watts represent a forward flow. VARs with a sign opposite to that of watts represents a leading power factor. The baseboard computes the magnitude and phase of the complex values. The magnitude represents the total apparent power (VA) and is computed analogously to the magnitude of the phasor values:

$$VA = \sqrt{WATTS^2 + VARS^2}$$

The phase angle of the apparent power is also computed as the phase angle of the phasor and gives the angle by which the current lags the voltage on the phase.

$$\theta = tan^{-1}\left(\frac{VARS}{WATTS}\right)$$

The baseboard also computes the power factor for the phase as:

$$PF = ABS\left(\frac{WATTS}{VA}\right)$$

The baseboard sums the real and reactive components for the three phases to compute the total apparent, real, and reactive power and the power factor for the circuit.

5.5.6 Power Quality Calculations

Each cycle, the ACI subsystem also computes several quantities intended to provide the user with a simple means for monitoring power quality on an ongoing basis, including computation of the current and voltage harmonic content up to the 7th harmonic (i.e., 120Hz through 420Hz for 60Hz systems) and recording the number of voltage sags and swells on each phase of the feeder.

The harmonic components are computed for the normal range phase currents and the phase voltages each cycle, using the same DFT routine as the phasor calculation, with the appropriate increment through the sine and cosine tables. The result is a very high accuracy estimate of the harmonic content of the current and voltage for each phase. The baseboard scans the harmonic data and converts the components to a percentage of the instantaneous magnitude of the associated current or voltage phasor.

5.5.7 ACI Analog Events

5.5.7.1 Voltage Quality

The ACI subsystem monitors the RMS voltage level on each phase and records the number of sags and swells. A sag occurs on a phase whenever the voltage on that line falls below a user-defined threshold and stays below that threshold for more than a programmable delay time. Similarly, a swell occurs whenever the phase voltage exceeds a user-defined threshold and stays above that threshold for more than the same delay time. Each time the voltage level returns to normal from a sag, the sag counter for that phase is incremented, and each time it returns to normal from a swell, the associated swell counter is incremented. These six counters are scanned and can be configured as pseudo accumulator inputs and displayed or reported back to the master station.

The sag/swell delay and the sag and swell thresholds are common for all phases. These thresholds are completely independent of the low voltage thresholds described in the next section.

5.5.7.2 Fault Detection

An overcurrent event in the RTU is processed in three phases:

Initial

This phase begins with the first cycle in which an overcurrent condition is detected and continues until the event has been validated as the start of a potential fault.

In-progress

This phase begins when the initial validation process is completed and continues as long as the overcurrent condition persists.

Final

This phase begins when the overcurrent condition ends and consists of special processing, based on the magnitude of the phase voltages, to validate the event as an actual fault.

Concurrent overcurrent events on one or more phases or the neutral is treated as a single event, i.e., the algorithm described in the following sections simultaneously monitors the RMS phase and neutral currents, and treats the cases of concurrent threshold violations (e.g., a phase current and a neutral current) as a single fault, possibly involving multiple phases.

5.5.7.3 Initial Processing

Each cycle, the DSP computes the RMS current and voltage on each phase and the neutral current, from the corresponding set of 16 samples taken during the cycle. The DSP compares each of the RMS currents to a user-programmed fault threshold. When a value exceeds its associated threshold, an overcurrent event record is initialized by recording the time of the initial limit violation and the magnitude of the RMS currents, and resetting a "pre-alarm" timer to zero.

The pre-alarm timer is analogous to a debounce timer on a digital input. Each subsequent cycle, after the one in which the overcurrent condition was first detected, that any of the four RMS current values exceeds its associated threshold, the pre-alarm timer is incremented. When the timer count reaches a programmable startup delay value, the event is considered to be validated for the next phase of processing. The time of the event however is the cycle in which the overcurrent condition was first detected and not the cycle in which this startup criterion is satisfied.

If any combination of the overcurrent conditions is present for the entire startup delay, the event is considered to be validated for the next phase of processing. If all of the RMS currents fall below their thresholds before the minimum startup delay is reached, the event is discarded and no further processing occurs. Note that this pre-alarm timer can effectively be disabled by setting the startup delay to 1, which is equivalent to treating every overcurrent condition, no matter how short, as the start of a potentially valid event.

Throughout the initial phase, all RMS currents are monitored each cycle, and if any exceeds the maximum value recorded since the start of the event, that value is recorded as the new maximum and the currents and voltages on each phase are snapshot, as described below. A duration counter, which records the length of the event in cycles, is also incremented each cycle that any of the currents continue to exceed its threshold.

5.5.7.4 In-progress Processing

After the initial validation criterion has been met, the DSP continues to monitor the RMS currents and increment the duration counter, once each cycle. If a new maximum RMS value is detected on any phase or the neutral, it is recorded along with a snapshot of the phase voltages and currents measured during that cycle. The end result of this recording during the initial and in-progress phases is that when the event is over, the DSP will have a snapshot of the various voltages and currents, taken at the time of the maximum RMS fault current.

When all RMS currents are below their threshold, the duration counter is not incremented and final phase processing begins.

5.5.7.5 Final Processing

When each RMS current value is below its associated threshold, a "post-alarm" timer, called the "delay time counter", is reset and then incremented, once each cycle, until a programmable delay time is reached. At that point, the algorithm begins a computation of average RMS voltage on each phase.

The averaging period, called the "signal integrity", is user-programmable and specifies the number of cycles over which the phase voltages are averaged. At the end of the signal integrity interval, the average voltage on each phase is compared to a user-programmable low voltage threshold.

If all three average phase voltages are less than the threshold, the event is validated and is processed as described in the next section. Otherwise, the event is invalidated and is discarded. In either case, the algorithm is rearmed for the start of a new overcurrent event.

As an example of the fault detection algorithm, consider a simple A-G fault. In this case the DSP will detect overcurrent conditions on both phase A and the neutral, although possibly not in the same cycle, since the sampling cycle and occurrence of the fault itself are not synchronized to the line. The DSP might detect the neutral overcurrent first, since its threshold is typically set lower, and then one or more cycles later, but while the neutral overcurrent condition is still in effect, the overcurrent condition on phase A might be detected. A similar difference in return-to-normal times might also exist at the end of the event.

This set of conditions would result in a single fault record, with an indication that both phase A and the neutral currents were involved. The start time of the fault would be the cycle in which the first overcurrent condition was detected and the duration would indicate the number of cycles until all overcurrent conditions had returned to normal. Thus, the fault persists as long as there is some overcurrent condition and any set of overlapping overcurrent conditions is treated as a single fault.

5.5.7.6 Fault Data

Recorded Data

Each fault recorded by the ACI subsystem of the RTU includes the following data:

1. The time of the fault, in the form of a 16-bit counter which indicates the cycle in which the event started. It is kept synchronized with periodic synch commands from the baseboard processor and is converted to a 1 msec resolution time by the ACI task running in that processor.
2. The duration of the fault, also in the form of a 16-bit counter which indicates the total duration of the overcurrent event, in cycles. It is used to determined the stop time of the fault.
3. A flag word containing bits which correspond to the particular phase(s) or neutral current which violated its threshold at some time during the event.
4. A snapshot of the RMS voltage and current on each phase and the neutral, taken during the cycle in which the RMS fault current reached a maximum value.
5. A snapshot of the complex voltage and current phasors on each phase and the neutral, taken during the cycle in which the RMS fault current reached a maximum value.

5.5.7.7 Computed Status Data

The data recorded by the ACI subsystem is converted to engineering units and optionally stored in the RTU analog data base. Two types of pseudo status points are also computed from the event record, either or both of which can be optionally assigned to digital input points in the RTU database where they will be processed the same as ordinary digital inputs, including optional SOE processing.

Fault Indication

When the fault record is completed, one or more (usually an overcurrent condition will exist on at least two phases or a phase and the neutral) fault pseudo status points are "closed", with a timetag equal to the recorded start time of the fault. The point is then immediately "opened", with a timetag equal to the start time + the recorded duration. A separate calculated status point is provided for each phase and neutral (although they could all be assigned to the same database point to provide an OR function), with the result that at least two pseudo points are updated for each event (i.e., phase-neutral, phase-phase, etc.). If the pseudo points are assigned to actual data base points, the changes will appear as ordinary status input changes, complete with accurate close/open SOE timetags if enabled. Otherwise, this information is discarded. The changes happen too quickly to be visible on the UIF displays, but can be seen in the SOE reports on a test set.

Direction Indications

The complex voltage and current associated with the faulted phase are used to estimate the direction (upstream or downstream) of the fault, as described below. A single pair of pseudo status points, corresponding to faults upstream and downstream of the remote is provided. If a direction is successfully computed from the fault record, the corresponding point is "closed" and then "opened", in exactly the same fashion as the fault indicators described above.

Aside from the details of the algorithm for computing the direction, once a direction is chosen, a pseudo status point corresponding to the direction is "closed" and then "opened", in exactly the same fashion as the fault indicators described above. Here, there are a pair of pseudo status, corresponding to forward and reverse, for each phase. There is no direction calculation for the neutral, since there is no voltage phasor available.

5.5.7.8 Fault Direction Computation

The fault impedance is computed from a simple ratio of the complex voltage and current phasors recorded at the time of the maximum fault current, but the choice of voltage and current in the ratios varies depending on the type of the fault. For a phase-neutral fault, the impedance is computed from:

Type	Impedance
AG	$Z = \dfrac{V_A}{I_A}$
BG	$Z = \dfrac{V_B}{I_B}$
CG	$Z = \dfrac{V_C}{I_C}$

And for phase-phase faults (including 3 phase faults), the Impedance is computed from:

Type	Impedance
AB	$Z = \dfrac{V_{AB}}{I_{AB}}$
BC	$Z = \dfrac{V_{BC}}{I_{BC}}$
CA	$Z = \dfrac{V_{CA}}{I_{CA}}$

where the current I_{AB}, between phases A and B, for example, is estimated from
$I_{AB}, = (I_A - 1_B)/2$.

These formulas ignore several effects, but should work reliably enough on radial feeders when the load current is small compared to the fault current.

The type of fault is determined from the flags in the event record and the impedance formula is chosen accordingly. The direction of the fault is determined from -Z, the angle of the computed impedance: an impedance vector in the first quadrant (resistive + inductive) indicates a forward (downstream) fault and a vector in the 3rd quadrant (- resistive + capacitive) indicates a reverse (upstream) fault. If the vector falls in either of the other two quadrants, the result is equivocal and no direction indication is generated.

The impedance calculation is also suppressed in cases where the magnitude of the numerator voltage or current phasor is less than 1% of full scale or in other cases where the event information is not reasonable (e.g., an overcurrent indication on a single phase without a corresponding indication on the neutral). The magnitude of the current phasor should always be large and the voltage phasor magnitude should only be very small in cases where the fault is physically located very close to the RTU.

5.5.8 Feeder Monitor Events

The parameters in the EVENT DETECTION PARAMETERS found in the config@web Software User Guide on page 1 of the "Edit AC analog Setup" configuration are used to control the generation of these events.

The "Event monitoring enabled" flag must be set to 'Y' before any events will be recorded.

There are four different events that can be recorded:

1. Overcurrent – One (or more) phase current(s) exceeds the "Phase current threshold" or the neutral current exceeds the "Neutral current threshold". The overcurrent event is always recorded.
2. Overvoltage – One (or more) phase voltage(s) exceeds the "Voltage swell threshold". The recording of overvoltage events is controlled by the "Report sag/swell events" enable(Y) or disable(N).
3. Undervoltage – One (or more) phase voltage(s) is less than the "Voltage sag threshold". The recording of undervoltage events is controlled by the "Report sag/swell events" enable(Y) or disable(N).
4. Outage – All three phase cuurents is less than the “Current outage threshold”, optionally qualified by all three phase voltages being less than the "Voltage outage threshold". The recording of Outages is controlled by the "Report outage events". If this flag is set to ‘Y’, the "Use voltages in

outage" flag is used to enable(Y) or disable(N) the testing of the voltage to qualify an outage event.

Each of these events must meet or exceed the number of AC cycles specified in the "Validation time (cycles)" before the event is qualified and recorded.

5.5.8.1 Event Detection

An event in the RTU is processed in three phases:

Initial

This phase begins with the first cycle in which an event condition is detected .

In-progress

This phase begins when the initial validation process is completed and continues as long as the event condition persists.

Final

This phase begins when the event condition ends and consists of special processing, based on the magnitude of the phase voltages, to validate the event as an actual fault.

Concurrent events on one or more phases or the neutral is treated as a single event, i.e., the algorithm described in the following sections simultaneously monitors the RMS phase and neutral currents, and treats the cases of concurrent threshold violations (e.g., a phase current and a neutral current) as a single event, possibly involving multiple phases.

Initial Processing

Each cycle, the DSP computes the RMS current and voltage on each phase and the neutral current, from the corresponding set of 16 samples taken during the cycle. The DSP compares each of the RMS currents and voltages to a set of user-programmed event thresholds. When a value violates its associated threshold, recording the time of the initial limit violation and the magnitude of the RMS currents and voltages initializes an event record.

In-progress Processing

The DSP continues to monitor the RMS values and increments the duration counter, once each cycle. A snapshot of the phase currents and voltages measured during that cycle is recorded. The end result of this recording during the initial and in-progress phases is that when the event is over, the DSP will have a snapshot of the various voltages and currents

When all RMS values are within their thresholds, the duration counter is not incremented and final phase processing begins.

Final Processing

The final processing consists of validation of the event. If the event has persisted over the “Validation time (cycles)” parameter, the event is validated and the event is written into DSP memory to be retrieved by the CPU and stored in the memory allocated for this purpose. If the event did not persist for this number of cycles, the event is discarded.

The Initial Processing state for the next event detection cycle is begun at the end of this state.

5.5.8.2 Event Data

Recorded Data

Each event recorded by the ACI subsystem of the RTU includes the following data:

1. The time of the event, in the form of a 16-bit counter which indicates the cycle in which the event stopped. It is kept synchronized with periodic synch commands from the baseboard processor and is converted to a 1 msec resolution time by the ACI task running in that processor.
2. The duration of the event, in the form of a 32-bit counter which indicates the total duration of the event, in cycles. It is used to determine the start time of the event.

3. A flag word containing bits which correspond to the particular phase(s) or neutral current that violated its threshold at some time during the event.
4. One cycle of pre-event waveshape data and up to 19 after the start of the event. This data, for each of the phase currents and voltages, consists of the 16 samples for each of the cycles that the event persists, up to a limit of 20 cycles. If the event persists over 20 cycles, up to 101 cycles of mean square data is retained for the phase currents and voltages and the neutral current.

   An outage event contains only the first three items.

   An overcurrent event trigger ends any in-progress outage events. An outage event trigger ends any in-progress undervoltage event.

5.5.8.3 Computed Status Data

Pseudo status points are also computed from the overcurrent event records which can be optionally assigned to digital input points in the RTU database where they will be processed the same as ordinary digital inputs, including optional SOE processing.

Overcurrent Indication

When the overcurrent event record is completed, one or more (usually an overcurrent condition will exist on at least two phases or a phase and the neutral) event pseudo status points are "closed", with a timetag equal to the recorded start time of the fault. The point is then immediately "opened", with a timetag equal to the start time + the recorded duration. A separate calculated status point is provided for each phase and neutral (although they could all be assigned to the same database point to provide an OR function), with the result that at least two pseudo points are updated for each event (i.e., phase-neutral, phase-phase, etc.). If the pseudo points are assigned to actual data base points, the changes will appear as ordinary status input changes, complete with accurate close/open SOE timetags if enabled. Otherwise, this information is discarded. The changes happen too quickly to be visible on the UIF displays, but can be seen in the SOE reports on a test set.

The status points change state for only overcurrent event records.

5.5.9 Analog Reporting

The various data values measured and computed by the analog subsystem are equivalent to accumulator inputs and status inputs, as monitored by the SAGE 1X50 from field devices. Since most communication protocols have no provisions for explicit calculated data types (e.g., floating point values) the simplest solution is to scale the calculated results back into an integer format (usually 12 or 16 bits) so that they can be inserted into spare points in the communication protocol and thus be scanned by the master station. The details for making these assignments to protocol points are described in the config@WEB Software Users Guide.

5.6 Select Before Operate

The SBO interface uses one execute line EXE-PWR and eight select lines to form a matrix for driving SBO relays (8). Led indication of execute power is provide by DS26 while indication of the closure of each relay is provided by DS27-DS34 for K1-K8 respectively.

Both the EXE-PWR and select lines (CSEL8-CSEL14) are read back to the CPU by means of a feedback register U38 and the RB-EXE signal connected to the EPLD (U13). Remote/Local function can be made external via jumper W13.

5.7 Digital Input

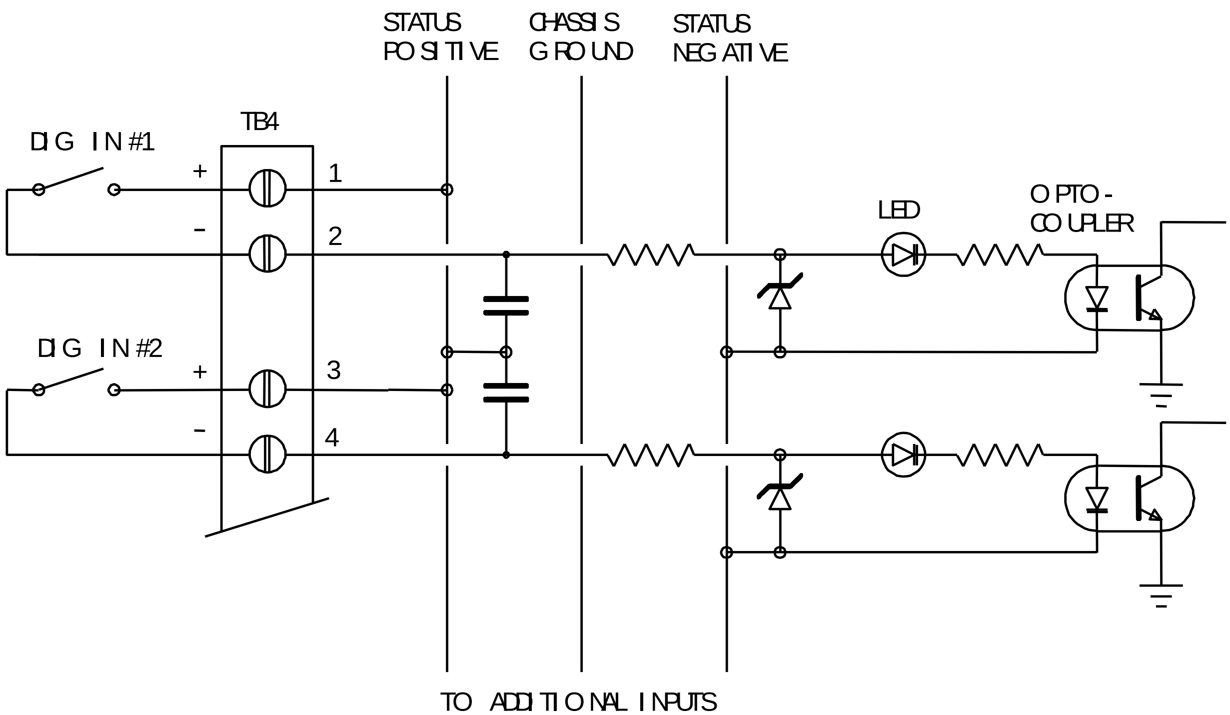
The digital input subsystem accepts contact closure inputs as field status or low speed accumulator inputs. All inputs are optically isolated, and debounced by firmware. Input processing is determined by the input assignment as status, accumulator, etc. and is also firmware controlled. This allows the same hardware to be used for both types of inputs. See Figure 5-7.

The Baseboard has 8 digital inputs. Digital input loops may be powered internally or externally (controlled by W11 & W12). The loop voltage is also varianced and can be 12VDC to 24VDC, 48VDC, or 129VDC with appropriate current limiting loop resistors R181-R188.

5.7.1 Firmware Debounce Algorithm

The Digital Inputs are processed through a digital filter to prevent erroneous Changes Of State (COS) being reported because of contact bounce. The inputs are sampled each 5 msec. Any input that does not match the state of the previous scan is time stamped and stored as a possible COS. A 20 msec counter is started for the suspect input. When the 20 msec timer expires, the point is again sampled. If it has remained steady it is considered to be a valid COS. The COS flag is set and the status buffer is set to the new point condition. A hardware RC network on each digital input provides additional filtering.

Figure 5-7 Typical Digital Input



6 Drawings

The following schematic and assembly drawings are included in this manual as a convenience to allow for troubleshooting. See the 1X50 Drawings.pdf document to see the full drawings.

C3600-AXX-XX000	Assembly Drawing, SAGE 1150 Baseboard	5 pages
C3600-3XX-XXYYY	Top Level Board Assembly – 586 CPU	1 page
C3600-4XX-XXYYY	Top Level Board Assembly – LX-800 CPU	1 page
C3600-002-REV-G	Schematic, SAGE 1150 Baseboard	8 pages
C3600-002-PLDA1	CD PLD PGRM EPM8282 C3600-1	4 pages
S1150-600-00001	Application Dwg. for S1150 with LPS type Inputs	1 page
S1150-600-00002	Application Dwg. for S1150 with CT & PT type Inputs	1 page
S1150-600-00003	Application Dwg. for S1150 Outline & Mounting	1 page