



# **InsulGard™**

## **USER'S MANUAL**

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**Version 2-0X  
Revision 1.1  
(December 2005)**

### **PREDICTIVE DIAGNOSTICS DIVISION**

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### **What is new in InsulGard™ Firmware version 2.0X**

Starting from July, 2004 new firmware version 2.0X is preloaded in InsulGard™ monitor. This updated manual is applicable to old firmware version and states the difference where necessary.

The following table describes major differences between the version 2.0X and all previous versions.

<b>Description</b>	<b>Version 2.0 and newer</b>	<b>Older versions</b>
Modbus RTU Data access via registers	Full support	Supports data access without phase-resolved matrices
Modbus RTU InsulGard Setup access via registers	Full support	NO
Modbus TCP	Full support of data extracting and InsulGard settings	NO
Firmware upgrade via RS-485/232 port	YES	NO
Display version at InsulGard booting	Displays -- <b>2.0X</b> --	NO
Display Max. PD magnitude	Displays <b>XXA- XXXX</b> [mV] The first two digits – channel number	Displays <b>XX0.-XXXX</b> [mV] The first two digits – channel number
Accuracy of maximum PD magnitude measurement	0.75dB	3.2dB
Error message on set clock earlier than preexisting data in InsulGard memory	Displays <b>CLOCKErr</b> and turn on RED alarm LED. Also opens device status relay contact	NO
Saving FULL (phase-resolved) data any time an alarm set point by level (Qmax or PDI) is exceeded only for a parameter selected for Alarm	Starting from the version 2.03 stores full data on alarm on LEVEL event. Does not apply for an alarm on TREND.	NO
Display at Phase Reference Shift measurement	Displays dashes at Phase Reference Shift measurement while the signal does not present or has abnormal characteristics	Displays close to zero number. Signal presence must be checked with AC voltmeter. Signal magnitude should exceed 100mVAC.
<b>Important NOTE for version 2.07 ONLY!</b>	Phase Shift detected in the version 2.07 should be corrected manually by subtracting automatically detected phase shift from 360 Deg.	

The current manual is applicable to all InsulGard™ firmware versions. Pay attention to some version's differences noted in several locations of this manual.

### **Revision 1**

Some changes are made to the sensor interface board in order to simplify start up procedures eliminating temporal connections to IG during start up. All necessary commutations are done with additional switch located at the bottom of sensor interface board. InsulGard™, revision 1 can be identified by the presence of described switch or by a wiring diagram identification label located on power outlet panel. The label looks like **WD-2-X**. X – identifies real wiring diagram, used for assembly on particular InsulGard™ device.

***Note: Changes reflecting new features will be labeled as Rev1 down in the manual!***

# 1 Description

## 1.1 General

Partial discharge (PD) is a small spark that commonly occurs within or on surface of insulation in various types of medium and high voltage equipment. Over time, PD destroys the insulation, eventually causing insulation breakdown (full discharge). In general, it takes months or even years before PD will cause a failure of insulation. Therefore, PD is a good indicator of insulation degradation and should prompt maintenance or repair.

Cutler-Hammer InsulGard by Eaton Corporation is a standalone microprocessor-controlled continuous PD monitoring device for a wide range of medium voltage power equipment. It is designed to provide an alarm based on PD characteristics at an early stage of insulation degradation. It measures partial discharges from up to 15 different partial discharge sensors and stores the information in internal memory; alarming users if any set points are exceeded. InsulGard can work with constant 50/60 Hz frequency powered equipment as well as with variable frequency applications.

Various PD sensor types can be used, depending on the application.

InsulGard has three auxiliary inputs for PD data correlation to additional parameters. One of the inputs is designated for temperature, where the other two are commonly used for load, voltage, or humidity depending upon the application. InsulGard has several interfaces that allow for easy implementation into any alarm or SCADA system:

Three C-form dry relay contacts provide Yellow or Red alarm indication, and the Device Status relay indicates any device malfunction

4-20 mA optically isolated output can be configured to represent Partial Discharge Intensity (PDI) or maximum discharge magnitude to any SCADA system

RS-485 optically isolated interface based on ModBus RTU protocol allows for remote device configuration and data download. InsulGard can be networked with an existing ModBus, allowing for up to 231 addressable devices

*[Note: RS232 is also available on special order]*

Communication protocol includes Modbus, proprietary binary and ASCII text options allowing a software programmer to build InsulGard into a high-level software program using simple text type commands. InsulGard is supplied with database software that allows for automated communication to a device or several devices for data acquisition and analysis. The software allows for either direct network or dial up connection to a device by a regular telephone landline or a cellular connection.

## **1.2 Principles of Operation**

InsulGard has 15 signal inputs (Ch1 - Ch15) for partial discharge measurement and a noise input dedicated for noise suppression (Ch16). All sixteen inputs have identical conditioning circuits (CC) providing signal isolation, transient suppression, and high-pass filtering of the input signals. The frequency band of the InsulGard is from 1 MHz to 20 MHz.

InsulGard acquires PD data in the form of three dimensional phase-resolved pulse height distribution (PRPHD) - PD pulse count as a function of pulse magnitude and 60(50) Hz phase. It has 24 ( $15^0$ ) phase windows and a magnitude dynamic range of about 70dB, divided in 21 magnitude windows.

The data can be stored in the internal device memory in the form of three-dimensional PRPHD matrixes and/or in the brief form of integral quantities derived from these matrixes. Each record is accompanied by three additional correlation parameters.

Before each measurement, InsulGard performs self-calibration and self-test. If any problem is detected, the status relay dry contacts will open and an appropriate message will appear on the InsulGard display. Loss of power will be indicated in the same way by opening status relay contacts.

InsulGard measures signals from signal inputs sequentially multiplexing them to a single metering channel. Each pulse from each sensor is validated by the allowed pulse width. In the case of non-compliance, InsulGard will not count the pulse.

After each measurement, data from all active signal channels will be compared to alarm thresholds. If any of the Yellow threshold limits are exceeded, the Warning LED will be turned on and the Warning relay dry contacts will close. In the case of a Red level achieved, InsulGard will trigger additional measurement and, if confirmed, an Alarm LED will be turned on and the Alarm relay dry contacts will close. If Red alarm is detected, full measurement data will be stored in the memory.

PD measurements can be performed on a time schedule (up to 50 per day) or in specified time intervals (from 1 minute to 23hours 59 minutes). Four measurements per day are recommended.

Between scheduled measurements, the “High Alarm” feature is enabled. All signal sensors are connected to a summation unit and further to a separate “High Alarm” channel. InsulGard continuously searches for an appearance of high magnitude pulses and pulse series. Magnitude threshold and repetition in series are configurable. If five events of pulse series were detected between the scheduled measurements, InsulGard will trigger a full PD measurement, and display an alarm, if any.

## 1.3 Important Features and Options

### 1.3.1 Specifications

Small Footprint	12"x12"x8" Flush-mounted
Enclosure	NEMA 4 (4X) or Panel Mounted
Power Source	115V/230V AC +/-10% 60 (50) Hz
Power Consumption of device (max)	10 W
Power consumption from outlet for 120VAC application (Amps max)	10A
Installation category	II
Pollution Degree	2
Temperature Range	-40 <sup>0</sup> C - +70 <sup>0</sup> C (+85 <sup>0</sup> C without NEMA 4 enclosure)
Relative humidity	15%RH – 90%RH
Maximum Altitude (m)	2000
Sensor Interface Board	1
Input Channels (PD), Isolated	15
Noise Channels (PD), Isolated	1
Continuous Watch (High PD activity) Channel	1
Auxiliary Temperature Input (10, 100, 1000 Ohms RTD, specify while ordering)	1
Auxiliary Analog Inputs (specified to use for Voltage, Current or Humidity)	2
Alarm C-form Dry Type Relay Contacts (Yellow and Red alarms, fully configurable)	2 120VAC/ 5 Amps 28VDC/ 5 Amps <sup>1</sup>
Device Status Dry Type, C-form Relay Contacts	1 120VAC/ 5 Amps 28VDC/ 5 Amps <sup>2</sup>
4–20 mAmps Optically-isolated Interface Represents Highest PDI or Max. Magnitude as % of the Red Alarm Threshold	1mAmp per 10% slope
Interface Optically-isolated RS-485 or None-isolated RS-232	
Communication Protocol	ModBus RTU, ModBus TCP-(version 2.0 and higher) Binary Text commands
Addressability (with RS-485 Interface)	231 addresses
Internal Data Memory (allows for up to 2000 days data storage @ 2 measurements per day)	2 MB
Display	8-digit, Alphanumeric
Keypad	4 arrows and 4 functional keys
LEDs (Normal condition, Red and Yellow alarms, and History and Setting modes)	5 LEDs
Setup	Fully configurable from keypad and PC

<sup>1</sup> For another rating refer to the relay specification

<sup>2</sup> For another rating refer to the relay specification



Applications	MV equipment (motors, switchgears, generators, bus ducts, cable terminations)
Calculated Parameters for Each PD Channel	Partial Discharge Intensity (PDI), Pulse Repetition rate (pps), Max Pulse magnitude ( $Q_{02}$ )
Alarming Parameters	PDI, $Q_{02}$ , trend
Data Record Types	Full/Brief
Basic Type of Data	Phase-Resolved PD Distribution
PD Channel Dynamic Range	68dB
Number of Magnitude Windows (3.23 dB each)	21
Number of Phase Windows ( $15^\circ$ each)	24
Power Frequency at the Monitored Object	25–120 Hz
Maximum Measured Pulse Repetition Rate	367,300pps @60Hz 306,000pps @50Hz
Self-test and Self-calibration	At powering up and before every measurement
Allowed Coax Cable Length to a Sensor	Up to 150ft (50m)
Cable Type for PD Sensors	RG-58 or similar

### **1.3.2 Display, Keypad, and External Connections**

InsulGard is shipped fully assembled in NEMA4 (4X) enclosure, mounted on aluminum plate with selected communication options or in panel-mount version. These options may include RS485/RS232 converter (Figure 2), landline (Figure 1 & 3) or cellular modem, radio-modem (Figure 2).

Sensor Interface Board (on the left hand in Figure 2) handles all signal connections including 15 PD channels, one noise channel and auxiliary signals. All outputs and AC power are connected to the terminal board located on the right in Figure 2. Outputs include 2 alarm relay contacts, device status relay contact, 4-20mA output and RS-485 or RS-232 interface.

Five LEDs are placed on the front panel of the device, three for indication of alarm status (Green, Yellow, and Red) and two for Memory and Setup operation modes. (Figure 1)

A bright, 8-digit alphanumeric screen displays information at setup, memory mode operation, normal operation, and all error messages. During normal operation the display continuously scrolls the current data.

The membrane keypad has four navigation ARROW keys ( $\leftarrow \rightarrow \uparrow \downarrow$ ) and two function keys (Esc and Enter), as well as two specific function keys (Set and Memory).

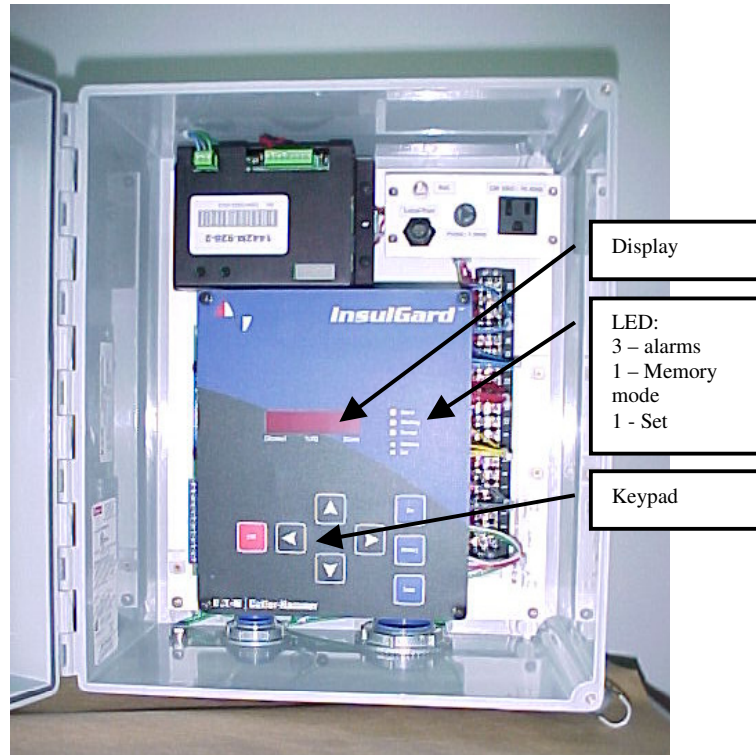


Figure 1

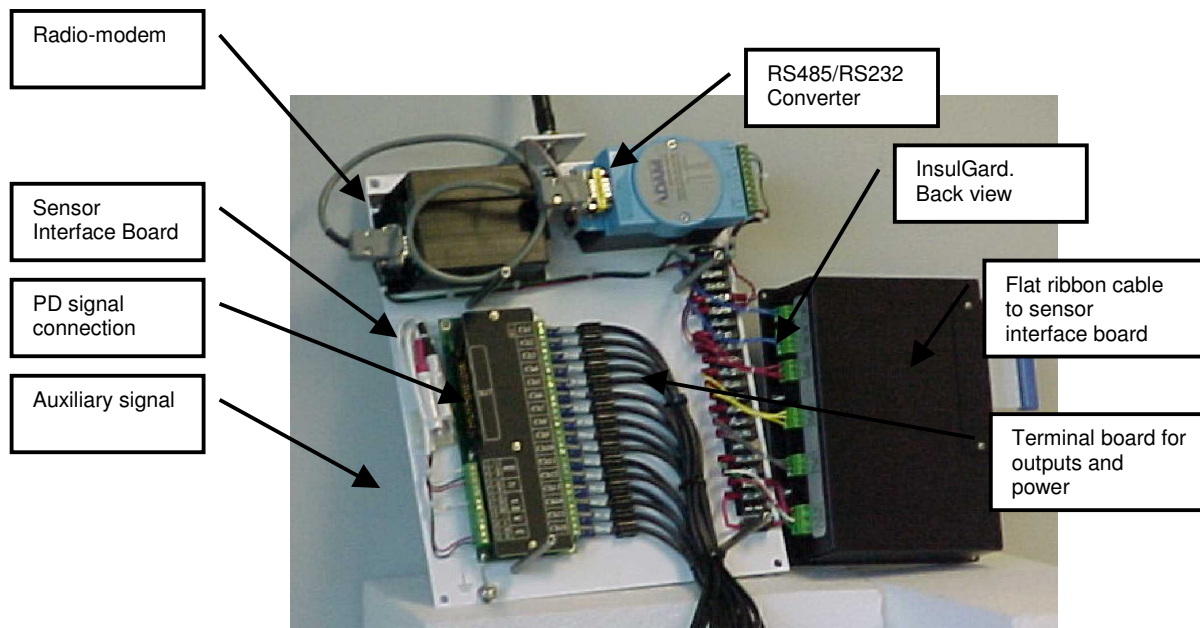
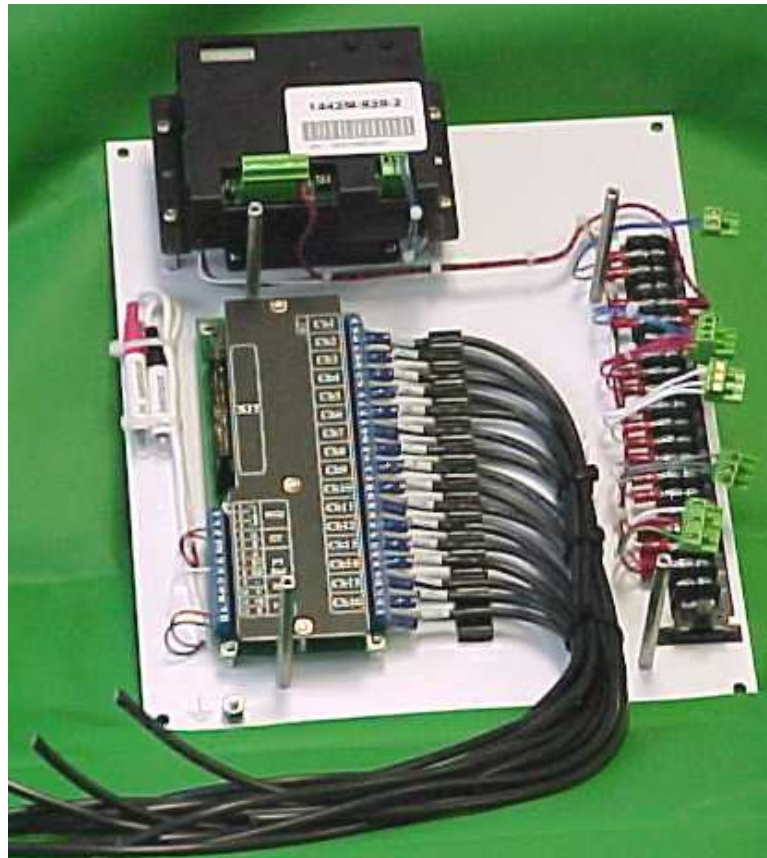


Figure 2



**Figure 3**

### **1.3.3 Data Structure**

Full PD measurement by InsulGard involves a measurement of statistical Phase Resolved Partial Discharge Distribution (PRPDD) for every active channel. After each measurement for every active channel, InsulGard calculates PDI, Maximum PD magnitude, PD pulse repetition rate, and trend parameters (rate of PD parameter change). The calculated parameters are compared to alarm set points and alarm status is determined. All calculated and alarm status parameters are stored in the internal memory for each measurement. Additionally, three auxiliary parameters (temperature, % of full load current and operating voltage or humidity) are assigned to the measurement data. PRPDD can, optionally, be stored in the internal memory. There are two modes of PD data storage “Brief” and “Full.”

Full – during this mode PRPDD is stored in the memory with the mentioned above parameters for each active channel and every measurement.

Brief – in order to save a memory, PRPDD can be stored in the memory several times a month. An operator should set a number of days and a measurement number at the current day for storing PRPDD. During the remaining measurements InsulGard will store the brief version of PD data.

InsulGard has two Megabytes of internal flash memory for data storage allowing for its standalone operation. When the memory is filled, the device starts replacing the oldest data with the latest data. The rate of the memory consumption depends upon a number of active channels, frequency of measurements, and frequency of PRPDD storage. As an example, if all 15 channels are active for measurements four times a day and PRPDD are stored twice a month, the device holds 17 months of the latest PD data in its internal memory. All stored data and settings can be accessed from the keypad, or remotely from a PC.

#### **1.3.4 Alarms**

InsulGard has two configurable alarms, Red and Yellow that connect to two C-form relays. There are two groups of parameters that can generate an alarm. One is if an alarm set point is exceeded (Partial Discharge Intensity (PDI) and its trend or PD pulse magnitude and its trend). One of two, PDI or Magnitude, can be configured for alarm at one time. The same parameter is configured for 4-20 mA interface output automatically. 4-20 mA output provides a signal with the slope of 10% of Red Alarm Threshold per 1mA. That means that Red alarm threshold corresponds to 14 mA output.

Alarm set points for PDI are represented in terms of mW. Magnitude is represented in terms of mV.

Trend is set in terms of times per year for both PDI and Magnitude. Alarm on trend is enabled after a training period of 1/3 of the trend-sliding window.

Yellow and Red alarms operate differently. In the case of a Yellow alarm, it will appear on the corresponding relay as received. In the case of a Red alarm, InsulGard will initiate an additional measurement at the time of alarm, and only if confirmed, will indicate the alarm by relay. If the Red alarm is not confirmed, the status of the alarm will be set per the last measurement. If at any measurement the alarm status will be reduced, InsulGard will indicate the reduced alarm status with both an alarm LED reading and relay.

Alarm relays can operate in two modes (configurable). Relays lock in an alarm status received at the last measurements, until the next measurement. Or a relay can operate for a limited configurable time and then open the contacts. At the next measurement, if an alarm status is detected, relays will hold the alarm contacts closed for the same time.

#### **1.3.5 Trend**

InsulGard calculates trend of a parameter enabled for alarm. Trend is normalized to the value of the parameter change in times per year. Trend has two alarm thresholds, Yellow and Red, connected to alarm relays and also to the alarm status LED at the front panel of the device. Trend is calculated as a linear approximation of data over specified time interval (default is 18 weeks). This 18-week time window is sliding over time while device monitors partial discharges.

### **1.3.6 Continuous Watch Feature**

Between the scheduled measurements the Continuous Watch feature (“High Alarm”) is initiated. At this time all signal sensors are summarized and connected to the separate High Alarm channel. InsulGard is continuously watching for the events of high magnitude pulses (configurable) and their series. If five series of such events are detected, InsulGard starts full PD measurement and, in the case of Red alarm confirmation, InsulGard indicates this alarm and stores full PD data in the internal device memory.

### **1.3.7 Phase Resolved Data and Phase Reference**

In order to provide a phase-resolved data, InsulGard should be synchronized with a signal that is synchronous with the voltage at the object under monitoring and known constant phase shift to that voltage.

There are two options of supplying the synchronization:

- In most of cases power source (120/230 VAC) powering up InsulGard is used as a synchronization signal. The device has the internal connection of the power circuit voltage to its synchronization circuitry. This option (default) always works on monitored objects powered from a regular power system (60/50Hz) in the area. *Be cautious if power an Insulgard from UPS, unless UPS has constant phase shift to the voltage in the monitored object in Standby mode. If not you get an “asynchronous” situation (see below).* Phase shift between power voltage and object high voltage should be determined during InsulGard startup and can be used at all times, while the same object is monitored and the same power circuit is used. InsulGard allows for automated detection of a phase shift between its power circuit and an external phase reference signal. (On automatic phase shift detection refer to the Quick Start Up or Appendix 1. For more detailed information on synchronization and phase reference options refer to Appendix 2.)
- External synchronization should be used if the InsulGard power supply voltage is not synchronous with the voltage on the test object. Examples can be variable frequency drives, 25 or 400 Hz systems, etc. This option can be used, of course, in the synchronous situation as well. An external synchronization signal should be continuously provided to the special synchronization input and appropriate jumpers in the device should be configured. Low frequency component of a signal applied to the channel #1 (coupling capacitor option) may be used also for external synchronization. For more information on synchronization and device configuration refer to Appendix 2.

### **1.3.8 Schedule**

PD measurements can be performed at specified times during a day or time interval basis (configurable). The device is shipped with “time basis” schedule enabled and set to record measurements four times a day. This is sufficient for all common applications. If necessary, InsulGard can be set to measure up to 50 times per day at scheduled times or in specific time intervals varying from 1 minute to 23 hours 59 minutes.

### **1.3.9 Device Address and Communication Options**

InsulGard has isolated RS-485 interface using ModBus RTU communication protocol (most commonly used in industry) and can be networked to any local device network supporting the protocol. InsulGard is shipped with the device address #1, unless otherwise specified. The address can be changed from the keypad and set to the value from 1 to 231. In any case, the address **must be unique** at each particular local device network.

There are two communication options to the device from a PC for set up or to download data. Most preferable is using a landline or cellular modem equipped with RS-485 interface. Up to 231 devices can be connected to one modem. A modem allows a user to remotely download data and get an expert opinion on a critical situation within few hours. Another option is using RS-485/232 converter or a device equipped with RS-232 interface to connect the device to PC directly. In this case, it would require a periodic (monthly) connection to a device, or group of devices, connected by one RS-485 network with the converter and downloading the data into the database. In an emergency, data from database can be e-mailed to an expert for analysis.

### **1.3.10 Self-test and Self-calibration**

While powering up, and before each PD measurement, InsulGard performs a self-test and calibration of PD and noise channels. In the case of a fault, an error message will be displayed and the status relay contacts will open. Error status can be remotely requested through interface.

### **1.3.11 PDI (Partial Discharge Intensity) and PPS (Pulse per Second PD pulse repetition rate) Calculation**

PDI and pulse count (PPS) are calculated for each channel at every measurement starting from some preset magnitude zone and up. This feature allows for rejecting background noise from affecting PDI and pulse count calculations. The low magnitude threshold to calculate parameters can be set for each channel independently, based on its own background noise level, if any. There are options to set these values manually or automatically. Automatic low magnitude threshold detection could be launched only from the keypad (usually during device start up or during initial period of operation).

### **1.3.12 Auxiliary Inputs**

It is well known that operation conditions of monitored equipment can significantly affect PD behavior. Correlation of PD activity changes can be used as valuable diagnostic information for further defect type identification. In general, insulation temperature, mechanical vibration reflected by load current, voltage on the object, and humidity of air are some of the most valuable parameters to correlate with PD characteristics.

InsulGard has three auxiliary inputs. One of the inputs is strictly designated for temperature. 10, 100, and 1000 Ohms RTD can be used as a sensor. This setting is factory configured and should be specified at the time of device ordering.

Two other inputs can accept any AC or DC signals within a specified voltage range. As factory default, they are configured for accessory sensors providing load current, humidity, or voltage inputs and are supplied with the device. These parameters are important to correlate with PD signals.

### ***1.3.13 Measurement Suspend***

Frequently, measurements need to be suspended for some time. Measurements can be suspended in three different ways:

- Monitoring can be stopped. The operator is responsible for resuming monitoring.
- Monitoring can be paused. In this case, monitoring will resume automatically in three hours.

Auto-suspend mode is controlled by any of three auxiliary parameters. The device allows the user to set low and high thresholds for three additional parameters brought to three auxiliary inputs and enables parameter checks to comply with the thresholds. The check can be performed to any of the parameters (configurable) and suspend measurements, if at least one of them extends beyond the allowed boundaries. Measurement will be automatically resumed at the next scheduled time, if parameters will comply to allowed boundaries.

This feature is widely used to suspend measurements while monitored equipment is out of service (load current is 0 for example). Therefore, trend calculations are not affected by zero readings. It also allows users to perform measurements under the same operational conditions, if required.

### ***1.3.14 External Interfaces***

InsulGard has built-in isolated RS-485 interface (RS-232 is optional). Device supports ASCII-type and binary command protocols. Most commands and settings are supported in both command protocols and from the device keypad. Isolated 4-20 mA interface provides PDI or Magnitude levels as a percentage to Red alarm threshold. Two C-type dry relay contacts provide Yellow and Red alarm status. One C-type dry relay contact provides device status.

### ***1.3.15 Software***

InsulGard comes with Database InsulGard software that allows it to communicate with a PC via a local RS-485 network or a modem. It also provides automated or manual data downloading and storage for several devices at different locations, device setting, data analysis, and presentation.

## 2 Installation

### 2.1 *Application Issues*

InsulGard is a versatile device that can be applied to most medium voltage equipment. Specifics of a particular application (optional components and planning installation) should be taken into account when ordering.

Issues that should be considered are:

- ***Type and specifics of equipment to monitor***
- ***Configuration of PD sensors***
- ***Noise aspects***
- ***Device location and environmental issues***
- ***What additional parameters to measure?***
- ***Networking and Communicating to the device***

You may wish to use a short Manual “InsulGard Guide: How to Choose Proper Installation Options”, CHPD, 2003. For sensor installation use corresponding CHPD Installation Manuals.

#### 2.1.1 *Type and specifics of equipment to monitor*

In general, InsulGard was designed to monitor partial discharges in medium voltage rotating machines, switchgear, cast transformers and associated connections. The connections may include cable terminations and portions of cable and portions of bus feeding an object. InsulGard can be used for additional variations of medium voltage and high voltage equipment, but application of the technology will require special pre-engineering and adaptation. Consideration should be given while attempting to use InsulGard on high voltage equipment above 120kV. External noise in the form of corona discharges should be addressed in this case.

The nature of PD indicates it will not occur in the equipment 2300 Volts and below. Marginally, 2300V equipment can be considered, but the technology is inconclusive. It may or may not detect a significant problem at 2300V. Ratings 4160V and higher are considered reliable for PD diagnostic applications. In general, higher voltage provides greater destructive power of partial discharges and problems can be detected and predicted.

#### 2.1.2 *Configuration of PD Sensors*

Configuration of PD sensors is really application specific. There are some general guidelines below. We recommend discussing any sensor installations with a Cutler-Hammer application engineer.



### **2.1.3 Noise Aspects**

Noise is a major issue in any type of partial discharge measurement. Noise is always site specific. There is not an absolute solution for noise suppression in the modern world. However, most noise issues can be overcome. InsulGard has been designed with several noise suppressing algorithms and, along with recommended sensors, is able to suppress most industrial noises. While planning InsulGard installation, keep in mind most common noise sources:

- Power thyristor firing
- Switching power supplies in modern metering and protective electronics
- Arcing and sparking somewhere at the facility
- Aerial corona on overhead lines on high voltage substation
- Partial discharges in the adjacent equipment
- Pulse signals coming from incoming lines and feeders

### **2.1.4 Device Location and Environmental Issues**

InsulGard can be shipped with or without an environmental enclosure. Without the enclosure, it can be used indoors on switchgear lineups (given a relatively clean environment).

In most applications, indoor and outdoor, InsulGard is contained in a NEMA-4 enclosure protecting the device from direct rain, sun, and dust. If the application environment is a chemically aggressive medium, or a company policy requires a stainless steel enclosure (NEMA-4X), please, specify this while ordering InsulGard. Also you may use if specified NEMA4X plastic enclosure with a clear window.

In a switchgear lineup InsulGard can be installed without an environmental enclosure.

When planning to install InsulGard, consider a non-vibrating location, conveniently located in a centralized position between all sensors and possible communicating means (phone jack, tray to control room for alarms, etc.). The length of PD signal coaxial cables (RG58 or similar, 50 Ohm) can be up to 150ft. It is preferred to keep the PD signal cables short and uniform in length.

### **2.1.5 What Additional Parameters to Measure?**

Several factors can affect PD level: temperature, humidity, voltage, mechanical vibration, etc. In North America voltage commonly is not an issue. It is stable and does not commonly affect PD. If more than +/-5% voltage variation is expected, plan correlating PD to voltage. Temperature is very important for rotating machine monitoring. Temperature variations can change size of voids and surface conductivity thus affecting PDs. Humidity is also a factor for line terminals in rotating machines, especially in an outdoor installation.

Temperature and humidity are important factors in switchgear; often affecting contaminated surface conductivity or condensing moisture on some surfaces and

pulling. Therefore, a varying range of PD is expected. If insulation can vibrate against support or core rotating machines, load current is a good parameter to correlate. Also zero load currents could be used to suspend monitoring during equipment outage.

### **2.1.6 Networking and Communicating with InsulGard**

InsulGard provides several interfaces for alarms, SCADA, and data retransmission

- Always wire alarm relays to an annunciation system. Use two relays for Red and Yellow alarm and the third relay for device status. If necessary, all three relays can be wired in series to the same enunciator.
- 20mAmps output is for SCADA systems. A SCADA system can trend the most important parameters.
- RS-485/232 with database software allows for remote device setting, initiating measurements, and downloading of data. If an expert opinion will occasionally be needed, designate a permanent or temporary phone line and specify a modem. Cellular modem subscriptions are available. If a Cellular modem is used, extra conduits for RS-485 networking can be excluded.

### **2.1.7 Application Specific for Motors and Small Generators**

PD sensors set for small generators and medium voltage motors typically include three sensors located at the line terminal and six to twelve RTDs. A necessity of having too many sensors comes from very strong high frequency signal attenuation in motor winding. Therefore, sensors located at the line terminals will not produce valuable information on a winding depth; likewise, a sensor embedded into a winding will not sense discharges at the line terminal.

Two types of sensors can be used at line terminals.

- Radio Frequency Current Transformers (RFCT) placed on incoming feeders' shield grounding conductor (one per phase) or on single-phase surge capacitor grounding conductor (one per phase). Using a single three-phase surge capacitor is not recommended. In such a case, phase-to-phase PD signals are shorted inside the capacitor and will not be detected by any of RFCT. An advantage of RFCT is that they are non-invasive (no connection to a live part is required). A disadvantage of using RFCT on a cable shield ground is, in some cases, a ground noise. This means that RFCT measures all radio frequency signals coming through the cable shield. Using RFCT on a single-phase surge capacitor ground is more noise immune.
- Coupling Capacitors (IPDS) commonly have an 80pF capacitance. They have sufficient insulation and connect directly to motor line terminals. These sensors exhibit the most noise-immune characteristics due to their low capacitance and, therefore, can suppress most low frequency noise by themselves. Using IPDS is a highly recommended option for line terminals. **Note: Installation of line terminal sensors always requires an outage.**

As stated above, additional sensors embedded into winding sensors are required. RTD outputs are commonly used for this purpose. RTD supplies DC temperature signal to a

metering device. RTD and its wires also operate as a local RF antenna for PD. High frequency signals can be filtered out and used for PD representation. Common noise disturbing PD signals from RTD comes from temperature metering system wires. A possible source of noise can be the operation (switching pulses) of the temperature metering system itself and/or pulses cross-coupled to wires from another wire at the same tray.

CHPD produces RTD PD sensor board with embedded filters, suppressing external noise. RTD PD sensors are designed as a single board replacing the existing RTD terminal board at the motor frame. It does not affect temperature measurements, and produces PD signals for InsulGard. RTD PD board is designed to handle six RTDs. If, in a particular application, the number of RTDs is greater than 6, additional boards might be needed. An RTD PD board can be installed online, disabling temporarily temperature alarm or relay system.

Winding temperature, load current, and humidity in a terminal enclosure are the three most important parameters to correlate. Use one of the winding RTDs for temperature. It can be difficult to bring a load current signal to the InsulGard enclosure from some distant CT (frequently in switchgear cubicle). In this case you can consider installing a FlexCore CT around a cable of the phase A in the motor terminal enclosure. The FlexCore CT is installed over the shielded part of a cable and, therefore, is under ground potential and does not endanger insulation integrity. Cable shield should be grounded through CT.

**Note: One InsulGard device is required for a motor.**

### **2.1.8 Application Specific for Large Generators**

The application for large generators is, in general, similar to one on a motor or small generator. Some specifics include:

- Coupling capacitor (IPDS) is commonly used as a sensor at line terminals. Generator equipped with iso-phase bus duct might produce sparking in bus supporting insulators. *The later firmware versions (02-14-03 and higher) have built in software filters. The older versions may require two sets of IPDS for noise suppression.*
- Certain generators do not have RTDs embedded into a stator winding. For example, large Westinghouse hydrogen cooled machines have RTDs near the hydrogen outlet from the winding. These RTDs cannot be used as PD sensors. Check RTD location in a winding.
- Large generators may have very long signal wires from RTD to the first RTD terminal board. Frequently, these wires are also placed into a spiral armature. These factors significantly affect high frequency signal propagation attenuating PD pulse. In order to minimize signal attenuation; install the RTD PD board at the generator gland, where the RTD wires come out of generator.

### **2.1.9 Application Specific for MV Switchgear**

Three types of PD sensors can be used for switchgear lineup: coupling capacitor (IPDS), RFCT and RFVS. **Preferred option is IPDS.**

- Three IPDS sensors (one per phase) are installed, commonly in every third cubicle. Therefore, each set of three IPDSs assess the cubicle, where it is installed, and on each sides. Increasing a distance between IPDS sets might cause some distant PD to be missed. Keep in mind that PD signals attenuate approximately twice from cubicle to cubicle due to energy splitting in every T-connection. IPDS can be installed on a bus side or load side of a breaker. In the case of a load side, the sensor will not measure PD while the breaker is open. In general, one InsulGard can handle up to 15 cubicles.
- An RFCT sensor is installed on incoming and outgoing feeder shield grounding conductors; commonly, one per cubicle. Phase to phase signals can be missed in such a configuration. Installing three RFCT sensors in every cubicle looks very difficult. RFCT sensors on cable shields are susceptible to any ground noise. Noise level should be checked before deciding to use an RFCT.
- An RFVS sensor is connected to C0 (common point) of a metering CT and to V0 (common point) of PT. Constructive capacitance of CT or PT to a bus is used as a small coupling capacitor. This sensor is the easiest to install, however, it is susceptible to many noises produced by modern metering and relaying electronics. These sensors work very well on older lineups without modern electronics.

Two main factors, temperature and humidity, should be considered to correlate with PD. Plan on installing temperature and humidity sensors with InsulGard. You may also consider voltage signal, if expected voltage variation can exceed +/-5%.

In indoor installation InsulGard can be mounted without NEMA-4 enclosure in one of the cubicles. Check for available space before ordering a device. In some cases, the bus and breaker structure is very complicated. Consult with a Cutler-Hammer application engineer before ordering sensors.

## **2.2 Installation**

InsulGard™ is normally shipped in one of the following options:

- In NEMA-4 (4X) enclosure. In such a case, all ordered options (modem, cellular modem, radio-modem and power supplies and so on) have already been installed onto internal mounting panel. The enclosure has two entries for power and signal cables in the bottom.
- On the mounting panel. This option is identical to the first one, except that mounting panel is not mounted into enclosure.
- Flash mount option. This option is used for panel mount predominantly in switchgear line up. InsulGard comes with Sensor Interface Board installed on it's back cover. Communication options (modems and their power supplies) are separate items.

End-user should install InsulGard and communication means at a convenient location(s).

### ***2.2.1 Important Note on Sensor Installation in Rotating Machines***

***InsulGard™ software has several useful configuration templates allowing simple configuration a majority of standard applications. These templates for rotating machines assume that all coupling capacitors connected sequentially to first IG channels in sequences of A-B-C. RTDs come after coupling capacitors again in sequences of A-B-C. Following this rule while connecting sensors to IG will allow you for simple configuration later on!***

### 2.2.2 InsulGard Kit Contents

<b>Item Description</b>	<b>Included/Optional</b>	<b>Quantity</b>	<b>Comments</b>
InsulGard Device with: <ul style="list-style-type: none"> <li>• Sensor Interface Board,</li> <li>• 44 wire ribbon cable,</li> <li>• Terminals for outputs connection.</li> </ul>	Included	1	
NEMA-4 enclosure and/or mounting panel	Included if not a flash mount option	1	
115VAC, 10 A receptacle	Included if not a flash mount option or 230VAC power	1	
Vinyl insulated Straight Blade Terminals TV14-10BL for termination of coaxial cable sheaths	Included	20	
Temperature sensor TS (RTD 100 Ohm Pt)	Optional	1	Comes as default for switchgear applications Installed permanently on the sensor interface board.
Load current Sensor CT (5 Amps)	Optional	1	Needed for rotating equipment
Split-core Current Transformer (Flexcore)	Optional	1	Convenient to install in motor termination enclosure. Eliminate need for bringing load current signal from distant locations. Specify current ratio while ordering.
Humidity Sensor HS	Optional	1	Comes as default for switchgear applications. Installed permanently on the sensor interface board.
Land Line Modem (RS-485/232) with power	Optional	1	Installed on the mounting panel, if

supply module			ordered.
Cellular Modem (RS-485/232) with power supply module	Optional	1	Installed on the mounting panel, if ordered.
RS485/RS232 converter with power supply module	Optional	1	Installed on the mounting panel, if ordered.

***Not included:***

RG-58 coaxial cables from sensors to the device if exceed a standard length of 25' and the length was not specified at ordering. For IPDS sensors it is possible to order from CHPD the cable in 1000' spools to cut it on-site.

Cable conduits for coaxial, auxiliary signals and communication cables.

Twisted pair cables (AWG16-20) for modem, and for voltage, and current sensors if exceed 25' and a 3-wire shielded cable (AWG 16-22) for the temperature sensor if exceeds 25'.

We recommend for these applications the following tray cables from ***Allied Electronics (Catalog 2001, page 309):***

Twisted pair:

***Stock # 216-2722 (22AWG) by BELDEN Mfr's #9322***

***Stock # 216-2724 (20AWG), by BELDEN Mfr's #9320 (Preferable for communications over 1000ft)***

***Stock # 216-2660 (20AWG), by BELDEN Mfr's #1033A***

Shielded 3-wire cable (if  $T < 80^{\circ}\text{C}$ ),

3.2.1. ***Stock # 216-2738 (22AWG), by BELDEN Mfr's #9363***

3.2.2 ***Stock # 216-2740 (20AWG), by BELDEN Mfr's #9364***

3.2.3. ***Stock # 216-2666 (18AWG), by BELDEN Mfr's #1036A***

You may also order these cables to CHPD.

115V AC power cable 3-wire (11 Amps). OD should not exceed 0.40".

### 2.2.3 Installation

#### 2.2.3.1 Step 1 – Hardware *(This paragraph covers main guide-line. Chosen InsulGard options must be taken into account in every particular case.)*

- Select a convenient location for an InsulGard enclosure. It should be as close as possible to the equipment being monitored. Avoid locations with excessive vibrations, heat and direct sun light. Cable length from PD sensors should not exceed 150ft (50m). It is usually convenient to install the device in the center of the sensor locations, keeping PD signal cable lengths approximately the same. It is not necessary having cable lengths exactly the same.
- Run conduits (if necessary) for the cables to all PD sensors, communication, analog signal cable, and for the power supply. The cable entry is at the right and the left bottom of the enclosure. Follow respective installation manual for the wiring to PD sensors.
- Install Current Sensor on the secondary circuit of a current transformer measuring the equipment load current. A phase is preferred, but is not obligatory. **Note: It is frequently less expensive installing an additional Current Transformer inside a motor termination enclosure, then run conduits and wires from a distant breaker. We designed an option using easy to install FlexCore CT. Check before making a decision.**
- Install the voltage sensor at the secondary of the closest PT associated with the monitored equipment. **Note: Do not connect to PT at this time.**
- Install an RTD sensor (if ordered separately) inside switchgear at a suitable location closely representing the inside temperature (It could be a rear compartment at the middle of a lineup). In case of a motor or generator, use one of the spare winding RTDs; otherwise, locate an additional RTD at a suitable location closely representing stator winding temperature.
- Install a humidity sensor (if ordered separately) inside the switchgear at a suitable location closely representing the inside humidity (a rear compartment at the middle of a lineup). In case of a motor or generator, a humidity sensor should be installed inside the motor terminal enclosure to represent humidity at the line terminals. Insulation near line terminals is mostly influenced by humidity variations.
- The modem has already installed (if ordered) on InsulGard panel. Use a 2-wire telephone cable with RJ11 connectors to connect the modem to a dedicated analog telephone line. The modem can also be installed at separate location. Several InsulGards can be networked together via RS-485 network and use one modem for all of them.
- If several InsulGards are networked together, use a daisy-chain configuration. The chain must be terminated with approximately 120 Ohms at the end.
  - Run all cables into the InsulGard enclosure. An excess of cables in the enclosure should not be less then 24" for terminating. **Note: Label all cables.**



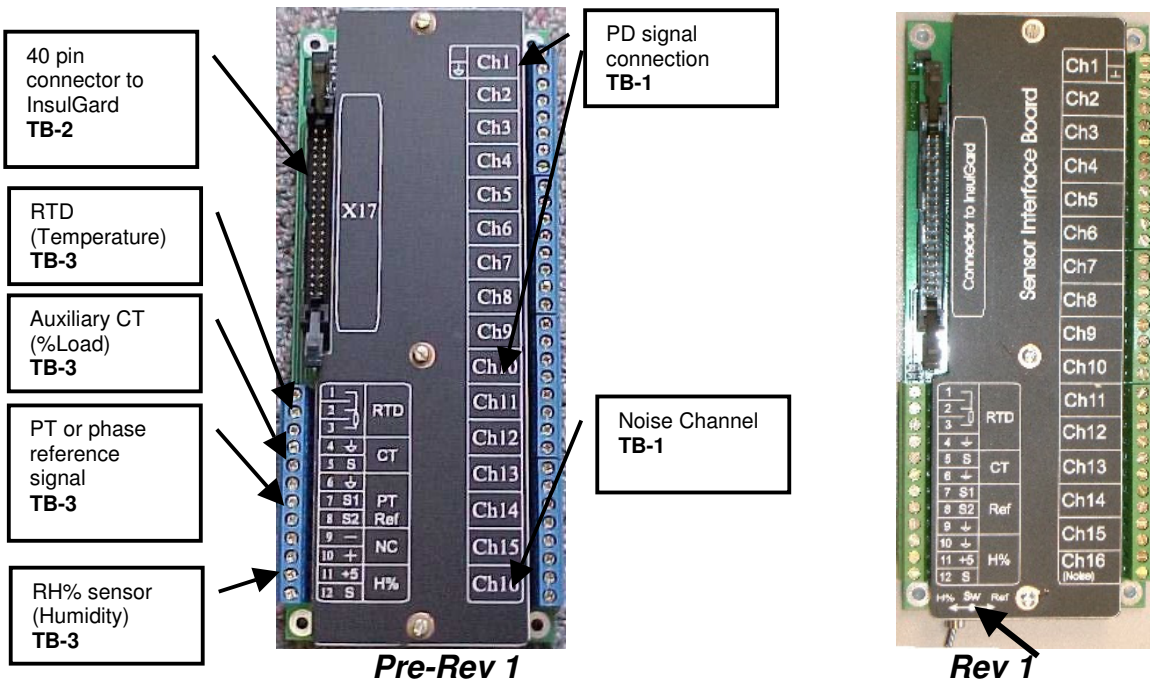
### **2.2.3.2 Step 2 – Sensor and power connections**

- Connect coax cables to all PD sensors according to correspondent PD sensor installation manual.
- Connect a 3-conductor shielded cable to RTD terminals in a motor (or generator) according to drawings and RTD type. If additional RTD was installed, connect its leads to RTD cable using appropriate crimping tool. Label all conductors on both ends. (Check IG documentation! RTD sensor may have been already installed in the sensor interface board.)
- Connect Current Sensor using appropriate crimping tool. Label positive polarity terminal (+) or dot.
- Connect Voltage Sensor. Label positive polarity terminal (+) or dot. **Note: Do not connect to PT at this time.**
- Connect the humidity sensor according to its description. A humidity sensor has three wires: +5 Volt, Ground, and Signal. Make sure that all wires are properly labeled of both sides. (Check IG documentation! Humidity sensor may have been already installed in the sensor interface board.)
- **Note: Do not connect 115/230 VAC power at this time**

### **2.2.3.3 Step 3. - Connections to the device.**

All signal connections inside the InsulGard enclosure are found on the Sensor Interface Board shown in Figure 4. Connectors are in red on in the Figure 5.

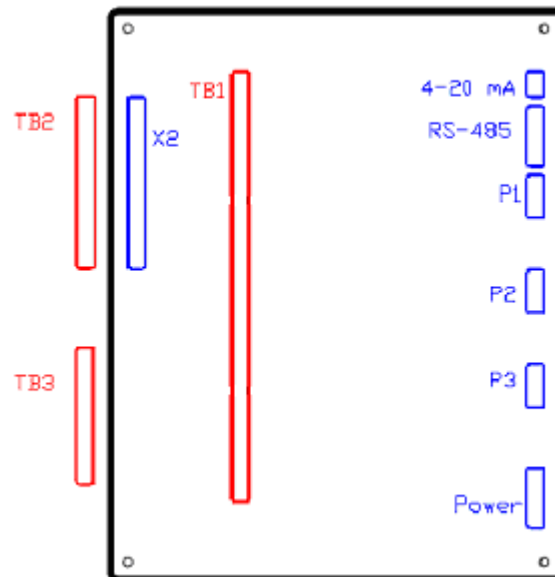
**WARNING: THIS MONITOR MUST BE INSTALLED AND SHOULD NOT BE USED FOR ANY OTHER PURPOSE THAN WHAT IS DESCRIBED IN THIS DOCUMENT. IF THIS DEVICE IS USED FOR ANY OTHER PURPOSE, OR NOT INSTALLED PER INSTRUCTIONS IT MAY NOT FUNCTION PROPERLY.**



**Figure 4. Sensor Interface Board**

The 40-pin connector TB2 (top left) serves the connection between the Sensor Interface Board and the InsulGard device via a flat ribbon cable included with the kit. The 12-terminal strip TB3 (bottom left) serves all auxiliary signal connections, such as temperature, current, humidity, and voltage. The 32-terminal strip TB1 (right) is dedicated for PD sensor connections using coaxial cables.

In the InsulGard enclosure, the sensor interface board is positioned vertically as show in Figure 5.



**Figure 5.**

Signal connections are summarized in two Tables below.

### TB1 (Sensor interface board)

<b>##</b>	<b>All revisions</b>	<b>Note</b>
1&2	PD#01 signal(1)&shield(2)	Coax Cable RG-58
3&4	PD#02 signal(3)&shield(4)	Coax Cable RG-58
5&6	PD#03 signal(5)&shield(6)	Coax Cable RG-58
7&8	PD#04 signal(7)&shield(8)	Coax Cable RG-58
9&10	PD#05 signal(9)&shield(10)	Coax Cable RG-58
11&12	PD#06 signal(11)&shield(12)	Coax Cable RG-58
13&14	PD#07 signal(13)&shield(14)	Coax Cable RG-58
15&16	PD#08 signal(15)&shield(16)	Coax Cable RG-58
17&18	PD#09 signal(17)&shield(18)	Coax Cable RG-58
19&20	PD#10 signal(19)&shield(20)	Coax Cable RG-58
21&22	PD#11 signal(21)&shield(22)	Coax Cable RG-58
23&24	PD#12 signal(23)&shield(24)	Coax Cable RG-58
25&26	PD#13 signal(25)&shield(26)	Coax Cable RG-58
27&28	PD#14 signal(27)&shield(28)	Coax Cable RG-58
29&30	PD#15 signal(29)&shield(30)	Coax Cable RG-58
31&32	Noise#16 signal(31)&shield(32)	Coax Cable RG-58

### TB3 (Sensor interface board)

<b>##</b>	<b>Pre-Revision 1</b>	<b>Revision 1</b>	<b>Note</b>
1.	RTD common wire	Same	For two-wire RTD terminal 1 should be shortened with the terminal 2
2.	RTD common wire	Same	
3.	RTD signal wire	Same	
4.	Current sensor common wire	RTD cable shield	
5.	Current sensor signal wire	Same	<b>Never exceed 0.6V AC! Must be isolated from the ground at the sensor location! Input Impedance 100/110 Ohms.</b>
6.	Voltage sensor or Reference sensor or Humidity common wire	Current sensor common wire	
7.	Voltage sensor signal wire <b>Normally not Used!</b>	External Reference signal. <b>Normally not Used!</b>	1. In Pre Rev 1 Input impedance 2kOhm, signal should not exceed 6VAC 2. Rev 1 Input Impedance 1MOhm, signal should not exceed 6VAC
8.	Reference sensor signal wire	<b>Control Point. Not Used.</b>	
9.	Reserved	Humidity Sensor cable shield	
10.	Reserved	Humidity Sensor common wire	
11.	+5 Volt for humidity sensor	Same	For H% sensor only
12.	Humidity sensor signal wire	Same	For H% sensor only

### Panel Terminal Strip

<b>Pin ##</b>	<b>Pre-Revision 1</b>	<b>Revision 1</b>	<b>Note</b>
1.	G - External AC power Ground	Same	

2.	G - External AC power Ground	Same	115/230 VAC <b>Important:</b> Power source must be synchronized with the power source for the monitored equipment, UPS can be used only if synchronized and has constant phase shift to HV bus power
3.	N - External AC power Neutral	Same	
4.	L - External AC power Line User is responsible to make sure an external means of circuit protection and disconnection is installed. It is recommended that this be as close to the device as possible.	Same	
5.	Device Status Relay (R3)	Same	NO
6.	Device Status Relay (R3)	Same	Common
7.	Device Status Relay (R3)	Same	NC
8.	Yellow Alarm Relay (Alarm 1)	Same	NO
9.	Yellow Alarm Relay (Alarm 1)	Same	Common
10.	Yellow Alarm Relay (Alarm 1)	Same	NC
11.	Red Alarm Relay (Alarm 2)	Same	NO
12.	Red Alarm Relay (Alarm 2)	Same	Common
13.	Red Alarm Relay (Alarm 2)	Same	NC
14.	RS-485 or RS-232 Interface Isolated ground (G)	Same	Normally Not Connected
15.	RS-485 or RS-232 Interface (B)	Same	Normally connected to modem or converter at factory
16.	RS-485 or RS-232 Interface (A)	Same	Normally connected to modem or converter at factory
17.		RS-485 & 4-20mA Interface cable shield	
18.			Not used
19.	Isolated 4-20mAmp interface	Same	-
20.	Isolated 4-20mAmp interface	Same	+

Figures 6.1 (Pre-Revision 1) and 6.2 (Revision 1) give typical connection diagram for panel mount IG option. **These are samples only! Actual wiring diagram is ALWAYS delivered with a device and MUST be used for connections!**

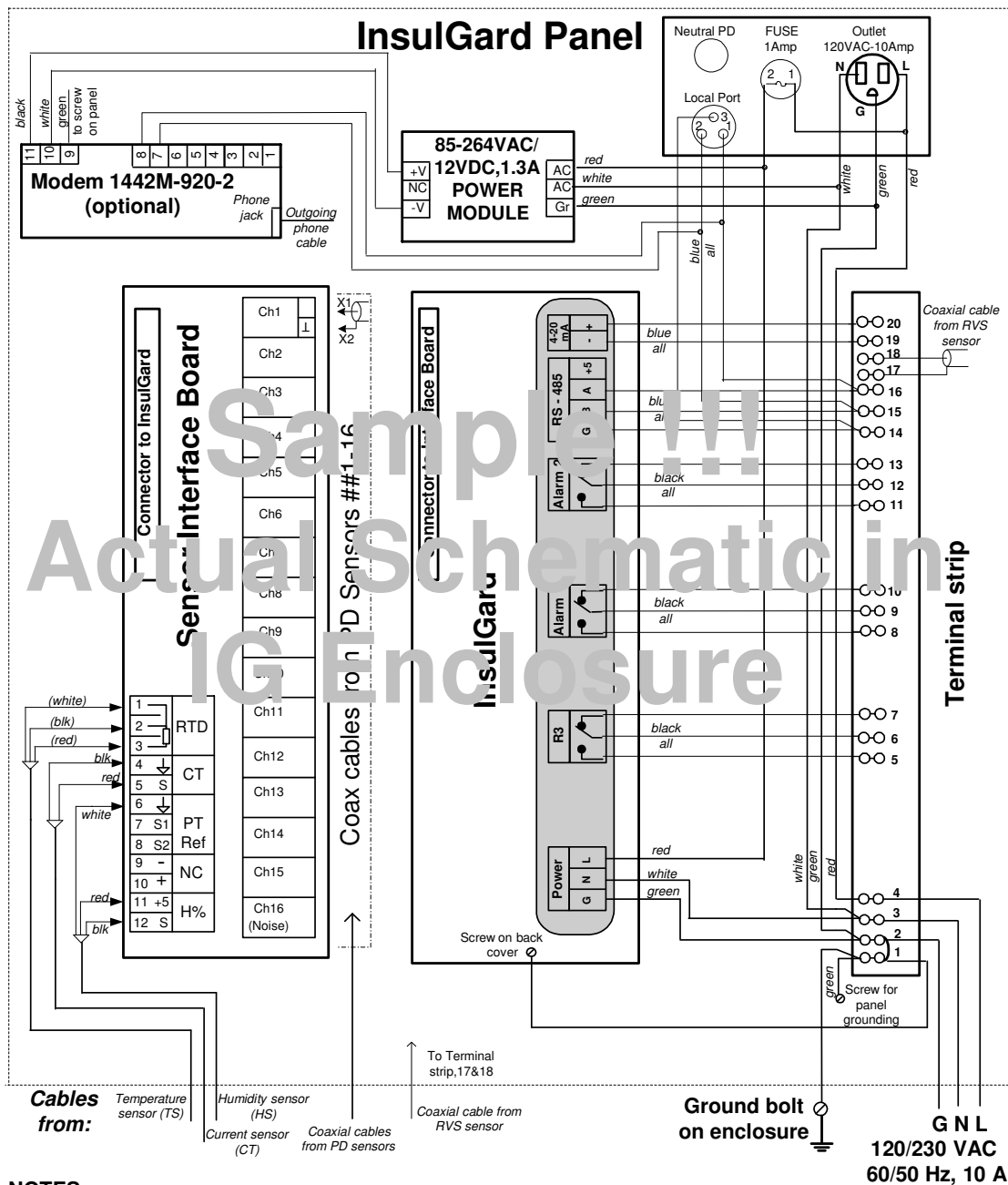


Figure 6-1 Typical connection diagram Pre-Revision 1.

## Sample InsulGard Panel Wiring Diagram, Revision 1

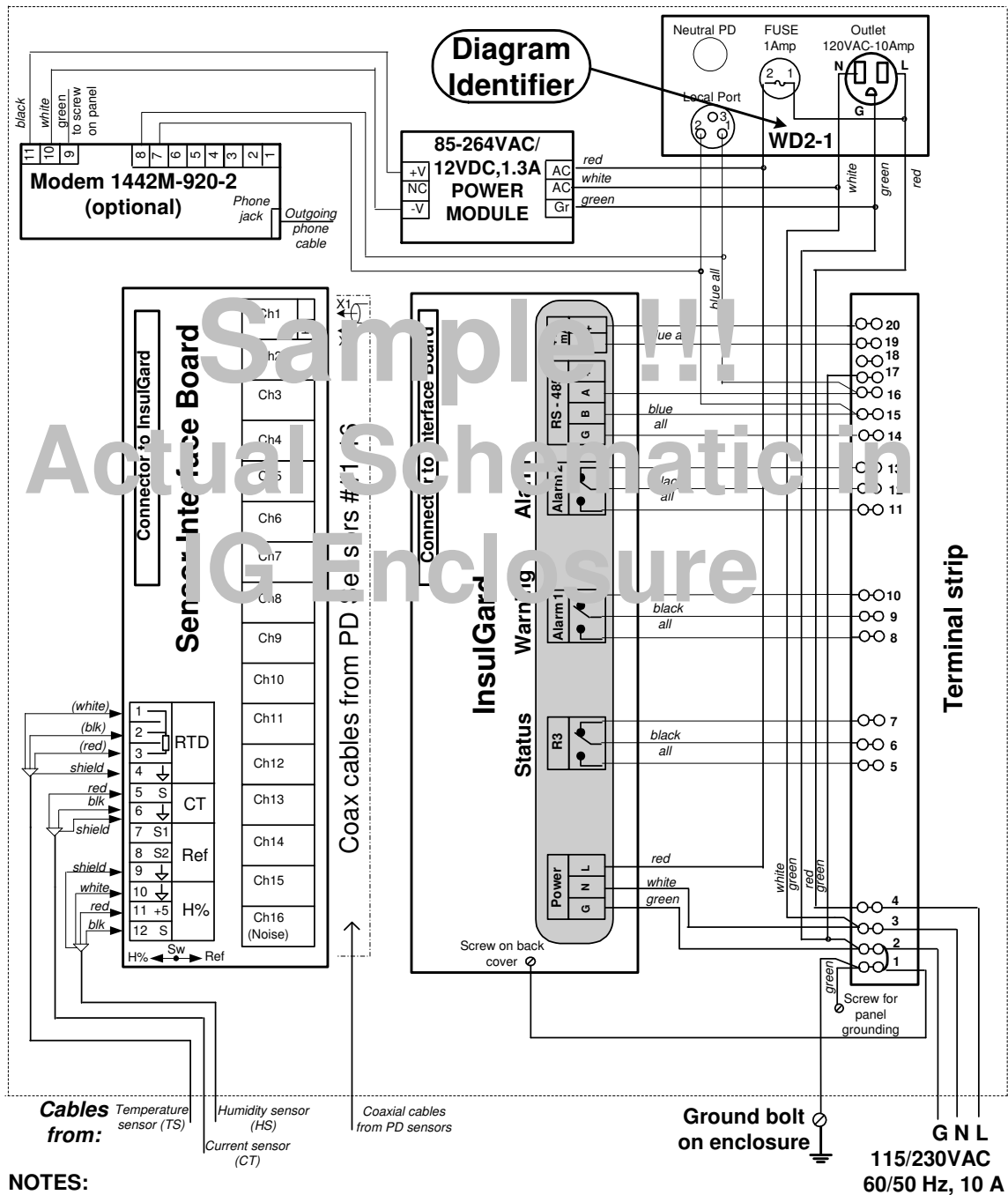
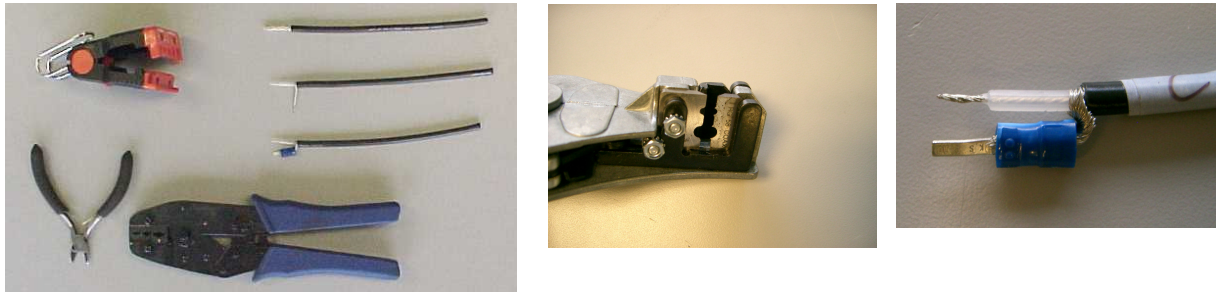


Figure 6-2 Typical connection diagram Revision 1

#### **2.2.3.4 Coax cables connections.**

Tie all cables together by tie-wrap at the top of the hub inside the device enclosure.

Using the coax cable stripper for RG58 cable (IDEAL part#**45264** STRIP MASTER for RG58 coax cable, Newark catalog#05H8227 or similar) strip the outer PVC jacket to the distance of 1-inch, unbraid the shield and remove the inner conductor insulation to the distance of about 0.3-inch, twist shield wires to avoid “hairs” and crimp the blade terminal to the shield. Cut stick out hairs to avoid short-circuiting. Do not use a blade to connect the signal (central) conductor.



**Figure 7.**

Connect the cables to their respective terminals at the Sensor Interface Board. Distribute cables evenly and secure them in place (Figure 3.).

Certain connections to InsulGard, such as the connections of the power supply, RS-485 Interface, 4-20 mA output, and the output relays utilize molded connectors supplied with the kit. All these connectors are pre-wired to the terminal board (refer to Figure 2 and Figure 6) except of the flash mount option.

#### **2.2.3.5 Step 4 - Device Installation and Final Connections**

- Connect the voltage sensor to the PT secondary at this time.
- Check with a DMM for the existence of signals across the respective terminals at the TB-3 terminal board: voltage channel (up to 6V AC), current channel (up to 0.6V AC). Check the resistance between respective RTD terminals of TB-3 terminal board.
- Check that the flat ribbon cable is connected to InsulGard inside its enclosure. Make sure that all connector latches are in vertical position (locked).
- Install InsulGard and fasten it to the standoffs with the supplied screws.
- Check that the 3-pin output relay terminal blocks are inserted in their respective terminals on the right side of InsulGard. The relay outputs are, from top to bottom:
  - P1– Red (alarm)
  - P2– Yellow (warning)
  - P3 – Device status

- In panel installations check for the presence of a 1A fuse. Replace with, **5x20 mm , 1.0 Amp, 250VAC . (We recommend 195 Series –(By Wickmann). Digi-Key part number – WK5048-ND)**. In a separately delivered InsulGard (for front installation) plug 115/230V power cord (supplied with the device) into the power connector at the bottom right of InsulGard.
- Energize the external power supply circuit (in a separately delivered InsulGard for front installation plug the InsulGard cord into an outside 115/230V AC receptacle). “Loading” should appear on the device display. Device is now ready for setup and operation. In a panel installed design check additionally that 115/230V is present in a receptacle inside the enclosure.
- In a panel-installed device with added power module and modem or converter power will be applied to them simultaneously with energizing the InsulGard. If modem and power source are mounted on a separate panel, as it is done for the front installed InsulGard, plug the cord from the power module into an outside 115 V AC receptacle. Power and TR LED should be on. The modem is ready for communication.



## 3 Startup

### 3.1 Setting InsulGard

#### 3.1.1 General

InsulGard allows for device setting from keypad and via RS-485/232 interface from PC using InsulGard software. (For software setting please refer to Software manual.)

Setting the device from PC is easier, but there are some settings available ONLY from the keypad. These are parameters or procedures that must be set at device commissioning time or at factory calibration:

- Device address on a network
- Automatic Phase Shift detection (Learn more in the Appendix 2 before starting this).
- Transmission Baud Rate
- Temperature channel calibration (Normally calibrated in the factory, if RTD type information is provided.)
- Voltage channel calibration
- Current channel calibration

#### 3.1.2 Quick Start Up

***Normally, InsulGard preset at the factory for particular application. The setup procedure below is a minimum procedure that is required for setting to monitoring. Specific applications might require some additional procedures. The sequence of the steps is most optimal. Try to follow the sequence.***

Once InsulGard is installed, all signals are connected and equipment is powered up, What are the most critical parameters to at commissioning? The following description attempts to present an order of the device setting. For full

description of setup options refer to sections below and the software manual. Some of setting procedures are skipped, instead, default factory settings are used. The following procedure assumes the most difficult manual setup. If set from a PC, many settings can be combined into one setup command. Refer to “InsulGard Software Manual”.

You can print the following table below and check that the procedures are completed.

**Quick Startup table**

<b>Parameter or Procedure</b>	<b>Description or Notes</b>	<b>Setup keys</b>	√
<i>Clear All Memory</i>	This is a very sensitive procedure. Performing it clears all device data memory. This is necessary at the beginning of PD monitoring on a NEW object.	Press simultaneously <b>←↑→</b> keys. <b>CLEARALL</b> will appear. To confirm press <b>Enter</b> , to exit press <b>Esc</b> . If confirmed, <b>CLEARinG</b> will appear. Wait until <b>CLEARed</b> appears. The memory is clear. Press <b>Esc</b> .	
<i>Enter Setup</i>	Enter appropriate password and enter setup. Your password is <b>5421</b>	Press “ <b>Set</b> ” key. <b>PSd-___</b> will appear on the display. A correct password must be entered, in order to enter the setup mode. Using <b>↑↓←→</b> keys enter password and press <b>ENTER</b> . Wait for about 20sec. The first option to appear is the date/time setup. Use the right and left arrow keys ( <b>←→</b> ) to scroll the setup parameters.	
<i>Date &amp; Time</i>	Note that IG with Firmware version 2.0 and later performs data continuity check while setting date and time. Setting data and time earlier then preexisting data causes ALARM status.	Scroll setup parameters until <b>d-XX.XX.XX</b> appears. Press <b>Enter</b> . Active digits will start flashing. Use <b>↑↓</b> keys to select the desired numeral. Use <b>←→</b> keys to activate the next (previous) segment of the display. When done, press <b>Enter</b> .  In the firmware versions 2.0 and later, If DATE that is set is earlier then preexisting data IG will prompt for clearing data that is later than date is set. The prompt is <b>EditArCH</b> If Enter is pressed all later data will be erased, if Cancel is pressed new date will be set without data erasing and then in normal mode <b>CLOCHErr</b> will be displayed.  Set time similarly to date setting manner.	
<i>Device Address</i>	<b>Device is shipped with the address 01, if other was not specified or manufacturer does not have data on previously installed in this location devices. If the</b>	Scroll setup parameters until <b>ndEVICE</b> appears. Press <b>Enter</b> . <b>ndEV-001</b> will appear. Use <b>↑↓</b> keys to set the required device address. Do not exceed 231. When done, press <b>Enter</b> .	

	<b>device is stand alone, do not change its address.</b> Make sure that the device address is unique in RS-485 network. The same addresses assigned to different devices will cause problems and contradictions in communications.		
<i>Rated Voltage</i>	Should be set before voltage channel calibration. Voltage is used in PDI calculations.	Scroll setup parameters until <b>VOLtAGE</b> appears. Press <b>Enter</b> . <b>VOL-XXX.X</b> will appear. Use <b>←→↑↓</b> keys to set the rated voltage of the object under test (kV, line-to-line). When done, press <b>Enter</b> .	
<i>Rated Current</i>	Should be set before current channel calibration.	Scroll setup parameters until <b>CurrEnt</b> appears. Press <b>Enter</b> . <b>I-XXXXX.X</b> will appear. Use <b>←→↑↓</b> keys to set the rated current of the object under test in Amps (usually full load or nominal current). When done, press <b>Enter</b> .	
<i>Activate channels</i>	Activate PD channel that will be used for monitoring. Any number of channels in any order can be activated. It is preferably activate the first necessary channels and leave all the rest inactive. If none of channels is active, the device will not start a measurement. Noise channel normally should be ON.	Scroll setup parameters until <b>CHAnnELS</b> appears. Press <b>Enter</b> . <b>CH01-On (OFF)</b> will appear. Use <b>←→</b> keys to set the channel to On or Off. Use <b>↑↓</b> keys to scroll the channels. When done, press <b>Enter</b> .  Next, <b>nCH</b> will appear. Use <b>←→</b> keys to set the noise channel to On or Off. In most applications MUST be ON. When done, press <b>Enter</b> .	
<i>Channel Sensitivity</i>	Ideally, sensor sensitivity should be determined during off line calibration test during the coarse of the sensors' installation. This does not always happen. Use suggested options below in such a case. Keep in mind that you may not be using an accurate number. <b>Make sure that sensors of the same type and similar purpose have the same sensitivity.</b> Recommended sensitivity, if unknown, is in parentheses:	Scroll setup parameters until <b>SEnSor</b> appears. Press <b>Enter</b> . <b>C01-10.00</b> will appear. This represents the sensitivity of Channel 01 equal to 10.00 nC/Volt. Press <b>Enter</b> to set the selected channel. Use <b>←→ ↑↓</b> keys to change sensitivity and/or channel. Press <b>Enter</b> when finished with selected channel. Using <b>↑↓</b> select another channel. Press <b>Esc</b> when done for all channels.	

	<ol style="list-style-type: none"> <li>1. Coupling Capacitor 3 - 5 nC/Volt (3)</li> <li>2. RFCT on cable drain shield 5 - 10 nC/Volt (10)</li> <li>3. RFCT on surge capacitor ground 3 - 5 nC/Volt (5)</li> <li>4. RTD sensor in motor/small generator (none of spiral shields on RTD wires) 5 - 15 nC/Volt (10)</li> <li>5. RTD sensor in large generator in spiral shields 50 - 70 nC/Volt (50)</li> <li>6. RFVS sensor in switchgear 10 - 20 nC/Volt. (15)</li> </ol>		
<i>Channel Phase</i>	<p>Sensors connected to a particular channel are in most cases associated with some phase. For example, a coupling capacitor connected to the phase B should be associated with phase B. Set associated phase to all active channels.</p> <p>In some cases a sensor senses all three phases (example, RFVS sensor in SWG). There is not a phase association in such a case - leave the phase A.</p>	<p>Scroll setup parameters until <b>ChPHASE</b> appears.</p> <p>Press <b>Enter</b>. <b>CH01</b> will appear.</p> <p>Press <b>Enter</b>. <b>PHASE-A</b> will appear.</p> <p>Use <b>↑↓</b> keys to set the phase assignment for the current channel. The options available are: A, B, C, AB, AC, BC.</p> <p>When done, press <b>Enter</b>.</p> <p>Use <b>↑↓</b> keys to select another channel and repeat the procedure.</p> <p>When done with all channels, press <b>Esc</b>.</p>	
<i>Parameters to Display</i>	<p>Set parameters to scroll on the display you need in monitoring mode. This includes almost all parameters excluding some auxiliary that are not connected.</p>	<p>Scroll setup parameters until <b>SET Shou</b> appears.</p> <p>Press <b>Enter</b>. <b>dAtE-On(OFF)</b> will appear. Use <b>←→</b> <b>↑↓</b> keys to select an item for display (On/Off).</p> <p>When done, press <b>Enter</b>.</p> <p>Items available for display are:</p> <ul style="list-style-type: none"> <li>Date - (<b>dAtE</b>)</li> <li>Time - (<b>timE</b>)</li> <li>Time of next measurement - (<b>rEAd</b>)</li> <li>Scroll channels - (<b>CHAn</b>)</li> <li>Power Frequency - (<b>FrEQ</b>)</li> <li>Temperature - (<b>Fr06</b>)</li> <li>Voltage - (<b>Fr07</b>)</li> <li>Current - (<b>Fr08</b>)</li> </ul> <p>Scroll setup parameters until <b>SHt</b> appears.</p> <p>Press <b>Enter</b>. <b>SHt-03</b> will appear.</p> <p>Use <b>↑↓</b> keys to set desired scroll time between the displayed items (seconds).</p> <p>When done, press <b>Enter</b>.</p>	

Determine Low Limit for PDI and PPS Calculation	<p><b>This procedure is not necessary in most applications. You can omit it.</b></p> <p>Run the utility called “<b>nOiSetSt</b>”. This utility is available only from the keypad. This utility will detect the Low Limits for each channel independently. Wait until complete. Scrolling results compare detected values for channels with the same sensitivity. If they differ for not more than 3 zones, allow the device to align them for the channels with the same sensitivity. Otherwise, leave them as is. <b>Remember: sensitivities should be set earlier!</b></p>	<p>Scroll setup parameters until <b>nOiSetSt</b> appears. Press <b>Enter</b>. “nL” will appear, press <b>Enter</b>(The device will start measurements on all active channels in order to determine the best setting.)</p> <p>When done, <b>CH01- XX</b> will be displayed.</p> <p>Using <b>↑↓</b> channels can be scrolled and measured value displayed for each channel.</p> <p>Press <b>Enter</b>. The prompt <b>AliGn- Y</b> will appear. Use <b>↑↓</b> to choose from Yes (Y) and No (N). Press <b>Enter</b> to save new values or <b>Esc</b> to exit without saving. If YES is selected and <b>Enter</b> is pressed, the device will set the same maximum value for all channels with the same sensitivity. If NO is selected and <b>Enter</b> is pressed, the device will keep unique values for each channel as it was detected.</p>	
Calibration for Current and Voltage Channels	<p>The goal of the procedure is to convert current and voltage inputs into meaningful numbers on the display and in database.</p> <p>We recommend using % of rated as a number to represent.</p> <p>You may enter coefficients manually or automatically determine them while setting the device.</p> <p>Automatic procedure is available only from keypad. It converts voltage and current inputs into % of rated value.</p>	<p>Scroll setup parameters until <b>CALibr U</b> appears. Press <b>Enter</b>. <b>InPCoEFF</b> will appear. This is the prompt for manual coefficient entering.</p> <p>Use <b>↑↓</b> keys and <b>CLcCoEFF</b> will appear. This is the prompt for automatic detection.</p> <p>If press <b>Enter</b>. in automatic mode <b>UPc-000.0</b> will appear</p> <p>Use <b>←→↑↓</b> keys to enter % of the rated voltage that currently present on the object.</p> <p>Press <b>Enter</b>.</p> <p>The calculated coefficient will be displayed: <b>U-XXXX.XX</b></p> <p>Press <b>Enter</b>.</p> <p>If press <b>Enter</b>. in manual mode <b>U-0001.00</b> will appear</p> <p>Use <b>←→↑↓</b> keys to enter manually the coefficient (<b>k<sub>v</sub></b>).</p> <p>When done, press <b>Enter</b>.</p> <p>Scroll setup parameters until <b>CALibr I</b> appears.</p> <p>Repeat the same procedures as for the voltage</p> <p>When done, press <b>Enter</b>.</p>	
Activate	There is an option to use Current, Voltage, Temperature	Scroll setup parameters until <b>InPt</b> or <b>InPI</b> or <b>InPU</b> appears.	

<i>Auxiliary Parameters to Suspend Measurements</i>	<p>or Humidity readings to suspend measurements, if any of them are out of pre-set boundaries. The main application of this feature is to suspend measurement, if equipment is out of service. Current is the best parameter to do so. Activate current for continuous check and set its boundaries. It is sufficient to set the current % lower boundary at 10–20%. It will suspend measurement, if it is below this value.</p> <p><i>The procedure on right describes set of Temperature channel. It is similar for two other auxiliary channels.</i></p>	<p>Press <b>Enter</b>. <b>InPt-On/OFF</b> will appear. Use <b>↑↓</b> keys to set the object temperature parameter check ON or OFF.</p> <p>Press <b>Enter</b>. If ON is selected, <b>tLO- 0050</b> appears. Use <b>←→↑↓</b> keys to set LOW temperature limit (deg C).</p> <p>Press <b>Enter</b>. <b>tHI- 1000</b> will appear. Use <b>←→↑↓</b> keys to set HIGH temperature limit.</p> <p>When done, press <b>Enter</b>.</p>	
<i>Number of Cycles of Power Frequency for Measurement</i>	<p>Represents a time of a single measurement. 60 cycle is optimal. You may set it higher, if better statistics is needed. Setting better statistics will proportionally increase a measurement time. Measurement time estimate in seconds is as follows: number of active channels * 21 magnitude windows * selected number of cycles / power frequency. As an example with 15 channels and 60 cycles = <math>15 * 21 * 60 / 60 = 315 \text{sec} \sim 5 \text{ minutes}</math>.</p>	<p>Scroll setup parameters until <b>SinCount</b> appears.</p> <p>Press <b>Enter</b>. <b>Cnt-060</b> will appear.</p> <p>Use <b>↑↓</b> keys to set the number of power cycles (of 60 or 50 Hz) for the measurement.</p> <p>When done, press <b>Enter</b>.</p>	
<i>Set 4–20 mAmps Output</i>	<p>Commonly PDI is the best parameter to represent the overall PD activity. In some cases, Maximum Pulse magnitude can be set for output. <b>Remember: enabling one of the parameters to 4-20mAmps output, enables the same parameter for Alarm and Display!</b></p>	<p>Scroll setup parameters until <b>Out tYPE</b> appears.</p> <p>Press <b>Enter</b>. <b>Out-PdI(Q02)</b> will appear.</p> <p>Use <b>←→</b> keys to set the required parameter to output.</p> <p><b>PdI</b> – Partial discharge intensity in % of “Red” threshold, or <b>Q02</b> – Pulse magnitude in % of “Red” threshold.</p> <p>When done, press <b>Enter</b>.</p>	
<i>Detection of Phase Shift</i>	<p><b>The procedure that is described in this section assumes that the device is configured for internal synchronization and its auxiliary inputs are load current and humidity. This is most common option. If the configuration is different from this, please refer to Appendix 2 for additional information.</b></p> <p><b>Note: Automatic phase shift detection is incorrect, if any of following has been observed:</b></p> <p><b>1. IG displayed dashes for several times in the versions 2.00 and higher (bad phase reference signal)</b></p>	<p>Scroll setup parameters until <b>PhShiFt</b> appears. Press <b>Enter</b></p> <p>Then you have a choice of manual (if phase shift known from another source) or automatic set of phase shift.</p> <p style="text-align: center;"><b>For manual setting</b></p> <p>press <b>Enter</b> and <b>PhSh-000</b> will appear. Use <b>←→↑↓</b> keys to set the relative phase shift from 0 to 360 (deg). Press <b>Enter</b> to Save new value, or <b>Esc</b> to exit without saving.</p> <p><b>Connections for automatic detection of phase shift in Pre-Revision 1:</b></p> <ul style="list-style-type: none"> <li>Humidity sensor wires (or jumper wire between terminals 10 and 12)</li> </ul>	

	<p><b>2. IG display shows continuously 357 (reference signal magnitude is too high).</b>  <b>3. Displayed values range exceeds <math>\pm 5^0</math> (low signal magnitude or high noise).</b>  <b>4. Any change in displayed phase shift has not been observed.</b></p> <p>As default, the device is synchronized from its power source. The device requires a phase shift between the source and the phase-A voltage on the object to be detected.</p> <p>Phase shift can automatically be detected by the device or entered manually if determined by any independent tool (UPDA or oscilloscope). <b>Phase shift is the phase between zero crossing of power source voltage and the first correspondent zero crossing of the voltage on the phase A of an object!</b></p> <p>If the A-phase reference is unavailable, another phase can be used, but manual adjustment will be required after automatic detection. The following phase angles must be added to the automatically detected value (pay attention to signs):  B-phase <b><math>-120^0</math></b>  C-phase <b><math>-240^0</math></b>  A-B-phase <b><math>+30^0</math></b>  C-B-phase <b><math>+90^0</math></b>  Coupling Cap on A-phase <b><math>+90^0</math></b></p> <p>If a result is out the range of <math>0-360^0</math>, you should add to the result or subtract from it <math>360^0</math> in order to get it within the range. This result should be entered in manual mode.</p> <p><i>Example: Reference signal from A-B phase (open delta PT) is used. Automatically detected phase shift is <math>345^0</math>. Adding <math>+30^0 = 375^0</math>. Subtracting <math>360^0 = +15^0</math>. <math>15^0</math></i></p>	<p>in case of internal Humidity sensor) must be temporally disconnected.</p> <ul style="list-style-type: none"> <li>Place temporal jumper between terminals 8 (“Ref.”) and terminal 12 (“S of H%”).</li> <li>Temporally connect the phase A voltage signal of the object instead of <b>Humidity signal on the Sensor Interface board</b> (terminals ## 6 - ground and 12 - signal). <b>Never exceed 5 V AC!!!</b></li> </ul> <p><b><i>In Revision 1 set switch in Sensor Interface Board to the right in “Ref” position. This will bring power frequency signal from coupling capacitor in the channel 1 to reference circuitry. You do not need to account for any additional sensor phase shift!</i></b></p> <p><b><i>Using potential transformer for phase shift measurement is described in Appendix2. Note that Jumper J1 (shown in the figure 6.3a Appendix2) should be removed.</i></b></p> <p style="text-align: center;"><b>For automatic detection</b></p> <p>Press <b>Set</b> and wait until <b>PhSh-XXX</b> appears. The device is automatically detecting the required phase shift between power source and the reference signal and displays it. Write down every 15 seconds several readings (<math>&gt;10</math>) that appears on the display and calculate the average value. If this average value is within <math>\pm 5^0</math>, setting is correct. If variations are higher – high frequency noise is essential in the reference signal. Press <b>Enter</b> to save new value, or <b>Esc</b> to exit without saving. If <b>Enter</b> has been pressed, the device will store the last detected phase shift.</p> <p><b>For firmware 2.07 version only, subtract detected phase shift from 360Deg and use this number for all following procedures!</b></p> <p>Restore original connections or set switch back to “<b>H%</b>” position.</p>	
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	<p><i>should be entered in manual mode.</i></p> <p><b>Important Note! In the firmware version 2.07 ONLY! Automatically detected phase shift MUST be manually correctet by subtracting detected value from 360 Deg! Than follow this manual with newly determined number.</b></p>		
Measurement Schedule	<p>The device is shipped with a schedule enabled of four measurements a day. This is the factory default setting. If needed, a single measurement can be done any time by a command from a PC.</p> <p><b>There is an option to set measurements by time interval. Remember: the interval can not be less then a time of single measurement!</b></p> <p><b>To estimate a time of a measurement use the formula <math>t = N_{\text{cycle}} * N_{\text{ch}} * 21/60 + 1</math> minute, <math>N_{\text{cycle}}</math> – number of power cycles, <math>N_{\text{ch}}</math> – number of active channels. Never set time interval in minutes less, then calculated by the formula. Otherwise, you might create an infinite cycle and will not be able to get out without rebooting.</b></p>	<p>Scroll setup parameters until <b>trEAdinG</b> appears. Press <b>Enter</b>. <b>rEG-dt</b> will appear. Use <b>←→</b> keys to schedule the measurement by a time interval <b>rEG-dt</b> or a fixed time of a day <b>rEG-t</b>. When done, press <b>Enter</b>.</p> <p>Select <b>rEG-dt</b> and press <b>Enter</b>. Set time interval in format XX.XX (hh.mm) using <b>←→↑↓</b> keys. Military format (24 hour) is used. Maximum interval can be 23 hours and 50 minutes. Press <b>Enter</b>.</p> <p><b>OR</b></p> <p>Select <b>rEG-t</b> and press <b>Enter</b>. <b>t01-00.00</b> will appear. Set <b>t01</b> to a desired time in the (hh.mm) format using <b>←→↑↓</b> keys. Press <b>Enter</b> when finished with <b>t01</b>. Use <b>↑↓</b> keys to select <b>t02</b> to the desired time. Continue until the required number of daily measurements specified.</p> <p>When finished with all time settings, press <b>Esc</b>.</p>	
Save Mode	<p>As default, the device is shipped with “Brief” mode of data saving. That will save a full PRPDD matrixes only twice a month. For commissioning one might need “Full” save mode for single measurements. <b>Remember: Set it back to Brief when finished!</b></p>	<p>Scroll setup parameters until <b>SET SAVE</b> appears. Press <b>Enter</b>. <b>S-briEF</b> will appear. Use <b>←→</b> keys to select <b>S-briEF</b> or <b>S-FULL</b> mode. When done, press <b>Enter</b>.</p>	
Alarm Relay Mode	<p>Alarm Relay can be set in one of three modes:</p> <ol style="list-style-type: none"> <li>1. Disabled (<b>OFF</b>) – Relay will not close contacts in a case of alarm</li> <li>2. Enabled (<b>On</b>) – Relay will keep alarm contacts closed all the time while alarm conditions are present</li> <li>3. Enabled for Time (<b>t</b>) – Relay contacts will be closed</li> </ol>	<p>Scroll setup parameters until <b>rELAY</b> appears. Press <b>Enter</b>. <b>rELE-On</b> will appear. Using <b>←→</b> keys select <b>On, OFF, or t</b> Press <b>Enter</b>.</p> <p>In case <b>On or OFF</b> was selected, the setting will be stored. In case <b>t</b> was selected, <b>t-0000</b> will appear. Using <b>←→↑↓</b> set time for relay closing in seconds.</p>	



	any time alarm is received for some specified time (in sec.)	When done, press <b>Enter</b> .	
<i>Select version of MODBUS protocol</i>	The firmware version 2.0 or later supports RTU TCP versions of MODBUS protocol. All earlier versions support only RTU version.	Scroll setup parameters until <b>Hodbus</b> appears. Press <b>Enter</b> . <b>tYPE rtU</b> will appear. Using <b>↑↓</b> you may change protocol to <b>tYPE tCP</b> . Press <b>Enter</b> .	
<i>Exit Setup</i>		Press <b>Esc</b> and <b>SAVinG</b> will appear	
<i>Start a Single Measurement</i>	Check that results are reasonable!		

### 3.2 Working with Data Memory

- ◆ InsulGard allows observing all stored information in the memory data.
- ◆ Press the **Memory** key to enter memory mode.
- ◆ Device will display **ALL-XXXXX** - total number of records in its memory.
- ◆ Press **Enter** key. The current month and date will be displayed.
- ◆ Change the date to the desirable and press **Enter**. The earliest record date and time on this date will appear.
- ◆ Scroll records up and down by using **↑↓** keys. Alarm LEDs will change their colors correspondingly to alarm status obtained in the particular measurement.
- ◆ When the desired date and time is selected, press **Enter**. **01-XXX-Y (for PDI) or 01Q-XXX (for Q<sub>02</sub>)** will appear depending upon what parameter was chosen for alarm. You can switch between PDI and Q<sub>02</sub> by **←→** keys or between channels by **↑↓** keys.
- ◆ The first two digits represent channel #, Q – magnitude parameter, XXX – parameter percent of Red alarm, and Y – alarm code for the selected channel: 1 – **Good** (PD characteristics are below Green threshold), 2 – **Good** (PD above Green but below Yellow threshold), 3 – **Warning** (PD is above Yellow but below Red threshold), 4 – **Alarm** (PD is above Red threshold).

## 4 Troubleshooting

### 4.1 Error Messages

InsulGard performs various tests at powering up, before every measurement and in some more situations. In the case of a fault, an error message will be displayed and the status relay contacts will open. The error message on IG display will appear as follows:

- ♦ **--Sync--** - Loss of synchronization signal. Check the jumpers that are shown in the Figure 6.1 at the Appendix 2 for internal synchronization. Check for synchronizing external signal that should be above 0.4VAC and also refer to the Appendix 2 for correct jumper's configuration. Refer to Appendix 2 of this manual for more details.
- ♦ **CLOCHErr** – This message indicates that some data in the device internal memory has date stamp that is later then the current date. This destructs a consistency of data. The appropriate action will be set correct date and time and delete all data that is later then current time. (Refer to DATE setup from keypad).
- ♦ **ErrorICH** – PD measuring channel did not pass calibration. If appears consistently, the device must be repaired.
- ♦ **ErrornCH** – PD noise channel did not pass calibration. If appears consistently, the device must be repaired.
- ♦ **FLASHErr** – the error reading from internal flash memory. May be fixed by deleting data from device memory. If this does not help, the device must be repaired.
- ♦ **STOPPEd** – Measurements are stopped and the device will never resume measurements automatically. Use RESUME command from keypad or from PC.

### 4.2 Fuse Replacement

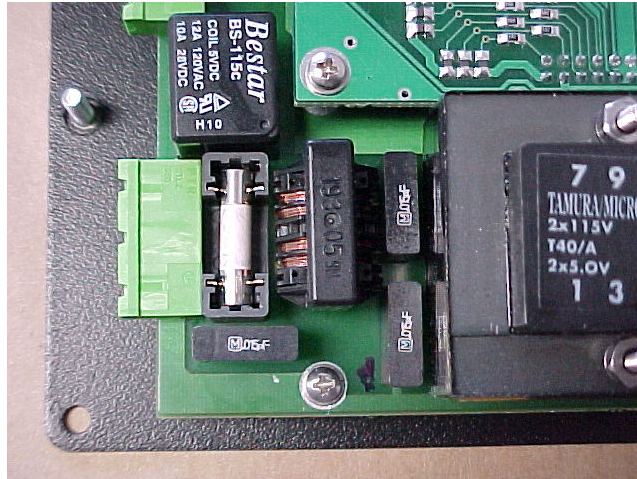
**Attention!!! Fuse replacement requires partial disassembly of the device and must be performed by a trained person. Contact your local Cutler-Hammer representative for assistance.**

If 120/230VAC power is present, but the device display does not light, the fuse then possibly been blown. Fuse replacement may address the problem.

**Attention!!! For 120 VAC Application use a 5x20 mm , 0.20 Amp, 250VAC . (We recommend 195 Series by Wickmann, Digi-Key part number – WK5034-ND). For 230 volt applications use a 5x20 mm , 0.08 Amp, 250VAC . (We recommend 195 Series by Wickmann, Digi-Key part number – WK5026-ND).**

**Attention!!! If after fuse replacement the second fuse is blown up while powering the device up, do not attempt replacing the fuse for the second time. Contact Cutler-Hammer representative for device service.**

Fuse location is shown on Figure 11 with the device protection cover taken off.



**Figure 11**

For fuse replacement:

- ♦ Disconnect the device from 115/230 VAC power;
- ♦ Disconnect flat ribbon cable from Sensor Interface Board;
- ♦ Disconnect all connectors located on the right side of the device;
- ♦ Unscrew four screws on the front panel, holding the device;
- ♦ Unscrew two screws on the back cover and disconnect flat ribbon cable from the device;
- ♦ Unscrew four screws holding the device back cover and carefully remove the cover. Pay attention to the flat cable connecting device's keypad;
- ♦ Replace fuse using appropriate fuse holder with new fuse. Check the old fuse, if it has been blown up.
- ♦ Assemble the device and make all connections;
- ♦ Check for correct connections and then power it up.

## 5 Appendix 1. Device Setup via Keypad

The following description follows the sequence of setup options that appears while using the RIGHT ARROW key. If the left arrow is used the sequence will be opposite.

### Entering Setup Mode:

- Press “**Set**” key. **PSd-\_\_\_\_\_** will appear on the display. A correct password must be entered, in order to enter the setup mode. Using **↑↓←→** keys, enter password and press **ENTER**. Wait approximately 20sec. The first option to appear is the date/time setup. Use the right and left arrow keys (**←→**) to scroll the setup parameters.

### Date:

Setting the current date.

- Scroll setup parameters until **d-XX.XX.XX** appears.
- Press **Enter**. Active digits will start flashing. Use **↑↓** keys to select the desired numeral. Use **←→** keys to activate the next (previous) segment of the display.
- When done, press **Enter**.

**Note:** In the firmware versions 2.0 and later, IG performs check on data preexisting in the device memory. If DATE that is set is earlier than preexisting data IG will prompt for clearing data that is later than that date is set.

The prompt is **EditArCH**. If Enter is pressed all later data will be erased, if Cancel is pressed new date will be set without data erasing and then in normal mode **CLOCHErr** will be displayed.

### Time:

Setting the current time

- Scroll setup parameters until **t-XX.XX.XX** appears.
- Press **Enter**. Active digits will start flashing. Use **↑↓** keys to select the desired numeral. Use **←→** keys to activate the next (previous) segment of the display.
- When done, press **Enter**.

### Activate Channels:

The device has 15 signal channels. Depending upon application, some channels can be used while the rest remain inactive. Do not activate more channels than necessary. This will conserve data memory.

- Scroll setup parameters until **CHAnnELS** appears.
- Press **Enter**. **CH01-On(OFF)** will appear. Use **←→** keys to set the channel to On or Off. Use **↑↓** keys to scroll the channels.
- When done, press **Enter**.
- Next, **nCH** will appear. Use **←→** keys to set the noise channel to On or Off.
- When done, press **Enter**.

### Parameters to Display:

Several parameters are available to display:

Date - (**dAtE**)

Time - (**timE**)

Time of next measurement - (**rEAd**)

Scroll channels - (**CHAn**) (This option will scroll data for all active channels in terms of % of Red threshold and Alarm status.)

Power Frequency - (**FrEQ**)

Temperature - (**Fr06**)

Voltage - (**Fr07**)

Current - (**Fr08**)

Humidity - (**Fr09**) (Activate this option, if one of auxiliary channels is configured for humidity.)

- Scroll setup parameters until **SET Shou** appears.
- Press **Enter**. **dAtE-On(OFF)** will appear. Use **↔** **↑↓** keys to select an item for display and activate it setting ON.
- When done, press **Enter**. See also **Setting Scrolling Time**.

#### **Sensor Sensitivity:**

InsulGard can use almost any PD sensor that is capable of operating in a radio-frequency band. Sensors differ by their response to the same discharge event, in other words, by their sensitivity. In order to take into account the specifics of a particular sensor, one should set proper sensitivity for every used sensor. In general, sensor sensitivity should be determined from off line sensor calibration.

We recommend using the same sensitivity for all sensors of the same type and function.

- Scroll setup parameters until **SEnSor** appears.
- Press **Enter**. **C01-10.00** will appear. This represents the sensitivity of Channel 01 equal to 10.00 nC/Volt. Press **Enter** to set the selected channel. Use **↔** **↑↓** keys to change sensitivity and/or channel. It is better to be consistent when changing channels. Here is the recommended way to change channels:
- Press **Enter** when finished with selected channel. Using **↑↓** to select another channel.
- Press **Esc** when done with all channels.

#### **Measurements Schedule:**

Two modes of measurements are available. These are based on the time interval between consequent measurements and on schedule. As default, the device is set to measure four times a day at 4:00AM, 10:00AM, 4:00PM, and 10:00PM. Up to 50 times per day can be set.

- Scroll setup parameters until **trEAdinG** appears.
- Press **Enter**. **rEG-dt** will appear. Use **↔** keys to schedule the measurement by a time interval **rEG-dt** or a fixed time of a day **t rEG-t**.
- When done, press **Enter**.

#### **Schedule by time interval:**

- Select **rEG-dt** and press **Enter**.
- Set time interval in format XX.XX (hh.mm) using **↔****↑↓** keys. Military format (24 hour) is used. Maximum interval can be 23 hours and 59 minutes.
- Press **Enter**.

#### **Schedule by fixed time of a day:**

- Select **rEG-t** and press **Enter**. **t01-00.00** will appear.
- Set t01 to a desired time in the (hh.mm) format using **↔****↑↓** keys.
- When finished with t01, press **Enter**.
- Use **↑↓** keys to select t02 to the desired time. Continue until the required number of daily measurements specified.
- When finished with all time settings, press **Esc**.

**Note: Device will take the scheduled readings only until the time setting 00.00 is reached. When 00.00 is reached, device will start the next measurement at the time t01 on the next day.**

#### **Data Save Mode:**

Single measurement data consist of PRPDD matrixes (one per active channel) and header containing common and calculated data for all channels. Size of either one matrix or header is about 1kByte.

The device has 2Mbyte of data memory available. The memory can be conserved choosing appropriate data saving mode. Matrixes should not be stored every time. Two data saving modes are available: FULL (saving all the data including matrixes for every measurement) and BRIEF (saving header only and full matrixes occasionally as preset).

We suggest saving full data, including matrixes, twice per month. This is sufficient for historical data and full data can be saved at any time by operator request, if needed.

- Scroll setup parameters until **SET SAVE** appears.
- Press **Enter**. **S-brief** will appear. Use **←→** keys to select **S-brief** or **S-FULL** mode.
- When done, press **Enter**.

#### **Setting to Store Matrixes in Brief Mode:**

This procedure sets the days between saving FULL PD data and setting a measurement number at a chosen day, to be saved as FULL. All other measurements will be saved as BRIEF.

- Scroll setup parameters until **ArCHdAtA** appears.
- Press **Enter**. **on 15dAYS** will appear. Use **↑↓** keys to select the number of days for the full PRPDD matrix storage. 15 days is the recommended setting.
- Press **Enter**. **nrEAD-01** will appear. Use **↑↓** keys to select the number of measurements at the selected day for the full PRPDD matrix storage. Suggest XX
- When done, press **Enter**.

#### **Pulse Width and Pulse Interval:**

This procedure sets allowed PD pulse width and allowed time interval (or dead time) between two consequent pulses. Pulse width is a helpful setting, allowing for the rejection of many industrial noises (based on the fact that noise often produces a much longer pulse than PD). Time between pulse is required to establish criteria, when a new pulse has appeared and when a signal is a continuation (tail) of the previous pulse.

The setting **dl** sets allowed pulse WIDTH and **dP** required PAUSE between pulses. Both settings have a choice of three settings 1, 2, and 3. As default, **dl=1** and **dP=3** are recommended.

- Scroll setup parameters until **PLS PAr** appears.
- Press **Enter**. **CH01** will appear. Press **Enter**. **dl-1dP-3** will appear. Use **←→↑↓** to set the desired value from 1-3 per each of the two parameters.
- Press **Enter**. Use **↑↓** keys to select another channel and repeat the process.
- When done, press **Esc**.

**dl** – sets the pulse width limit. The selections are:

- 1 – 640nS (recommended for RTD, IPDS, RFVS and RFCT sensors)
- 2 – 1280nS (may be used for RFCT sensors on cables)
- 3 – 2560nS

**dP** – sets the time interval between the two consecutive pulses (dead time). The selections are:

- 1 – 640nS
- 2 – 1280nS
- 3 – 2560nS (recommended)

#### **Alarm Status Thresholds for PDI and Magnitude (Q<sub>02</sub>) and Trend Thresholds:**

InsulGard operates Alarm contacts based on PD parameter LEVEL and TREND (rate of parameter change). Two PD parameters are available for alarm: PDI – partial discharge intensity and Q<sub>02</sub> – maximum PD pulse magnitude @ 0.2 PPC repetition rate. One of the parameters can be enabled for alarm at the time. The same parameter is enabled for 4-20mA output.

There are three level thresholds: Red, Yellow, and Green. Red and Yellow have a common sense meaning. Green threshold suppresses TREND alarm while any parameter variations occur below or at this level. In general, we recommend having proportion between threshold limits: Yellow 25-50% of Red, and Green 15-25% of Yellow.

*List of status thresholds for PDI and Q<sub>02</sub>:*

- **P0** – Green (normal) threshold for PDI (mW)
- **P1** – Yellow (warning) threshold for PDI (mW)
- **P2** – Red (alarm) threshold for PDI (mW)

- **P3** – Green (normal) threshold for Magnitude @0.2 ppc (mV)
- **P4** – Yellow (warning) threshold for Magnitude @0.2 ppc (mV)
- **P5** – Red (alarm) threshold for Magnitude @0.2 ppc (mV)

*List of status thresholds for trend:*

- **P0** – Yellow (warning) threshold for trend (times per year). Recommended 3-5times/year.
- **P1** – Red (alarm) threshold for trend (times per year). Recommended 5-10times/year.

**Level Alarm thresholds. PDI and Q<sub>02</sub> Yellow, Red, and Green thresholds for each channel.**

- Scroll setup parameters until **tHrESH** appears.
- Press **Enter**. **CH01** will appear. Press **Enter**. **P0-00005** will appear. You are now ready to enter the threshold for parameter **P0**. Use **←→↑↓** keys to change the threshold numerical value (refer to respective units below).
- When done, press **Enter**.
- Use **↑↓** keys to select another parameter and repeat the setup procedure.
- When done, press **Esc**. Use **↑↓** keys to select another channel and repeat.

**Trend Alarm thresholds. Yellow and Red thresholds (this setting is the same for all channels).**

- Scroll setup parameters using **↑↓** until **trEnd** will appear.
- Press **Enter**. **P0-010.00** will appear. Press **Enter**. Digit will start flashing. Using **←→↑↓** keys to change the threshold numerical value (refer to respective units below).
- Press **↑** key and **P1-020.00** will appear. Press **Enter**. Digit will start flashing. Using **←→↑↓** keys to change the threshold numerical value (refer to respective units below).
- When done, press **Enter**.
- Press **Esc**.
- When done with all thresholds setting, press **Esc**.

#### **Rated Voltage:**

Object under test rated voltage is used for calculation of partial discharge intensity. Set rated voltage line-to-line in terms of kV.

- Scroll setup parameters until **VOLtAGE** appears.
- Press **Enter**. **VOL-013.8** will appear. Use **←→↑↓** keys to set rated voltage of monitored object (kV, line-to-line).
- When done, press **Enter**.

#### **Rated Current:**

- Scroll setup parameters until **CurrEnt** appears.
- Press **Enter**. **I-00001.0** will appear. Use **←→↑↓** keys to set the rated current of the object under test in A (usually full load or nominal current).
- When done, press **Enter**.

#### **Number of Power Cycles for Data Acquisition:**

This setting determines the length of time the device will acquire data to get sufficient statistical PD representation. The parameter is measured in terms of number of cycles of power frequency. 60 cycles is recommended for rotating machines and 120 cycles for switchgear.

- Scroll setup parameters until **SinCount** appears.
- Press **Enter**. **Cnt-06** will appear. Use **↑↓** keys to set the number of power cycles (of 60 or 50 Hz) for the measurement.
- When done, press **Enter**.

#### **Alarm Relay Mode:**

Alarm Relay can be set in one of three modes:

Disabled (**OFF**) – Relay will not close contacts in a case of alarm



Enabled (**On**) – Relay will keep alarm contacts closed all the time while alarm conditions are present  
Enabled for Time (**t**) – Relay contacts will be closed any time alarm is received for some specified time (in sec.)

- Scroll setup parameters until **rELEY** appears.
- Press **Enter**. **rELE-On** will appear. Using **←→** keys select **On, OFF or t**
- Press **Enter**. In case **On or OFF** was selected, the setting will be stored.
- In case **t** was selected, **t-0000** will appear. Using **←→↑↓** set time for relay closing in seconds.
- When done, press **Enter**.

#### **Noise Channel Level:**

Noise channel slides down PD magnitude while measuring with PD signal channel. Noise channel will stop at the magnitude set as noise channel level while signal channel will slide till 4mV.

- Scroll setup parameters until **nCHLEVEL** appears.
- Press **Enter**. **n-0003.0** will appear. Use **←→↑↓** keys to set the required level for the noise channel (mV). Noise channel will not slide below this level.
- When done, press **Enter**.
- **Display Scroll Time:**
- Display item time can be configured from 1 to 255 second per item. As default it is 3 seconds.
- Scroll setup parameters until **SHt** appears.
- Press **Enter**. **SHt-05** will appear. Use **↑↓** keys to set desired scroll time between the displayed items (seconds).
- When done, press **Enter**.

#### **Device Address (required only when more than one device is on the same network):**

This is a sensitive setting. Make sure that the address is unique.

- Scroll setup parameters until **ndDEVICE** appears.
- Press **Enter**. **ndEV-001** will appear. Use **↑↓** keys to set the required device address. Do not exceed 231.
- When done, press **Enter**.

#### **Watch Function Settings:**

InsulGard has a Continuous Watch feature. This option is enabled between measurements and utilizes a separate counter. All PD signals are brought to this counter, which counts high level pulses and their series. If the device counts 5 series of high level pulses, it starts a regular measurement and, if Red alarm status is detected, stores FULL data and turns on the alarm.

- Scroll setup parameters until **HIGH ALr** appears.
- Press **Enter**. **HiA-010.0** will appear. Use **←→↑↓** keys to set the high alarm level to the required value (V). The High Alarm channel will detect all pulses exceeding this level.
- When done, press **Enter**.
- Scroll setup parameters until **HIALEVEL** appears.
- Press **Enter**. **HIA-0020** will appear. Use **←→↑↓** keys to set the high alarm pulse count level to the required value (pulse per second). Any series of pulses in excess of 20 pulses per second on High Alarm Channel will be counted as a series of pulses. Five series events occurred between scheduled measurements will initiate additional full measurement.
- When done, press **Enter**.

#### **Setting Full Data Saving Time Interval**

In Brief mode of data saving, the device automatically stores FULL data including phase-resolved data for every active channel. Two parameters required to configure this option: Number of days between savings (default is 15) and measurement number (default 2). If number of days exceeds 30 or measurement number exceeds the actual number of measurement scheduled per day, the algorithm will not work!

- Scroll setup parameters until **ArCHdAtA** appears.

- Press **Enter**. **on15dAYS** will appear and the number will flashing. Use **←→** keys to select a numeral and **↑↓** to set the required number.
- Press **Enter**. **nrEAd-02** will appear and the number will flashing. Use **←→** keys to select a numeral and **↑↓** to set the required number.
- When done, press **Enter**.

**RS-485 Interface Transmission Rate: (9600 BPS is a default for most of applications. You also may use 38400 BPS with good transmission lines.**

#### **Analog Interface (4-20 mA) Configuration:**

One of two parameters PDI or Q<sub>02</sub> can be brought to 4-20mAmps interface. The interface represents parameter value in terms of % of Red threshold. 14mAmps are equal to 100% of Red alarm. Enabling a parameter for the interface enables it to alarm automatically.

- Scroll setup parameters until **Out tYPE** appears.
- Press **Enter**. **Out-Pdl(Q02)** will appear. Use **←→** keys to set the required parameter to output.
- **Pdl** – Partial discharge intensity in % of “Red” threshold, or
- **Q02** – Pulse magnitude in % of “Red” threshold.
- When done, press **Enter**.

#### **Turn Monitoring OFF:**

It may be necessary to stop the monitoring mode for an undefined length of time (prolonged outage and so on). **(Remember: It is the responsibility of the operator to resume monitoring!)**

- Scroll setup parameters until **STOP** appears.
- Press **Enter**. **STOP-no** will appear. Use **←→** keys to set the control to **STOP-YES**.
- When done, press **Enter**.

This stops monitoring for indefinite time. To resume monitoring set control in **STOP-no** position.

#### **Setting Internal Phase Shift:**

By default, InsulGard uses the internal phase reference from its 115/230 VAC power source. (External phase reference is also available for specific applications such as, variable frequency drives (refer to the correspondent part of User Manual). Obtaining a correct relative phase shift between the internal phase reference and the voltage on monitored object is very important for correct interpretation of phase-resolved PD distribution (PRPDD). This value needs to be established by an operator during setup time. It is a value of the phase shift in degrees between the line A-to-ground voltage of monitored object and the Line-to-Neutral (Ground) voltage of the power supply. The phase shift is counted from the power supply positive zero crossing.

Required Phase Shift can be entered into device manually, or determined automatically with the precision of 5 degrees. For automatic detection a phase reference signal from the A-phase should be temporarily connected to the the device. Connection scheme of a reference signal depends upon device configuration and application. Please refer to the correspondent section for the right connection schematic for your application. **Remember: In all cases, the reference signal should not exceed 5V AC!**

- Scroll setup parameters until **PhShiFt** appears.
- Press **Enter or Set**.
- If **Enter** is pressed **PhSh-000** will appear. Use **←→↑↓** keys to set the relative phase shift from 0 to 360 (deg).
- Press **Enter** to Save new value, or **Esc** to exit without saving.
- If **Set** is pressed **PhSh-XXX** will appear. The device will automatically detect required phase shift and display it.
- Press **Enter** to Save New value, or **Esc** to exit without saving.

### **Phase Assigning to a Channel:**

As the InsulGard uses a variety of sensors that can be associated (directly or indirectly) with any phase (or their combination thereof) of the electrical system, it is important that each sensor be assigned to a correct phase. This is important for the accurate interpretation of PRPDD. For example, coupling capacitor connected to B-phase should be assigned to the phase B.

- Scroll setup parameters until **ChPHASE** appears.
- Press **Enter**. **CH01** will appear. Press **Enter**. **PHASE-A** will appear. Use **↑↓** keys to set the phase assignment for the current channel. The options available are: A, B, C, AB, AC, BC.
- When done, press **Enter**. Use **↑↓** keys to select another channel and repeat the procedure.
- When done, press **Esc**.

### **Auxiliary Input Channels (Temperature, Voltage, and Current). Activating for Measurement Suspend Mode:**

**NOTE: Activating options described below activate measurement suspend mode, if a parameter is out of permitted boundaries. Pay attention to parameter LOW and HIGH levels.**

#### **Temperature**

- Scroll setup parameters until **InPt** appears.
- Press **Enter**. **InPt-On/OFF** will appear. Use **↑↓** keys to set the object temperature measurement ON or OFF.
- Press **Enter**. If ON is selected, **tLO- 0050** appears. Use **↔↑↓** keys to set LOW temperature limit (deg C).
- Press **Enter**. **tHI- 1000** will appear. Use **↔↑↓** keys to set HIGH temperature limit.
- When done, press **Enter**.

#### **Voltage**

- Scroll setup parameters until **InPU** appears.
- Press **Enter**. **InPU-On/OFF** will appear. Use **↑↓** keys to set the object terminal voltage measurement ON or OFF.
- Press **Enter**. If ON is selected, **ULO- 0000** appears. Use **↔↑↓** keys to set LOW voltage limit .
- Press **Enter**. **UHI- 1000** will appear. Use **↔↑↓** keys to set HIGH voltage limit.
- When done, press **Enter**.

#### **Current**

- Scroll setup parameters until **InPI** appears.
- Press **Enter**. **InPI-On/OFF** will appear. Use **↑↓** keys to set the object load current measurement ON or OFF.
- Press **Enter**. If ON is selected, **ILO- 0000** appears. Use **↔↑↓** keys to set LOW current limit.
- Press **Enter**. **IHI- 1000** will appear. Use **↔↑↓** keys to set HIGH current limit.
- When done, press **Enter**.

### **Trend Time Window:**

The device allows providing an alarm based on both levels of PDI and Magnitude and on trend of these parameters. The setting below sets a sliding time window represented in WEEKS for trend calculations. At any time trend is calculated, the data is set weeks back from the current time and will be used for trend.

- Scroll setup parameters until **CALcSPd** appears.
- Press **Enter**. **SPEEd- 18** will be displayed. Using **↔↑↓** set required number of weeks for trend calculation.
- When done, press **Enter**.

### **Calibrating Auxiliary Input Channels (Temperature, Voltage, Current and Humidity):**

**NOTES:**

Do not calibrate Temperature channel without a necessity! It is pre-calibrated at the factory. Temperature input channel uses the resistance temperature detector (RTD) as a sensor. RTD can vary by type and resistance. If no other option is specified by the user at the time of ordering, InsulGard is supplied and calibrated for the Platinum (Pt) 100 Ohm RTD. Use of any other RTD type will require a hardware change and recalibration in the field. The field recalibration of the temperature channel is addressed in Appendix 3

Do not calibrate humidity channel without a necessity! It is pre-calibrated at the factory.

Voltage and Current input channels are normally calibrated on site. Sensors must be connected and the equipment energized, carrying a load. Voltage and Current calibration **MUST** be done after their Rated values were set. Ask an operator about current % of current and voltage to the rated ( $V_c$  and  $I_c$ ). Determine  $k_v = V_c/V_d$  and  $k_i = I_c/I_d$  (for the manual mode only).

- Scroll setup parameters until **CALibr U** appears.
- Press **Enter**. **InPCoEFF** will appear. This is the prompt for manual coefficient entering.
- Use **↑↓** keys and **CLcCoEFF** will appear. This is the prompt for automatic detection.
- If press **Enter**. in automatic mode **UPc-000.0** will appear
- Use **↔↑↓** keys to enter % of the rated voltage currently present on the object.
- Press **Enter**.
- The calculated coefficient will be displayed: **U-XXXX.XX**
- Press **Enter**.

If press **Enter**. in manual mode **U-0001.00** will appear

- Use **↔↑↓** keys to enter manually the coefficient ( $k_v$ ).
- When done, press **Enter**.
- Scroll setup parameters until **CALibr I** appears.
- Repeat the same procedures as for the voltage
- When done, press **Enter**

#### **4-20 mAmps Interface Calibration**

The interface is optically isolated and powered from InsulGard. It is normally pre-calibrated at the factory.

This output can be calibrated in order to adjust for specific circuitry. At this procedure the device will set 5, 7, 9, 11, 13, 15, 17 and 19 mAmps on its output. If receiving interface reads differently, its values can be entered into InsulGard, which will calculate linear approximation with the least square method.

- ♦ Scroll setup parameters until **CAL 4-20** appears.
- ♦ Press **Enter**. **05.00** will appear. Use **↔↑↓** keys to set the value that receiving device reads.
- ♦ Press **Enter**. **07.00** will appear. Use **↔↑↓** keys to set the value that receiving device reads.
- ♦ Press **Enter**. **19.00** will appear. Use **↔↑↓** keys to set the value that receiving device reads.
- ♦ Press **Enter**. **A XXXXX** will appear.
- ♦ Press **Enter**. **B XXXXX** will appear. These are coefficients in the linear approximation.
- ♦ When done, press **Enter**.

#### **Noise Channel Offset for Each Signal Channel:**

Noise channel offset allows set noise channel level on -5 - +5 magnitude zones relatively to signal channel independently for each signal channel. As default, all channels have +1 zone noise channel offset. Do not change unless necessary.

- ♦ Scroll setup parameters until **nCHOFFS** appears.
- ♦ Press **Enter**. **CH01 X** will appear. Use **↔** to set desirable offset and **↑↓** to scroll channels.
- ♦ When done, press **Enter**.

### **Low Limit for PDI and Pulse Count Calculations:**

PDI and pulse count are calculated for each channel starting from the magnitude zone and up. This feature allows rejecting background noise levels from affecting PDI and pulse count calculations. The low magnitude limit to calculate parameters can be set for each channel independently based on its own background noise level, if any.

There are two options to set these limits – automatic and manual.

In **automatic** mode the device will measure actual signals from each channel with the noise channel set OFF. It will count all pulses received by the channel and find a magnitude, when the total number of pulses above this magnitude will exceed 50,000 per second. The device will suggest the next magnitude window above detected as a low boundary for parameter calculation. If confirmed by a user, additional sub-function will align boundaries for all channels with the same sensitivity to the same maximum of all detected value.

**Manual** option allows setting all boundaries manually.

### **Automatic Detection**

- ◆ Scroll setup parameters until **nOiSEtSt** appears.
- ◆ Press **Enter**. The device will start measurements on all active channels in order to determine the best setting. When done, **CH01- XX** will be displayed. Using **↑↓** channels can be scrolled and measured value displayed for each channel.
- ◆ Press **Enter**. The prompt **AliGn- Y** will appear.
- ◆ Use **↑↓** to choose from Yes (**Y**) and No (**N**).
- ◆ If YES is selected and **Enter** is pressed, the device will set the same maximum value for all channels with the same sensitivity.
- ◆ If NO is selected and **Enter** is pressed, the device will keep unique values for each channel as it was detected.
- ◆ To exit without saving new values press **Esc**.

### **Manual Setting**

- ◆ Scroll setup parameters until **CALcPdl** appears.
- ◆ Press **Enter**.
- ◆ **CH01** will be displayed. Using **↑↓** scroll channels to get a desirable.
- ◆ Press **Enter**.
- ◆ **Pdl - XXXX** will appear. Use **←→** to scroll through available choices. When done, press **Enter**. Chose another channel and repeat the setting for this channel.
- ◆ When done with all channels, press **Esc**.

### **Software Filters**

At the latest firmware versions of InsulGard software filters based of PD fingerprint analysis are became available. These filters have been specifically developed for coupling capacitor sensors on large turbine generators equipped with long iso-phase bus ducts. We do not recommend to use these filters in another equipment or sensors without consulting to an expert.

- ◆ Scroll setup parameters until **FiLteR** appears.
- ◆ Press **Enter**. **CH01** will appear.
- ◆ Using **↑↓** keys select desirable channel and press **Enter**.
- ◆ **FiLteR-0** appears. Using **↑↓** keys select filter number from filter choice 1, 2 or 3. If 0 is selected no filter being used.
- ◆ Press **Enter** , select another channel and repeat the procedure.
- ◆ Press **Esc** when done with all channels.

### **Start Single Measurement**

This procedure forces a measurement to start immediately.

- ◆ Scroll setup parameters until **SinGLE** appears.
- ◆ Press **Enter**. This will force a measurement.

### **Selecting Modbus RTU or TCP protocol**

The firmware version 2.0 or later supports RTU and TCP versions of MODBUS protocol. All earlier versions support only RTU version

- ◆ Scroll setup parameters until **HodbuS** appears.
- ◆ Press **Enter**. **tYPE rtU** will appear.
- ◆ Using **↑↓** you may change protocol to **tYPE tCP**
- ◆ Press **Enter**.

**Note: By pressing ESC at any time during scrolling setup parameters, the current settings will be saved.**

## 6 Appendix 2. Synchronization and Phase Reference Shift

One should clearly distinguish between synchronization and phase reference shift. While the first is a vital part of taking PD reading, the second is used for correct phase-resolved data representation in InsulGard software and part analysis associated with this phase-resolved data.

**Loss of synchronization stops InsulGard operation! InsulGard displays this error as “-SYnC-”.**

Incorrect phase reference shift does not affect data acquisition by IG, integral quantities calculations and alarm operation. Even more, establishing correct phase reference shift later will allow for correct phase-resolved data analysis of the data acquired earlier.

Correct phase reference shift should be set regardless to the selected synchronization option.

### 6.1 Synchronization

InsulGard allows for external and internal synchronization from 115/230VAC power supply. The second is most reliable option and it is default for InsulGard. InsulGard stops operation only if power is off.

External synchronization is used only when it is really necessary, if power supply voltage is not synchronous with the voltage on the monitored object. This happens in VFD applications or isolated systems such as 25Hz systems.

***Be cautious if power an InsulGard from UPS, unless UPS has constant phase shift to the voltage in the monitored object in stand by mode. If not, you get an “asynchronous” situation.***

Two jumpers that are shown in the figure 6.1 in the internal synchronization position provide for a choice of synchronization. The jumpers are located inside InsulGard enclosure to the right from the power supply transformer. Both jumpers should be moved to the right for an external synchronization.

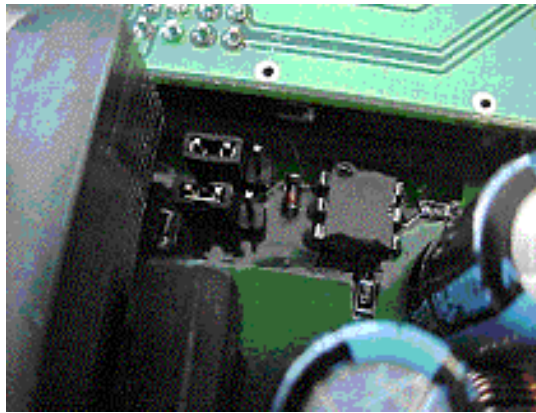


Figure 6.1

#### 6.1.1 Pre-Revision 1

External synchro-signal should be connected to the IG sensor interface board. There are two external synchronization options that are configured by jumpers in the sensor interface board:

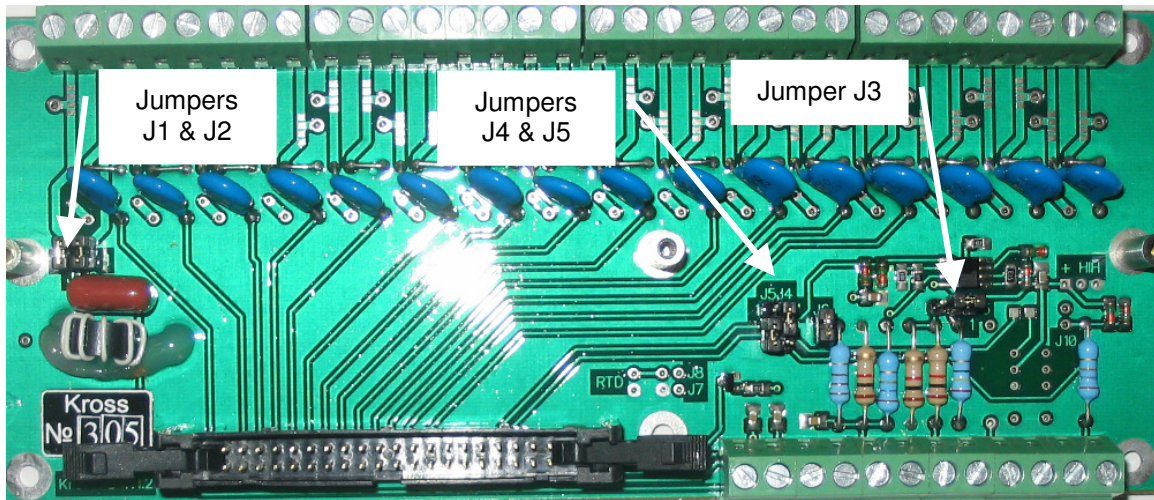
- Using an external signal (most preferred is potential transformer). This signal should be connected to the “Ref” #8 terminal and the ground wire should be connected to the terminal #6. The signal should not exceed 3.5 VAC and, if exceeds, should be externally conditioned by, for example, resistive divider. Note that “Ref” has 1 MOhm internal impedance and 47nF capacitance to the ground.
- Using coupling capacitor connected to PD channel #1. Coupling capacitor signal contains both high frequency partial discharge and power frequency components. Power frequency component



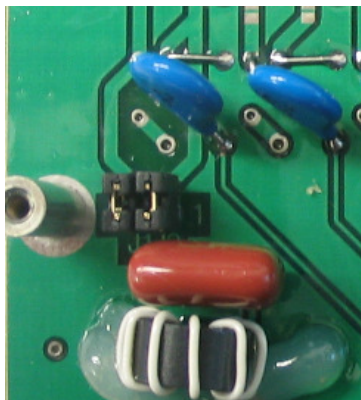
may be used for synchronization.

Sensor interface board with jumpers is shown in the figure 6.2a. Enlarged portions of the board are in the figures 6.2 b and c. Jumper positions as they are shown (default) configure external reference for a coupling capacitor. Arrows show default position of the jumpers. In this case power frequency signal component from PD channel #1 is brought to the “Ref” terminal #8 and may be used for both external synchronization and phase reference shift measurement.

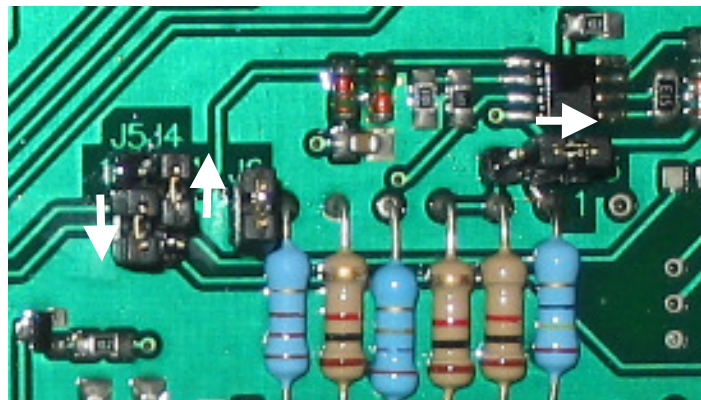
In order to use “Ref” terminal for an external signal, the jumpers J1 and J2 should be removed disconnecting “Ref” from PD channel #1.



a.



b.



c.

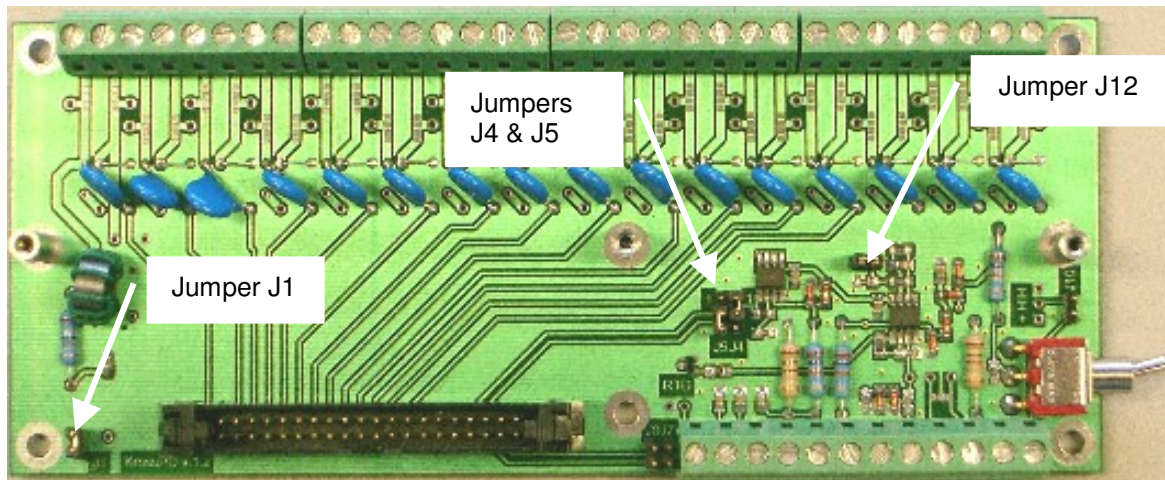
**Figure 6.2 Default jumper position as shown. Pre-Revision 1.**

### **6.1.2 Revision 1**

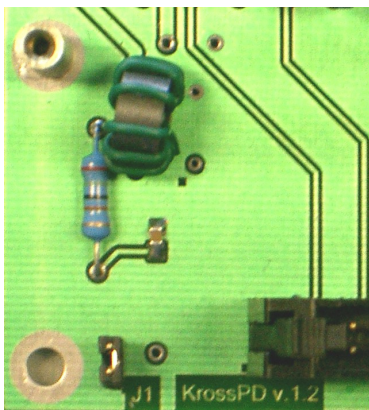
As default, jumpers in the sensor interface board are configured for synchronization from power frequency signal component of the channel #1. This assumes that coupling capacitor sensor from the phase A is connected to this channel. Therefore, once jumpers in IG are moved to external synchronization option, as it described in 6.1 (the figure 6.1) above, IG will be synchronized from PD sensor connected to the channel 1. Jumper J1 actually connects this input to synchronization circuitry. Refer to the figure 6.3 for jumper locations.



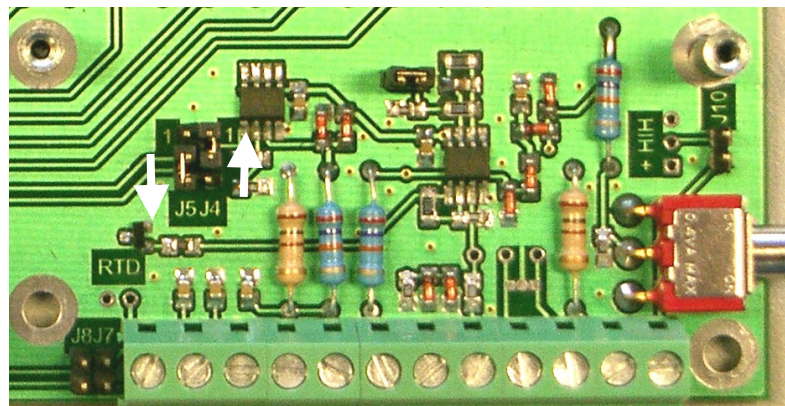
If an external signal (most preferred is potential transformer of the phase A), is planned for synchronization the jumper J1 should be removed. This allows using a signal connected to the “Ref” #7 terminal for synchronization. The signal should not exceed 6 VAC and, if exceeds, should be externally conditioned by, for example, resistive divider. Note that “Ref” has 1 MOhm-impedance to the ground.



a.



b.



c.

Figure 6.3 Default jumper position as shown. Rev 1.

## 6.2 Phase Reference Shift

Phase Reference shift is a phase angle between IG synchronization signal and the phase A voltage on the monitored object. It does not matter how this number is obtained. One may use InsulGard, a phase meter, oscilloscope or another instrument.

### 6.2.1 Internal Synchronization

Power source 115/230 VAC is used for synchronization, as default. Phase shift between power source voltage and the phase A voltage should be determined.

In case of a number known from any other source it can be manually entered.

### 6.2.1.1 Measuring phase shift with InsulGard

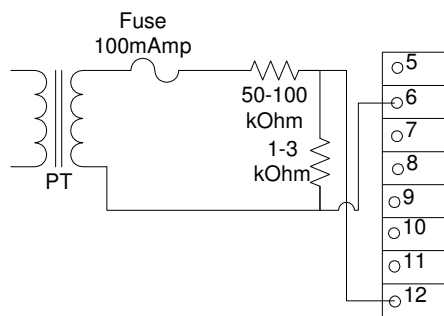
InsulGard may operate as a simple phase meter, if **PhShiFt** procedure is selected in setup mode and **Set** key is pressed.

#### Connections Pre-Revision 1

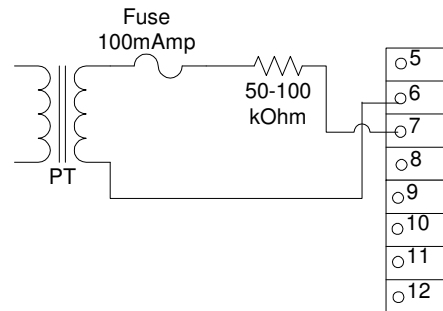
Phase reference signal should be temporarily connected to the terminal #12 (Humidity sensor should be disconnected). At some rare instances InsulGard is configured for Voltage signal. Then reference signal should be connected to the terminal #7 (marked as “PT”). In both cases, if other than coupling capacitor on Ch1 is used common wire (ground) should be connected to the terminal #6.

Note that the terminal #12 has 1Mohm to the ground (high impedance input) and the terminal #7 has 2kOhm to the ground (low impedance input).

Note that a reference signal should not exceed 3.5VAC. In case of PT signal is used and in order to protect both PT output and InsulGard input make simple resistive divider circuit.



**PT Connection to terminal #12**



**PT Connection to terminal #7**

#### Connections Revision 1

As it has been noted, all connections are pre-configured for using coupling capacitor on the channel 1 for the phase shift detection. All is needed is to set switch in the sensor interface board into “Ref” position to the right. **Note: do not forget to return it into Humidity mode after completion!**

If an external signal is needed for the procedure, it should be connected to the terminal #7 and common terminal #9. As above, the switch should be set into “Ref” position and jumper J1 (the figure 6.3a) removed. Note that input impedance is 1Mohm and a reference signal should not exceed 6AC. In case of PT signal is used and in order to protect both PT output and InsulGard input make simple resistive divider circuit made of 10kOhm and 100Ohm resistors.

#### Measurement

As mentioned above, in **PhShiFt** setup mode pressing **Set** key starts a phase angle measurement between InsulGard power source voltage and AC signal brought to the InsulGard. InsulGard display will be updated with a measured value once every 15 seconds.

Normally measured value deviates within the range of  $\pm 5^\circ$ . One need to observe IG display for 1-2 minutes and derive average of displayed angles.

A measured angle is the angle between InsulGard power source voltage and signal selected for phase reference purpose. If reference voltage is different from phase A, a correction for the difference between reference source and the phase A should made manually. A number that represents the difference must be added to a measured value. New number should be adjusted to  $0^\circ$ - $360^\circ$  range by adding or subtracting  $360^\circ$  and resultant number manually entered into InsulGard. The table below shows correction angle for most common phase reference signal options.

**Important Note: In the firmware version 2.07 ONLY detected phase shift MUST be manually corrected by subtracting the detected number from 360Deg. For example, display shows 135. The correct number for all following operations will be  $360-135=225\text{Deg}$ !**

Phase Reference Option	Additional Phase Shift
PT Phase A	0
PT Phase B	-120
PT Phase C	-240
PT Phase A-B	+30
PT Phase C-B	+90
RVS sensor of Cutler-Hammer	0
External signal from Coupling Capacitor on Phase A	+90

### **Precaution**

#12 terminal input is a very sensitive and it has high impedance. It is affected by power frequency noise. Below are some hints that may identify incorrect phase angle measurement:

- InsulGard displays dashes with some consistency in firmware version 2.00 and higher or 0 in older versions. Signal is likely close to zero.
- InsulGard reads  $357^{\circ}$  most of time in firmware pre-version 2.XX. Signal is too high.
- Phase angle varies on more than  $\pm 10^{\circ}$ . High noise content in the signal.

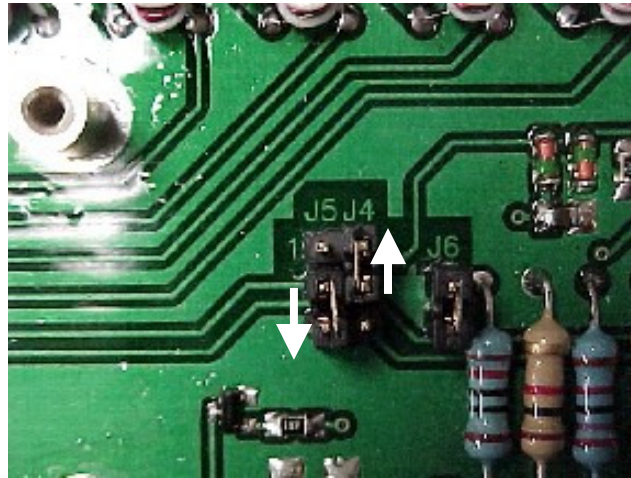
Check jumper position and reference signal magnitude in any of these cases!

### **6.2.2 External synchronization**

The table below presents phase angles for most common synchronization options. These numbers should be manually entered from IG keypad or IG software at InsulGard startup and commissioning.

<b>External Synchronization Signal</b>	<b>Phase Shift</b>
PT Phase A	0
PT Phase B	+240
PT Phase C	+120
PT Phase A-B (Open Delta)	+30
PT Phase C-B (Open Delta)	+90
Coupling Capacitor on the Phase A <b>Pre-Revision 1</b>	+90
Coupling Capacitor on the Phase A <b>Revision 1</b>	0
RVS sensor of Cutler-Hammer	0

### 6.3 Auxiliary input configuration



**Fig.6.4**

InsulGard accepts three additional signals for PD correlation to a dynamics. One signal is always a temperature. See the following paragraph for temperature channel configuration and calibration. Two another inputs are configurable for Load Current or Humidity (J4) and for System Voltage or Humidity (J5).

Most common configuration is Current and Humidity. The jumper position is shown in the figure 6.4. J4 configures Current channel for Current and J5 configures Voltage channel for Humidity.

**Pre-Revision 1:** J6 in the shown position sets Current channel input impedance to 100 Ohms. Removing the jumper will change the impedance to 1 kOhm. In **Revision 1** the current channel input impedance is always 100 Ohms.



## 7 Appendix 3. Temperature Channel Calibration

InsulGard can be configured for 10Ohms, 100Ohms and 1000Ohms Pt RTDs. 120 Ohm Ni fits 100 Ohm Pt range.

InsulGard is configured and calibrated at the factory for 100 Ohm Pt RTD, if other has not been specified. Reconfiguring temperature channel requires hardware jumpers' configuration and calibration. Procedures are described below.

### **Hardware Configuration**

Jumpers configuring InsulGard for different RTD resistance are inside the enclosure. Jumper position should be selected according to pictogram printed on PCB. The figure 7.1 shows jumper configuration for 100 Ohm Pt RTD.

**Note: Disconnect power source for hardware configuration! Pay attention to flexible keypad cable connected to PCB while opening or closing InsulGard enclosure!**

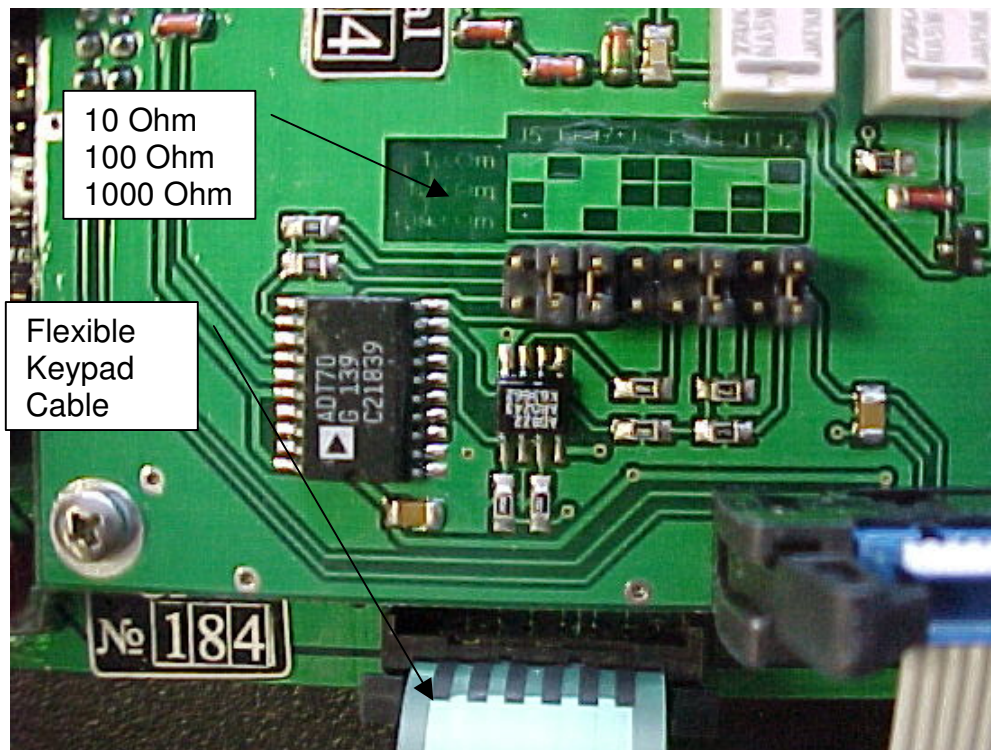


Figure 7.1.

### **Calibration**

You need two precise resistors representing temperatures of 0°C and 100°C for selected RTD type. The table below shows these resistances for most common RTD types.

RTD Type	Resistance @ 0°C	Resistance @ 100°C
Cu 10 Ohm	8.93	13.2
Pt 100 Ohm	100	138.6
Pt 1000 Ohm	1000	1386
Ni 120 Ohm	120	201

Resistors should be connected as it shown at the figure 2. Terminals 1 and 2 must be shortened and a resistor connected between the terminals 2 and 3.

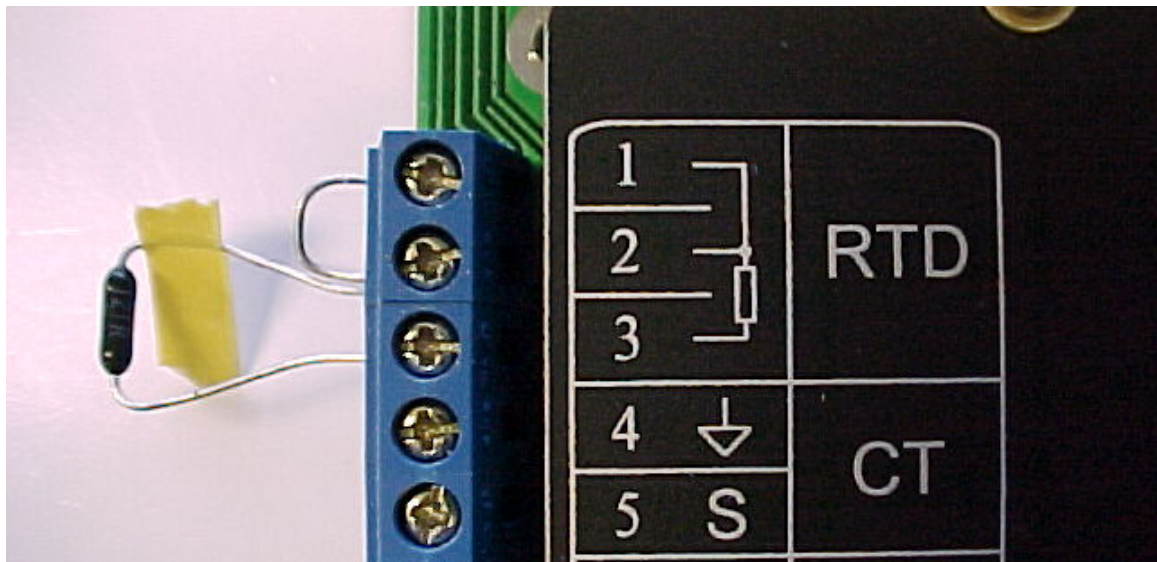


Figure 2.

sensor interface board must be connected to InsulGard with supplied ribbon cable and the device must be powered up.

- Enter setup mode by pressing "**Set**" key. **PSd-\_\_\_\_** will appear on the display. A correct password must be entered, in order to enter the setup mode. Using **↑↓←→** keys, enter password and press **ENTER**. Wait approximately 20sec. The first option to appear is the date/time setup. Use the right and left arrow keys (**←→**) to scroll the setup parameters.
- Scroll setup parameters until **CALibr t** appears.
- Press **Enter**. **0- XXX** will appear. This is the prompt for connecting resistor that represents 0C. Connect resistor and press **Enter**.
- **100- XXX** will appear. This is the prompt for connecting resistor that represents 100C. Connect resistor and press **Enter**.
- **0.XXX** will appear. Press **Enter**. **b- XX.X** will appear. These are determined calibration coefficients.
- Press **Enter** and **CALibr t** appears.
- Press **ESC** and **SAVING** appears. Calibration has been saved.