

# Partial Discharge Detector and Radio Interference Voltage Testing

## Partial Discharge Measuring

Partial discharge (PD) measurements are a proven method for effective, non-destructive evaluation of electrical insulation.

The PD2U provides a simple pushbutton interface with an LCD display. Display modes include a simple PD charge meter with adjustable "needle" sensitivity, monochrome phase-resolved PD patterns for characterization of defects, and a scope-like display showing phase-summed charge pulses superimposed with the applied voltage wave. High voltage is displayed showing the waveform and calculates  $\dot{U}$ ,  $\dot{U}/\sqrt{2}$ ,  $U_{rms}$ .

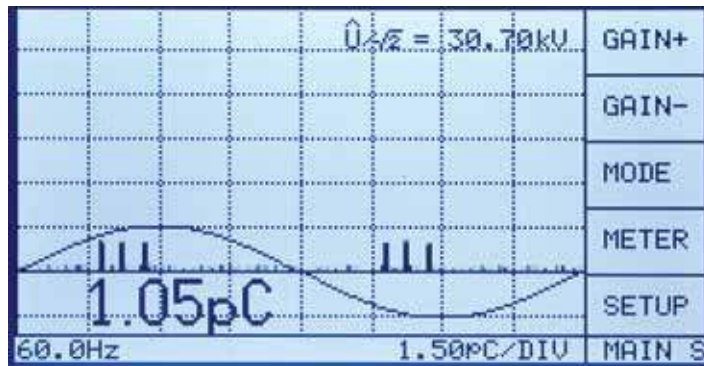
Although the PD2U is a stand-alone unit, it can be connected to a computer to capture screenshots or to implement remote control of the unit.

A wide range of accessories are offered adapting the PD2U to specific testing applications and noise conditions.

Measured results are in compliance with IEC 60270.

## Testing Applications

- Condition evaluation of insulation systems
  - Quality assurance testing in manufacturing plants
  - Routine testing in a variety of applications
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- **Compact** design
  - **Easy to use**
  - **Precise** results
  - **Stand-alone** or **computer** operated
  - An **economical PD testing** solution



Model PD2U



## Features

The PD2U offers convenient on-site testing of electrical equipment. The basic unit can be equipped with various options to suit special measurement requirements.

This unit can be used with a full range of preamplifiers covering the IEC60270 standard and ultrasonic frequencies up to the UHF range (20 kHz-2 GHz).

Cable PD location (Option). Equipped with a DSO board, the PD2U can be used to locate partial discharge defects in power cable. Using time domain reflectometry, in which the PD and its "echoes" travel the length of the cable under test, the PD2U provides the proportional distance of the PD fault along the cable. The additional DSO board samples the PD signal at 100M sample rate.

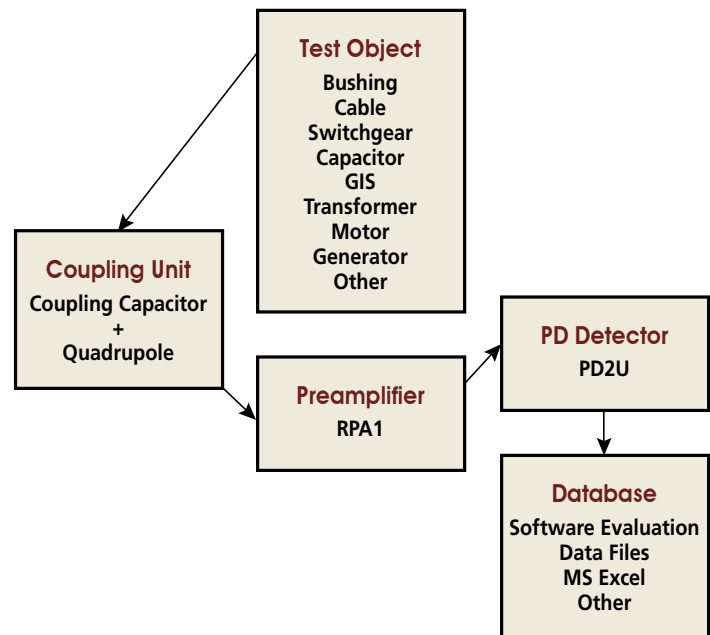
MUX4 (Option). 4-channel multiplexer for testing three-phase equipment such as power transformers. For each channel the unit maintains an individual set-up and calibration.



## Description

### Desktop Acquisition and Display Unit (Single Channel)

- Voltage measurement
- Backlit LCD 240 x 128 dots
- Scope and meter display
- Auto-range function
- Automatic storage of current settings
- Internal (line 50/60 Hz) and external synchronization (15-510 Hz)
- Universal serial interface (USB, up to 921 kB)



## Specifications

### Acquisition Unit

Input	100-240 VAC, 50/60 Hz
Power	25 VA
Temperature Range	10°C – 45°C
Dimensions	9 <sup>3</sup> / <sub>8</sub> " (236 mm) W
	11 <sup>1</sup> / <sub>2</sub> " (295 mm) D
	5 <sup>1</sup> / <sub>4</sub> " (133 mm) H
Weight	7 lbs. (3 kgs)

### Reference Voltage Input (BNC)

Input Impedance	1 MΩ / 200 pf
Input Voltage	Max. 120 V (rms)
Frequency	20-510 Hz

### Partial Discharge Signals

Coupling	AC
Input Impedance	50 Ω (without RPA)
Low Frequency Cutoff	40, 80, or 100 kHz
High Frequency Cutoff	250, 600, or 800 kHz

## Environmental Conditions

- 10-40°C, indoor/outdoor in fair weather
- Humidity <95% non-condensing
- Altitude <3300 ft (1000 meters)



**Frequency Range:** 40-800 kHz  
**Input Impedance:** 10 k $\Omega$ /50 pF  
**Input Sensitivity:** <200  $\mu$ V  
**Roll-Off:** 40 dB/dec  
**Bipolar**

## Description

### RPA1 Preamplifiers

The RPA1 is the standard preamplifier for measurements in the low frequency range according to standards such as IEC60270.

Preamplifiers serve to condition, filter, and amplify the partial discharge signal to be measured. Because the frequency range in which PD signals are measured is strongly dependent on the preamplifier used, proper selection of a preamplifier is an important part of noise mitigation and can have a strong effect on the appearance of the partial discharge pattern itself. All external signal conditioning modules and preamplifiers are remote supplied and remote controlled through a simple coaxial signal cable (RG58). This technique allows placement of these units close to the sensor or signal source. Furthermore, as these modules act as an impedance converter and line driver, the weak signal source, such as voltage divider or coupling impedance, is not loaded by the cable capacitance or impedance.

This technique also provides enhanced over-voltage protection. All preamplifiers can drive a 50  $\Omega$  cable up to 50 m long.

### Quadrupoles

When a quadrupole and a coupling capacitor are used together as the coupling device, high voltage is applied both to a test object and to the coupling capacitor in parallel with the test object. A quadrupole (sometimes called a measuring impedance) can then be placed in series with either the coupling capacitor or in series with the test object. Some quadrupoles also output a low-voltage copy of the applied high-voltage wave for synchronizing with the PD detector.

The CIL quadrupoles consist of an inductor in parallel with a damping resistor. The inductor and resistor are calculated to form, together with a high-voltage coupling capacitor, a second order high pass filter. Therefore, matching the range of the CIL with the size of the coupling capacitor with which it will be used is important.

The CIL/V quadrupoles are similar to the CIL quadrupoles but also contain a capacitor acting as a voltage divider together with the high voltage coupling capacitor. This provides a low-voltage copy of the applied high-voltage wave that can be used through a HST to synchronize the PD detector and monitor the quality of the applied high-voltage wave.

Optionally, the quadrupoles with built-in divider capacitor for voltage measurement can be supplied with a rotary switch to select the divider capacitor. When connected to the measurement tap of transformer bushings, the selectable capacitors expand the applicable voltage range.



Model	Range
CIL4M/V1 $\mu$ 0	Designed for up to 100 kV, 1 nF Capacitor Range, 400 mA max
CIL4M/V2 $\mu$ 0	Designed for up to 200 kV, 1 nF Capacitor Range, 400 mA max
CIL4M/V3 $\mu$ 5	Designed for up to 350 kV, 1 nF Capacitor Range, 400 mA max
CIL4M/V4 $\mu$ 0	Designed for up to 400 kV, 1 nF Capacitor Range, 400 mA max

\*Other quadrupoles are available

## CAL-4U Universal Partial Discharge Calibrator

A calibrator (calibration charge injector) is suitable for use in calibrating partial discharge measurements.



<b>Applicable Standards</b>	IEC 60270:2000, ICEA T-24-380-2000	
<b>PD Output Values</b>	1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, 2000, 5000 or 10000 pC (selectable through rotary knob)	
<b>Polarity</b>	either positive or negative (selectable through pushbutton)	
<b>PD Output Charge Tolerance</b>	< ±3%	
<b>Pulse Step Time</b>	< 60 ns	
<b>Injection Capacitance Values</b>	±1 – 100 pC:	$C_i \approx 0.7$ pF
	±200 – 1000 pC:	$C_i \approx 7.5$ pF
	±2000 – 10000 pC:	$C_i \approx 76$ pF
<b>Operation Modes</b>	single or double pulse (only single pulse output with external charge injection capacitor mode)	
<b>Double Pulse Time Interval</b>	1 – 120 $\mu$ s (selectable in CAL-4U menu)	
<b>Double Pulse Polarity</b>	either positive or negative (selectable through pushbutton)	
<b>Synchronization</b>	Internal or light synchronization (15 – 300 Hz)	
<b>Internal Synchronization Frequencies</b>	50 Hz or 60 Hz (selectable in CAL-4U menu)	
<b>PD Range for External <math>C_i</math> Mode</b>	±1 pC – 10 nC (depends on value of external charge injection capacitor $C_i$ ). Examples: for $C_i = 1$ pF: 1 – 100 pC for $C_i = 10$ pF: 10 – 1000 pC for $C_i = 100$ pF: 100 – 10000 pC	
<b>Power</b>	USB or two LR6 (size AA) 1.5V non-rechargeable batteries	
<b>USB Connector Type</b>	'Mini B'	
<b>CAL-4U Output Connector</b>	BNC	
<b>Remote Control Feature</b>	CAL-4U can be fully controlled through USB using the (optional) Phenix PD-CAL software	
<b>Dimensions (W x L x H)</b>	4.65" x 6.3" x 1.46" (118 mm x 160 mm x 37 mm)	
<b>Weight</b>	1.2 lbs (0.545 kgs)	



### Connecting Cables

A full set of high quality RG58 cables with BNC connectors is supplied.

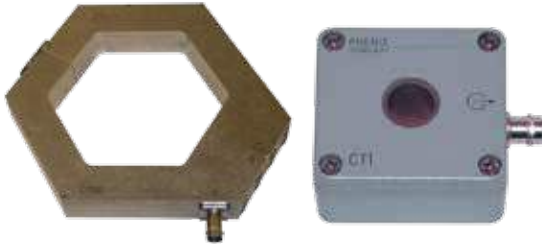
- 2 x 20 m
- Quadrupole Connection Set
- Power Lead

## Options

### Triggered Noise Cancellation

**GATE** Software controlled gating from a signal connected to an auxiliary input. Gating threshold may be set manually or automatically. Includes the built-in logarithmic preamplifier RPA6.

### Current Transformer



When a current transformer is used instead of a quadrupole, the current transformer can be placed around a coupling capacitor terminal or around a part of the test object itself. A current transformer has the advantage of providing galvanic isolation between the PD detector and the high voltage circuit. Current transformers are offered as separate modules or integrated with a coupling capacitor into a single unit.

### Rack Mounting Kit

- 19", 3RU standard rack mount for PD2U acquisition unit

### DSO, Cable PD Fault Location

- Digital Signal Processor
- Built-in digital scope (100M sample)
- DSO (TDR) Display

### MUX4: 4 Channel Measurement Upgrade

A built in multiplexer with four inputs for PD measurement and four inputs for voltage measurement. Firmware offers four individual setups and calibration factors. Additional line of pushbuttons for direct channel selection. Includes the following components:

- Voltage Measurement
- [3] additional sets of Connecting Leads
- [3] additional Quadrupoles
- [3] additional Pre-Amplifiers

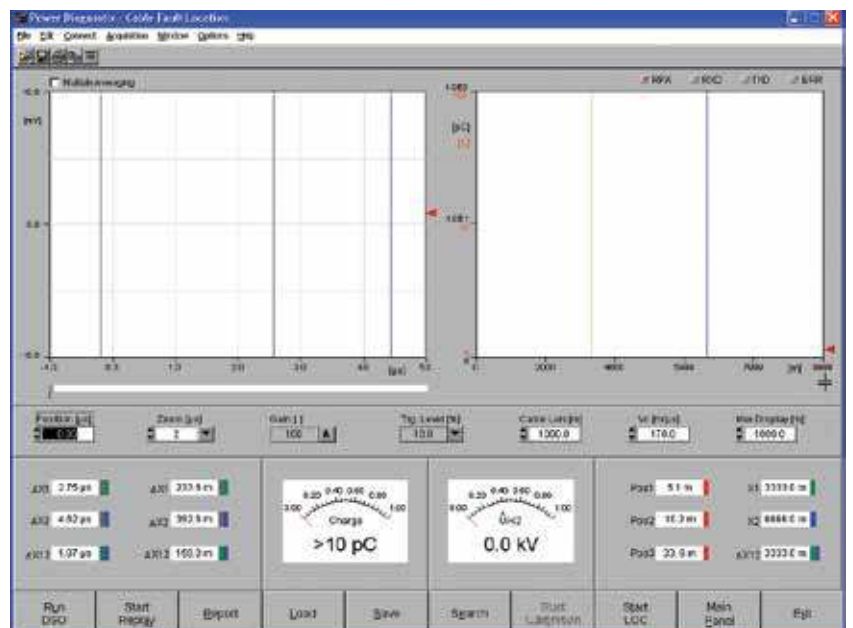
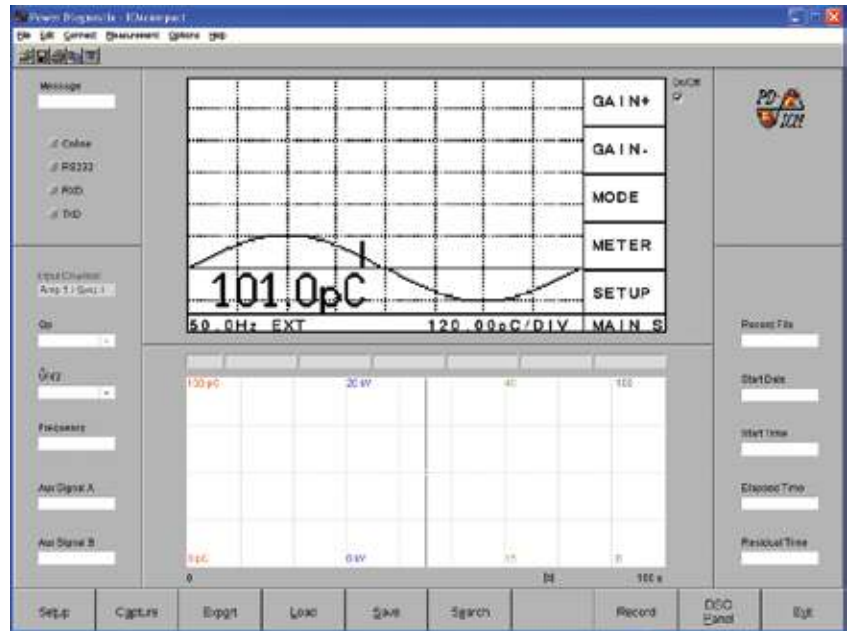
### Standard Control Software

Software to remote control the PD2U and for data acquisition

- 3-D Phase Resolved PD Pattern Acquisition
- ActiveX Driver License
- Supports fast USB communication

### Enhanced Cable Location Software

Software to remotely control the PD2U with the PD fault location option. Offers automatic scanning, viewing, editing, re-playing, and printing of partial discharge signals. Zoom and cursor functions offer precise location results. Includes the standard control software.





## Radio Interference Voltage (RIV) Testing

The RIV meter is an instrument for the measurement of Radio Influence Voltage according to NEMA 107-1987 and other relevant standards (ANSI 63-2-1996, VDE 876, DIN EN 55016-1-1). The instrument has a bandwidth of 9 kHz and a tunable center frequency of 10 kHz-10 MHz. Technically, the RIV meter is a selective  $\mu\text{V}$ -meter. However, the meter reading is weighted according to the CISPRE weighing curve, whereas the repetition rate has a strong impact on the reading. The RIV meter is an ideal instrument to replace outdated RIV measurement instruments in transformer testing labs.

Some routine PD measurements are still done according to IEEE standards requiring the measurement of RIV. The RIV value is given in  $\mu\text{V}$  (interference voltage). A narrow band filter performs a quasi-integration of the PD pulses with a quasi-peak detection at the center frequency. This center frequency can be adjusted between 10 kHz and 10 MHz.

Two factors determine the RIV in  $\mu\text{V}$ : the transferred charge and the repetitive rate of the PD impulse (number of PD pulses per second). Because of this proceeding, a direct translation of the measured RIV values ( $\mu\text{V}$ ) into values of apparent charge in pC is not possible.

Historically, the RIV technique is based on measurement receivers to estimate the disturbance of communication lines. Thus, properties of those instruments then available became part of the NEMA standards. However, both the 9 kHz bandwidth and the CISPRE weighing curve put emphasis on some partial discharge activity while they tend hiding others.

The calibration of the RIV measurement is done using an RIV calibrator, injecting a sine wave of typically 100  $\mu\text{V}$  into the bushing. The multiplexer of the RIV meter is used to conveniently determine the correction factor according to NEMA 107-1987 and other standards. Here, the unit compares the voltage injected (loaded by the bushing's impedance), with the voltage detected at the bushing tap to automatically determine the k-factor. This correction factor is then stored independently for each channel during calibration. The standard calibrator for RIV calibration, CAL3A, offers a selectable frequency range of 600-1350 kHz in steps of 50 kHz. The output voltage covers 10  $\mu\text{V}$  to 10 mV in 1-2-5 steps.

### Model RIV-3

#### COMPONENTS

##### Desktop Acquisition and Display Unit (Three Channel)

- Backlit LCD Display
- Meter display 0-2500  $\mu\text{V}$  (@ k=1)
- Auto-range function
- Automatic storage of current settings
- RIV bandwidth 9kHz (ANSI C63.3-1996)
- Reference channel for RIV calibration
- Center Frequency 100 kHz – 2MHz (10 kHz steps)
- Serial Interface (USB, 57.6 Bit/s fixed)

##### Calibrator

###### Model CAL3A

- Selectable level 10  $\mu\text{V}$  (20dB $\mu\text{V}$ ) to 10 mV (80 dB $\mu\text{V}$ )
- Available in steps of 1-2-5
- Error rate of +/- 5%
- Adjustable Frequency between 600kHz & 1350kHz (50kHz steps)
- Comes with ISO17025 Calibration Certificate traceable to DKD

##### 3 Channel Multiplexer

###### Model MUX3

- Built in multiplexer with three inputs for RIV measurement and three inputs for voltage measurement
- Firmware offers individual setups and calibration factors
- Second line of push buttons for direct channel selection

**Note:** Multiple channel RIV systems require a coupling capacitor per channel. For a Coupling Capacitor to operate in the range of 50 to 500 Hz, it requires the next higher rated voltage capacitor.

## Partial Discharge Free Coupling Capacitors

- Model CC25-1, 25 kV, 1 nF, 50-400 Hz with base
- Model CC50-1, 50 kV, 1 nF, 50-400 Hz with base
- Model CC100-1, 100 kV, 1 nF, 50-400 Hz with base
- Model CC200-1, 200 kV, 1 nF, 50-60 Hz with base and casters
- Model CC300-1, 300 kV, 1 nF, 50-60 Hz with base and casters
- Model CC400-1, 400 kV, 1 nF, 50-60 Hz with base and casters
- Model CC500-1, 500 kV, 1 nF, 50-60 Hz with base and casters
- Model CC600-1, 600 kV, 1 nF, 50-60 Hz with base and casters

## Partial Discharge Free Injection Capacitors

- Model IC100-0.1, 100 kV, 100 pF, 50-400 Hz with base
- Model IC200-0.1, 200 kV, 100 pF, 50-60 Hz with base and casters
- Model IC300-0.1, 300 kV, 100 pF, 50-60 Hz with base and casters
- Model IC400-0.1, 400 kV, 100 pF, 50-60 Hz with base and casters
- Model IC500-0.1, 500 kV, 100 pF, 50-60 Hz with base and casters

### NOTE:

- Injection capacitors require CAL1C PD Calibrator
- Multiple channel PD systems require multiple capacitors
- 400 Hz operation available only up to 200 kV on both Coupling and Injection Capacitors





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