BVM Systems Limited

PQSensor™ MkVIa
Installation & Commissioning Manual

Patents: 1295133, 6,919,717

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Important Safety Notice

Aspects of the installation and commissioning of the PQSensor™ involve working on equipment where errors in installation or failure to follow appropriate safety procedures could result in exposure of personnel to **Lethal High Voltages**.

Installation of the PQSensor™ should only be performed by personnel with the necessary knowledge and training.

Pay particular attention to the safety aspects of those sections of the manual marked with the 

symbol.

Ensure that the CVT input is solidly earthed at all times when any installation work is being carried out.

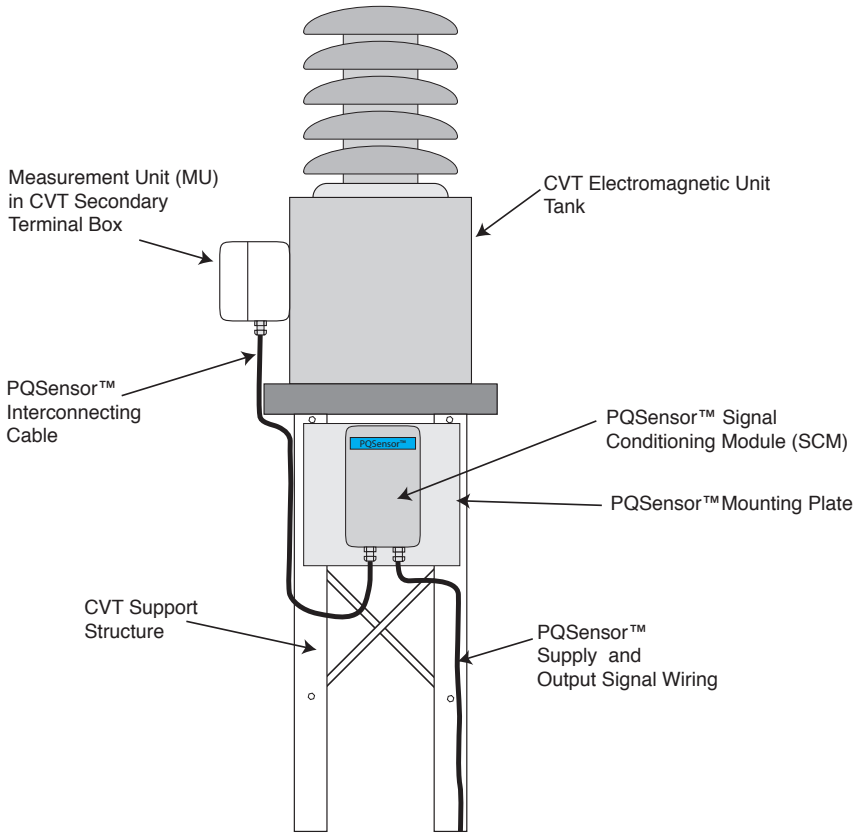
Never open the CVT secondary terminal box unless the CVT is solidly earthed.

Always ensure the bottom end of C_2 and the EMU are solidly earthed before energising the CVT.

The nominal output signal from the PQSensor™ is 63.5V. This can be present at any time that the PQSensor™ is energised.

1 GENERAL

The purpose of a PQSensor™ is to equip a standard CVT with an interface that enables it to be used to make accurate measurements of harmonic levels and transients on h.v. power networks.



PQSensor™ - Installation

Figure 1

The PQSensor™ consists of three separate components

The Measurement Unit (MU)
The Signal Conditioning Module (SCM)
The Interconnecting Cable

An typical installation is shown in Figure 1.

When installing the SCM box ensure that it is positioned below the safety clearance height that will permit it to be accessed while the CVT is in service. The ideal mounting height for the PQSensor™ SCM is between 0.9m and 1.5m above ground level and for future access and serviceability after commissioning it should always be mounted in this area.

1.1 The Measurement Unit

The Measurement Unit (MU) is a 66mm (w) x 66mm (d) x 88mm (h) module that contains the transducers that acquire the signals used to produce its high accuracy wide band voltage output. There are two sets of inputs, HCCT and LCCT together with their associated outputs. The

Measurement Unit is also equipped with a test circuit that can be used for on-site testing and calibration. It is equipped with three M3 mounting holes on the base. These holes are compatible with the Phoenix UTA98 DIN rail adapter (provided) and can also be used together with other custom made mounting plates. See Appendix I.

1.2 The Interconnecting Cable

The Interconnecting Cable, with a standard length of 3 metres, takes the signals from the Measurement Unit to the SCM. Lengths up to 5m are available on request. Both ends of this cable are provided pre-terminated and equipped with the appropriate glands for making off in the CVT secondary Terminal Box and the SCM Box. This steel wire armoured (SWA) cable contains two individually screened twisted pairs together with a collective screen. The twisted pair conductors in this cable are stranded with 0.5mm^2 cross section using 16/0.2 conductor stranding.

1.3 The SCM

The SCM is designed to be mounted on the structure of the CVT as shown in Figure 1. Dimensions and mounting details for the box are provided in Appendix II. The OEM must provide a mounting plate or bracket on the CVT structure compatible with the holes shown in the drawing in Appendix II. The mounting plate is not supplied with the PQSensor™ as there are many different types of CVT support structures.

2 INSTALLATION OF THE MEASUREMENT UNIT (MU) IN THE CVT TERMINAL BOX

Whether the PQSensor is being installed in a new CVT at the time of factory test or being retrofitted to a CVT that is already in service, the first step is to install the MU in the secondary terminal box of the CVT.

2.1 MU Connections

The function of the MU is to measure the currents flowing in the capacitor divider circuit and in the primary winding of the CVT wound transformer (the electromagnetic unit or EMU).

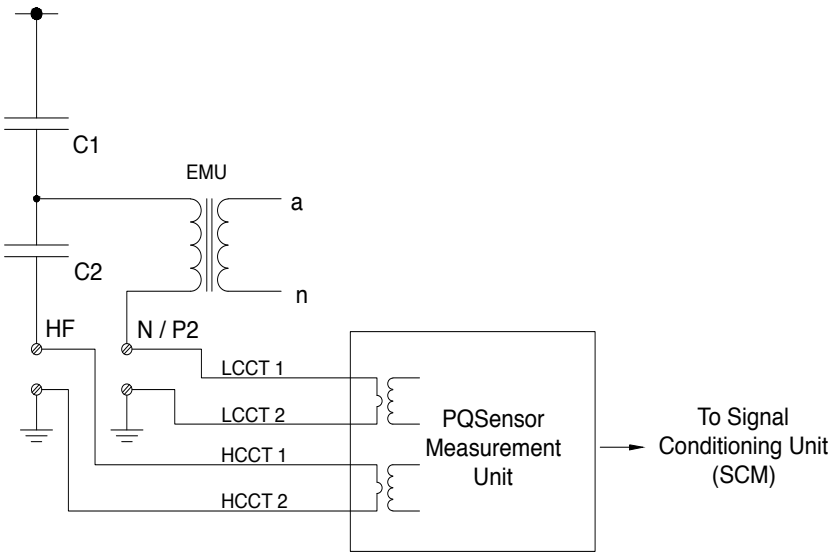


Figure 2

In many cases the bottom of the capacitor circuit is called the ‘HF’ terminal as this is where power line equipment can be connected. The bottom of the EMU circuit is sometimes referred to as ‘P2’ or ‘N’.

These circuits are normally available in the CVT secondary terminal box and are usually connected directly to ground with links. The installation of the MU involves the replacement of these links with the input circuits of the MU - the MU HCCT input circuit replaces the capacitor divider earth link and the MU LCCT input circuit replaces the EMU primary ground link (see Figure 2). The polarity of these inputs must be respected by connecting the HCCT2 and LCCT2 inputs to ground as shown. Use a schematic of the target CVT to identify the connection points for these MU inputs. In all cases a marked up CVT schematic must be used for the design, installation and checking of the MU installation.

The MU is fitted with a Phoenix UTA 89 TS35 DIN rail adapter and in many cases this can be used to mount the MU on an available section of DIN rail in the CVT terminal box. The DIN rail adapter can be removed and the three mounting holes can be used with a third party custom bracket if required.

2.2 Verifying the MU Installation

After the Measurement Unit has been installed the terminations of the HCCT and LCCT inputs must be carefully checked to ensure that they have been correctly and securely made and are physically robust, as an incorrect or faulty connection will result in **LETHAL VOLTAGES** being present in the CVT secondary terminal box when the CVT is energised. If in any doubt about the installation or connection points for the MU inputs consult a qualified technical expert in your organisation.

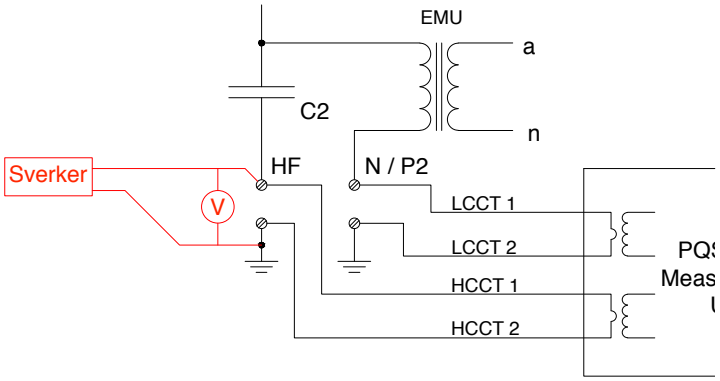


Figure 3

The HCCT and LCCT input circuits are low impedance circuits with guaranteed continuity that will not have any impact on the earth circuits of the Capacitor or EMU circuits of the CVT. These circuits are formed using a single piece of cable with no connections or joints.

For the safe operation of the CVT it is essential that the integrity of capacitor and EMU earth paths are preserved. To ensure this is the case we recommend carrying out the following test after the MU has been installed in the CVT secondary terminal box.

- Using a secondary injection test set (e.g. Sverker) inject 1A ac between the bottom of the capacitor stack (HF) and ground.
- Measure the voltage drop from the bottom of the capacitor stack to ground (Figure 3)
- The measured voltage should be less than 40mV ac (equivalent to 40mΩ)
- Repeat the about test between the bottom of the EMU and ground where the measured voltage should be less than 60 mV.

(Note:- To achieve the target test results above, the MU must be connected to the PQSensor™ SCM using the interconnection cable)

3 FACTORY INSTALLATION AND CALIBRATION OF THE PQSensor™

Only the Measurement Unit is permanently installed in the CVT in the factory - the Interconnecting Cable and the SCM should be installed as part of the site installation and commissioning procedure. However, for test purposes, the SCM must be connected to the CVT, usually using a dedicated cable installed in the factory test bay to permit the PQSensor™ to be calibrated when rated voltage is applied to the CVT.

3.1 Measurement Unit Installation

See Section 2 for details of the Measurement Unit (MU) installation.

3.2 Factory Calibration Of The PQSensor™

To perform the calibration of the PQSensor™ SCM it must be wired to the Measurement Unit installed in the CVT terminal box as shown in the wiring diagram in Appendix IV.

This can be done using the Interconnecting cable provided with the PQSensor™ or for factory testing a dedicated Interconnection Cable between the CVT test bay and the SCM under test/ calibration can be used. This cable must be twin twisted pair cable with individual and collective screens connected as shown in the wiring diagram in Appendix IV.

A suitable supply voltage must be connected to the PQSensor™ SCM on terminals 1 & 2 - this can be 110V - 230V ac or 110V dc - this supply input is not polarity sensitive. Terminal 3 must be grounded.

This calibration process involves adjusting the output of the PQSensor™ so that it delivers its Nominal Output Voltage when the CVT is energised with nominal substation voltage. (see Figure 4)

With the CVT energised with nominal substation voltage measure the SCM output voltage on terminals 4 & 5 with a calibrated true rms voltmeter. Using the output adjust potentiometer set the output voltage to be equal to the PQSensor Nominal Output Voltage as given in the PQSensor Test report.

N.B. Record the results on the calibration label inside the PQSensor. Also record the serial number of the CVT on the same label to ensure that at site the PQSensor™ is installed on the CVT with which it has been calibrated.

4 SITE INSTALLATION AND TESTING OF THE PQSensor™

4.1 Mounting The SCM Enclosure.

The signal conditioning module (SCM) box is a weatherproof IP66 enclosure, with approximate dimensions of 260mm x 160mm x 90mm. For full details of dimensions and mounting hole locations see Appendix II. The SCM box is typically installed on the CVT support structure in a vertical position with the cable entries on the bottom face. There must be a solid ground connection between the SCM enclosure and the CVT structure, This is usually achieved by making a ground connection to the CVT structure using the earth tag provided as part of the interconnection cable gland kit.

N.B. A mounting plate or bracket will be required to secure the SCM to the CVT structure. Since there is a wide variety of support structures used in substations this bracket is NOT provided with the PQSensor™ and will normally be sourced locally.

4.2 Installation in Hot Climates

In climates where ambient temperatures can exceed 40˚C it is highly recommended to mount the SCM in a location that will afford the maximum shade from direct sunlight. While the PQSensor™ is rated for temperatures up to 65˚C, in warmer climates it is prudent to limit exposure to direct sunlight. This is best achieved by using a mounting plate at least 500mm wide which is fitted on the shaded side of the CVT structure. A sun shade can also be provided for such installations.

4.3 Installing the Interconnecting Cable

The standard Interconnecting cable is 3m in length and is pre-terminated at both ends for connection between the CVT secondary terminal box and the SCM enclosure. The interconnecting cable should be wired between the MU in the CVT secondary terminal box and the SCM using the SWA cable glands supplied. First terminate the connections in the SCM as shown in Figure 4 and the drawing in Appendix IV and then terminate the other end of the cable on the MU in the CVT terminal box. A full wiring diagram for the Interconnecting Cable in contained in Appendix IV. The interconnecting cable should be securely fixed to the CVT structure at as many points as necessary to ensure there are no loose sections of cable.

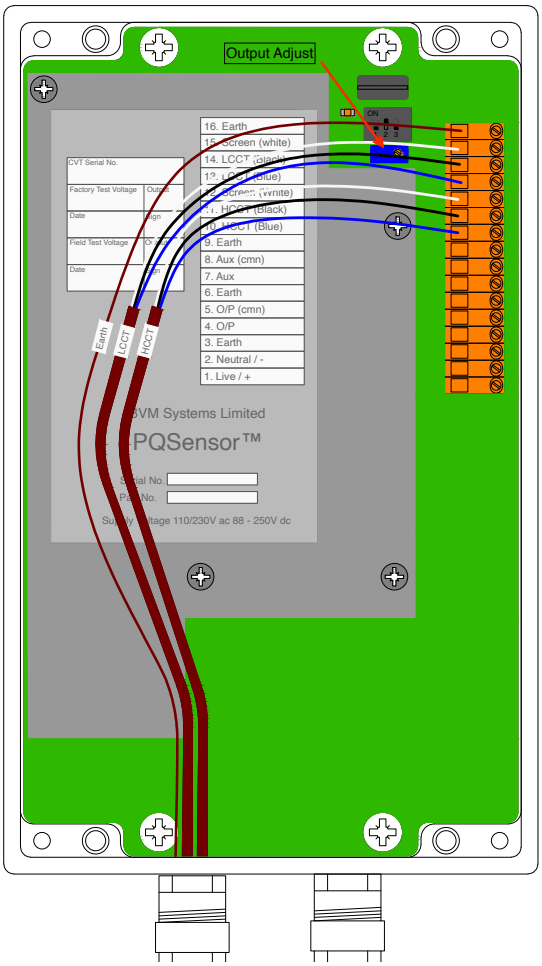


Figure 4

4.4 Supply Voltage and Output Signal connection

In addition to the connections to the Measurement Unit the supply voltage and the output signal need to be connected. These connections should be made using stranded cable with a minimum size of 1mm^2.

The PQSensor™ accepts a universal supply and can be powered from 110V ac, 230V ac or 80 - 250V dc. Pin 3 of the PQSensor™ terminal block should be grounded. Pins 3, 6, 9 and 16 are connected internally. Total power consumption of the PQSensor™ SCM is less than 5VA.

The nominal output signal from the PQSensor™ is of the order of 60V ac so appropriate safety precautions should be taken when working with a voltage of this level. For safety purposes it should be assumed that when the PQSensor™ is powered on there is always a voltage of 60V ac present on the output terminals.

The PQSensor™ is intended to be used with recording equipment that has an input impedance of greater than 1Mohm.

4.5 PQSensor™ Installation wiring check

When the CVT is energised it is not possible to gain access to the CVT secondary terminal box so the wiring must be checked and tested before energisation. The MU installation can be verified by following the procedure in section 2.2. To facilitate testing apply a suitable supply voltage to the SCM. Next, using a secondary injection test set inject the Reference Test Current as given in the PQSensor™ test report between the 'Test' terminal (5) on the MU and ground and measure the PQSensor output voltage. The output voltage should be within 2% of the Nominal Output Voltage as given in the SCM Test Report. If the measured voltage is outside tolerance then the installation wiring should be checked as this is the most likely cause of the output voltage error.

4.6 Site Calibration Of a PQSensor™ retro-fitted to an existing installed CVT

Using a calibrated voltmeter measure the output voltage of the SCM while the CVT is energised. The output voltage should be equal to the Nominal Output Voltage as given by the PQSensor™ Test Report. If required use the 'output adjust' potentiometer to correct for any difference. (See Figure 4)

Where the substation primary voltage differs from nominal voltage the expected PQSensor™ output voltage can be scaled accordingly.

When testing is complete record the substation voltage and output voltage on the results label provided inside the PQSensor™.

4.7 Site Verification For a Factory Calibrated PQSensor™

For a factory calibrated PQSensor™ no site calibration is required as this will have been completed by the CVT manufacturer. However the output voltage value should be checked after the CVT has been energised.

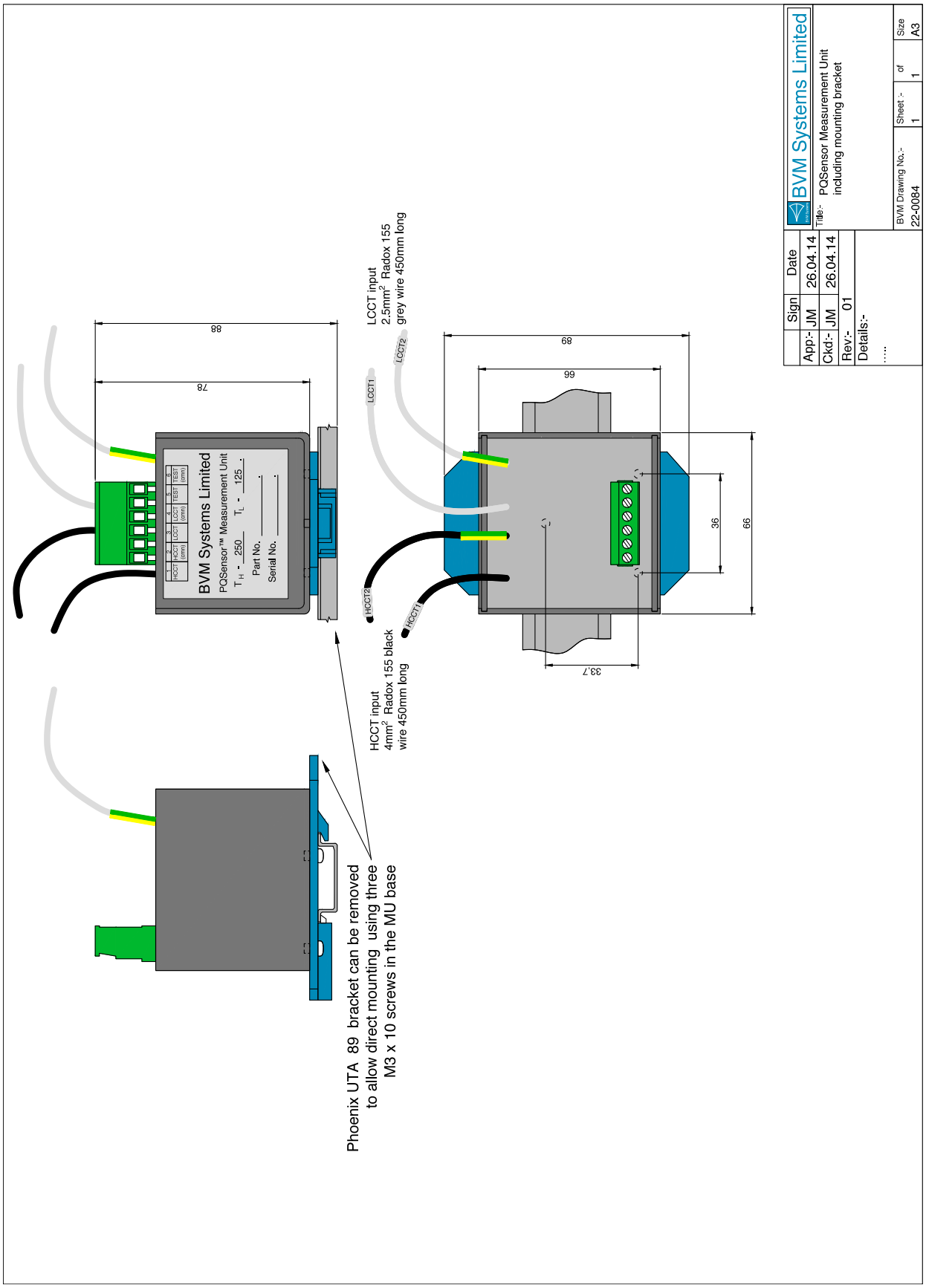
Where the substation primary voltage differs from nominal voltage the expected PQSensor™ output voltage can be scaled accordingly.

4.8 PQSensor™ Substation Wiring

All PQSensor™supply and output cables must have a grounded screen or armour to shield the signals from electromagnetic radiation. The total length of the cable from the PQSensor™ SCM output to the connected PQ monitor should not exceed 300m. 1.5mm^2 conductors are recommended for both the supply and output voltage connections however many utilities may mandate the use of larger conductors.
BS6724 SWA cable is recommended for both supply and output connections to the PQSensor™.

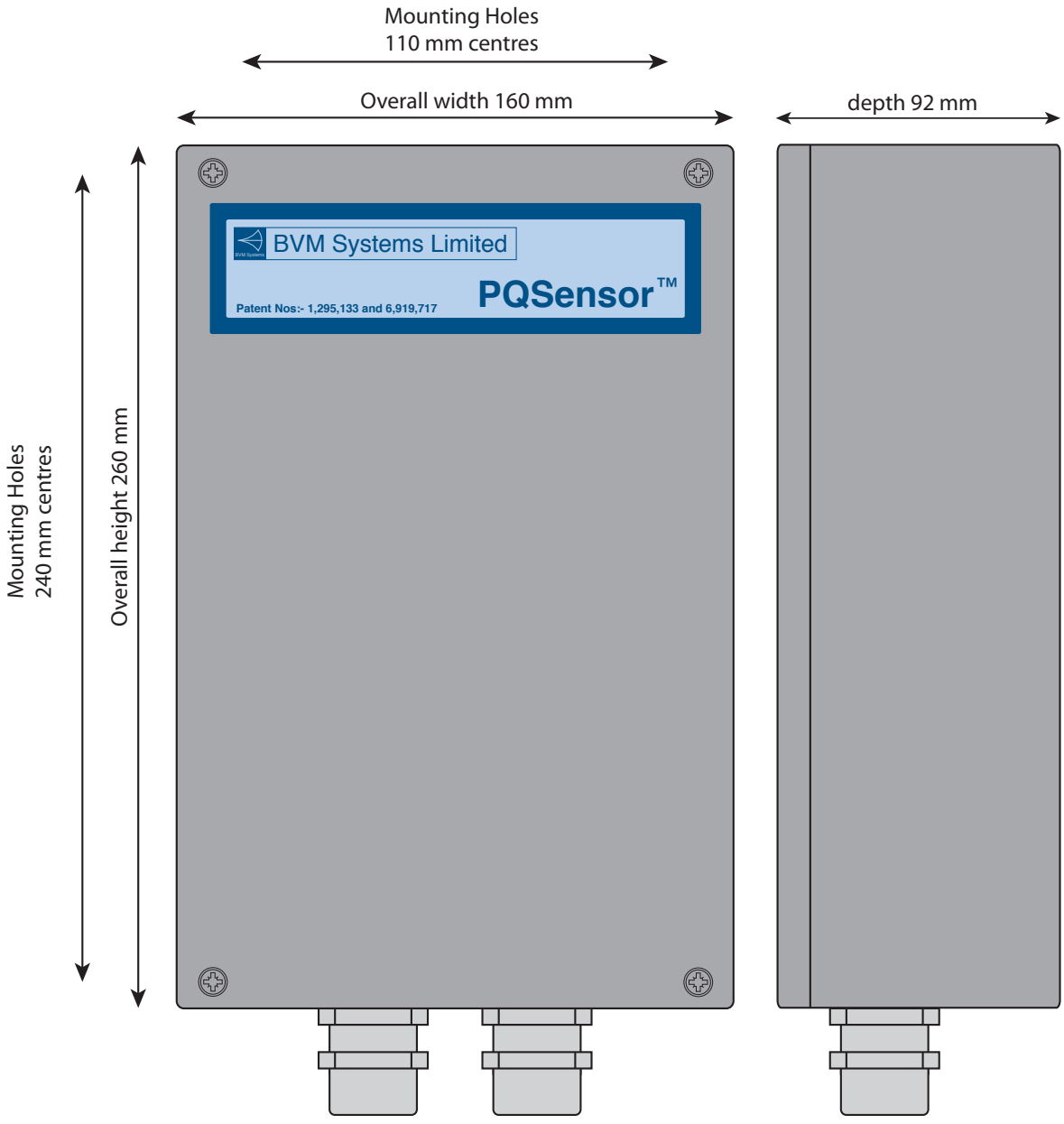
For a three phase installation the O/P (cmn) from each phase can be commoned to provide a four wire three phase voltage signal. The neutral of this four wire voltage should be grounded - this is usually done in the vicinity of the CVTs in a marshalling box but can also be done at the inputs to the recorder if individual cables are used from each PQSensor™.

Appendix I
Measurement Unit Details



Appendix II

SCM Dimensions



Fixing bolts - M6 x 30mm

Appendix III

PQSensor™ - Sample Test Reports

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Measurement Unit Test Report

Date:- March 9, 2022

Customer:-

Serial Number:- 2203-3688

P.O. Number

Input Continuity Check

Test Current (A)	2.65
Resistance (mOhm)	31.46
Result	Pass

Hi-Pot Test (2.5 kV ac)

I/P - O/P (mA)	0.10
I/P - Gnd (mA)	0.10
O/P - Gnd (mA)	0.30
Result	Pass

MU Ratio And Phasing Check

HCCT Ratio Test Error	0.74%
LCCT Ratio Test Error	0.58%
HCCT & LCCT Phasing	Pass

Overall Result Pass

Signed

Hi-Pot Test Details

MU inputs (HCCT1, HCCT2, LCCT1, LCCT2) are commonned and tested together.
Input to output and Input to Ground test voltage is 2.5kV
Output to Ground test voltage is 1kV

All tests are of 5 seconds duration

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PQSensor Test Report

Date:- March 11, 2022

Customer:-

SCM Serial Number:- 2203-3392

P.O. Number

HCCT Injection (@ 50 Hz)

Measurement Error (less than)	1.89%
Result	PASS

LCCT Injection (@ 50 Hz)

Measurement Error (less than)	1.45%
Result	PASS

Test Injection (@ 50 Hz)

Measurement Error (less than)	0.65%
Result	PASS

Frequency Response

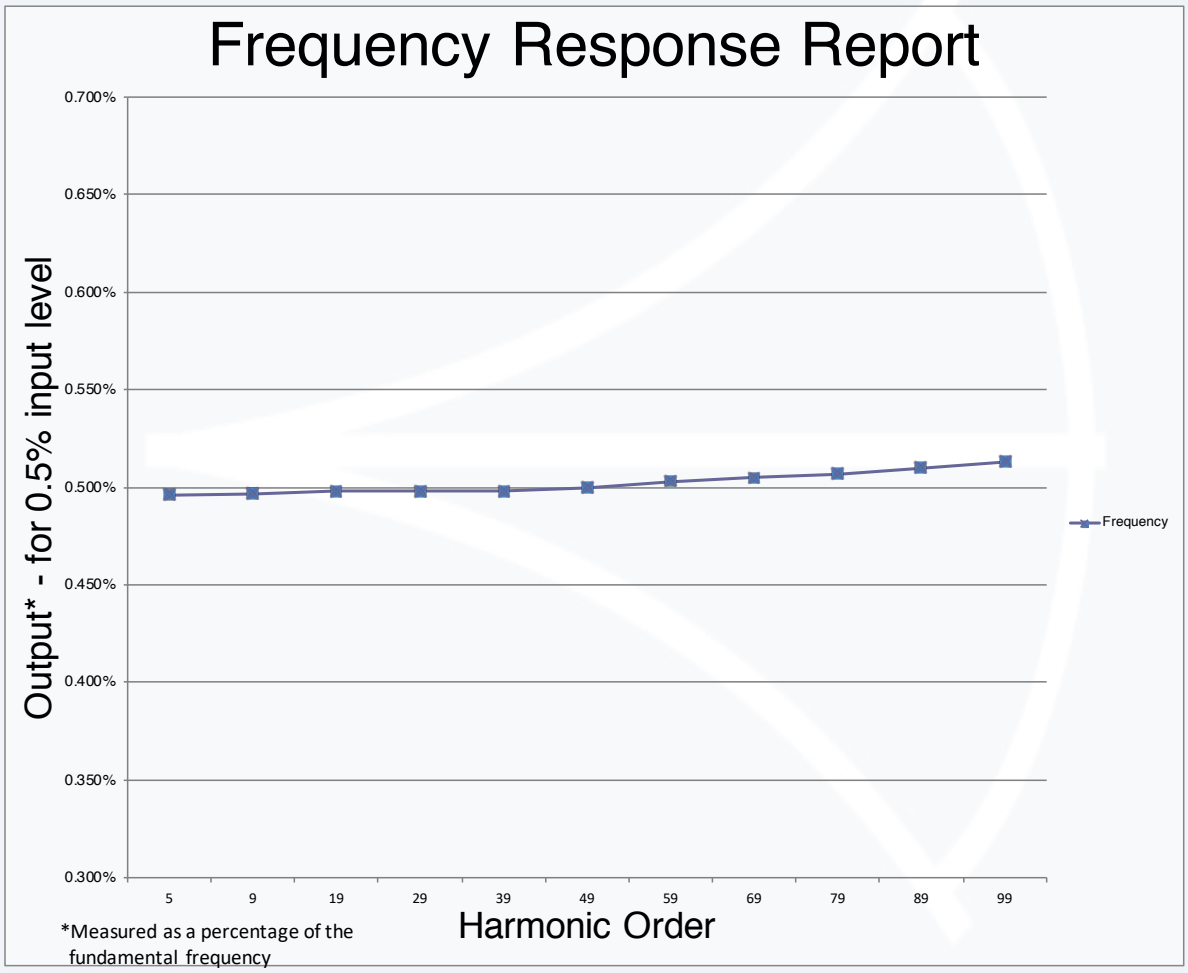
Result	PASS
(see attached graph)	

Signed

Reference Data

CVT Voltage (kV)	500/√3
C1 (pF)	5424
C2 (pF)	137005
TH	250
TL	125
Nominal Output Voltage	63.5
50Hz Reference Test Current (mA)	1279
60Hz Reference Test Current (mA)	1535

SCM Serial Number - 2203-3392



Appendix IV

PQSensor Wiring Diagram