BVM Systems Limited

PQSensor™ MkIII

Installation & Commissioning Manual

Patents: 1295133, 6,919,717

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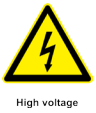
Important Safety Notice



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.

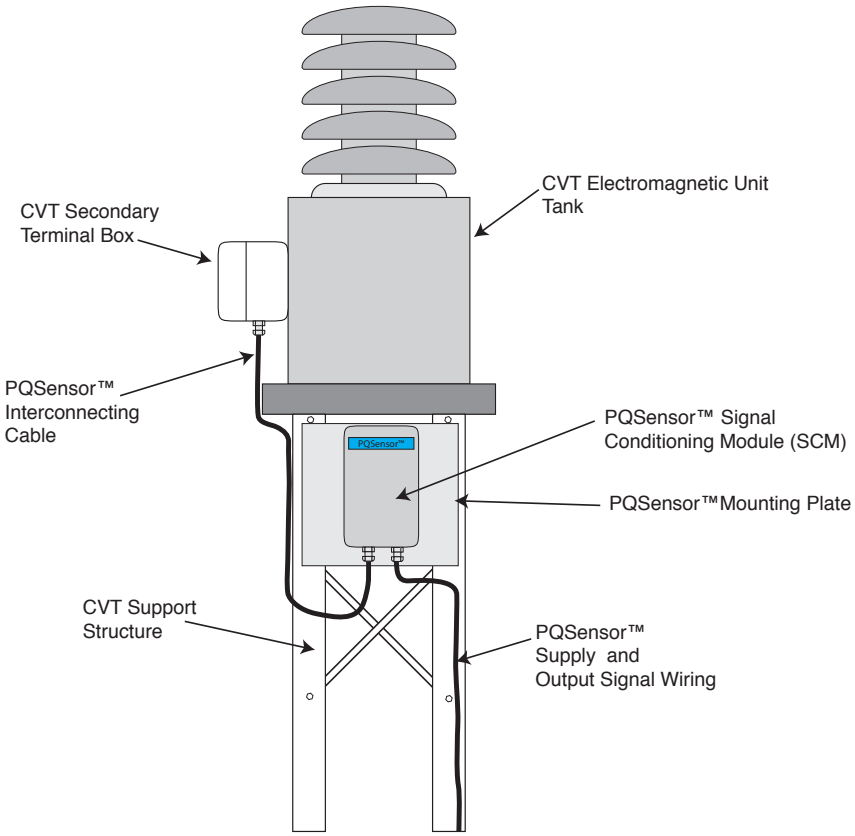
Never open the CVT secondary terminal box unless the CVT is solidly earthed.

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

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

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 example of a PQSensor™ installation is shown in Figure 1.

When installing the SCM box it is essential to ensure that it is positioned below the safety clearance height that will allow it to be worked on while the CVT is in service. The ideal mounting height is between 0.9 m and 1.5 m above ground level.

The Measurement Unit

The Measurement Unit consists of a 66 mm (w) x 65 mm (d) x 75 mm (h) box which contains the transducers that acquire the signals used to make the high accuracy broadband measurements. 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. The two sets of outputs are equipped with shorting jumpers and these should only be removed as and when required by the instructions contained in this document. Detailed dimensions of the Measurement Unit are given in Appendix I. It is equipped with three M3 mounting holes on the base. These holes are compatible with the Phoenix UTA98 DIN rail adapter and can also be used together with other custom made mounting plates.

The Interconnecting Cable

The Interconnecting Cable takes the signals from the Measurement Unit to the SCM. 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 armour (SWA) cable contains two individually screened twisted pairs together with a collective screen. The twisted pair conductors in this cable are stranded with 0.5 mm^2 nominal conductor area - usually a 16/0.2 conductor stranding.

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 compatible with the holes shown in the drawing in Appendix II. The mounting plate is not included as part of the PQSensor™ as there many different types of CVT support structures.

Factory Installation 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 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.

Measurement Unit Installation

The Measurement Unit should be installed before the final factory CVT testing and calibration is performed.

The Measurement Unit is installed in the secondary terminal box of the CVT and is usually fixed to an existing section of TS35 DIN rail using the Phoenix UTA 89 adapter provided. The three M3 mounting holes located in the base of the Measurement Unit can also be used with other custom mounting plates if required. The Measurement Unit has two inputs called the HCCT input and the LCCT input and these are wired in series with the capacitor and the EMU earth circuits respectively as illustrated in Figure 2. The HCCT input wiring is black and is clearly labelled. The earthed side of the input wiring is identified by green/yellow sleeving. The LCCT input wiring is grey and the earthed side of the input wiring is also identified by the green/yellow sleeving. Use the wiring schematic of the CVT to identify the connection points required to connect the input signals to the measurement unit.

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 additional security high current continuity tests are performed on these circuits as part of the factory test procedure and the results are contained in the Measurement Unit test report, a copy of which is included with the Measurement Unit.

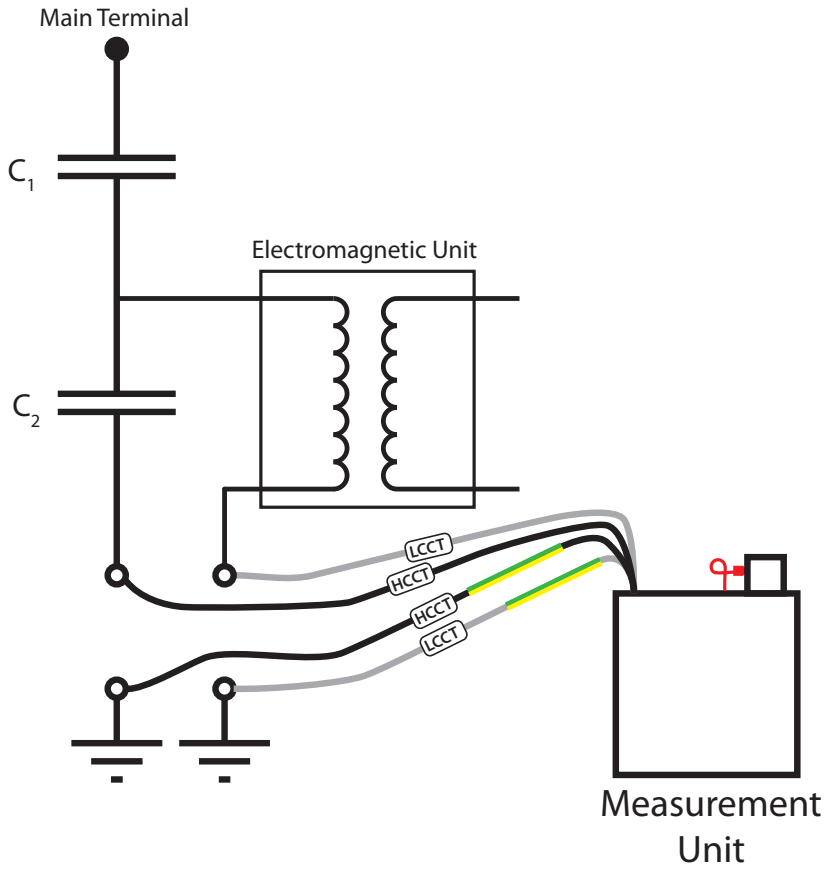
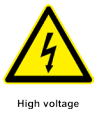


Figure 2

After the Measurement Unit has been installed the terminations of the HCCT and LCCT input wiring 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.



The shorting links that are fitted to the outputs of the Measurement Unit are removed to carry out the calibration of the SCM but they should be replaced after calibration has been completed and remain in place until the final site installation of the PQSensor™.

During the site installation the SCM will be connected to the CVT secondary terminal box by means of the SWA Interconnection Cable. This cable is fitted using a gland that requires a 20mm hole in the CVT secondary terminal box (either a threaded or clearance hole) and it may be more convenient to prepare this hole before the CVT leaves the factory than to do it on site.

Factory Calibration of the PQSensor™

To perform the calibration of the PQSensor™ it must be wired to the Measurement Unit installed in the CVT terminal box as shown in the wiring diagram in Appendix IV. The cable used for the connection of the HCCT and LCCT signals must be twin twisted pair cable with individual and collective screens as can be seen in the wiring diagram. The cable is terminated at the measurement unit as shown in Figure 3 and the connections in the SCM are shown in Figure 4. The cable used for the other connections is less critical and any twisted pair cable should suffice. For factory testing it is normal to install a dedicated Interconnection Cable between the CVT test bay and a location outside the high voltage test area - the length of this cable should be kept to a minimum, ideally less than 10m. Using this approach the PQSensor™ can be checked and calibrated while high voltage is applied to the CVT.

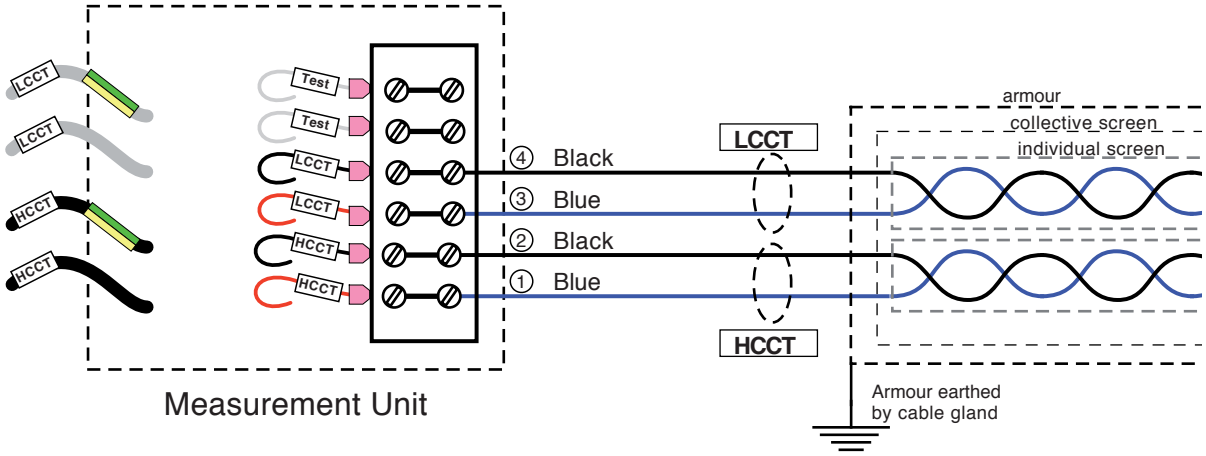


Figure 3

The factory calibration of the PQSensor™ involves two steps

Step 1 - Wiring and Installation Validation

This first check is performed to verify the correct wiring of the Measurement Unit to the SCM and to validate the correct operation of the PQSensor™. It involves injecting an ac current into the test inputs in the Measurement Unit and measuring the output voltage from the PQSensor™ on terminals 4 and 5. The level of test current to be injected is the Reference Test Current given in the factory test report and the output signal should be the Nominal Output Voltage - also included in the factory test report. A copy of the factory test report is enclosed with the each PQSensor. For other levels of input current the expected output voltage is given by the formula :-

$$\text{Output Voltage} = \frac{\text{Injected Test Current} \times \text{Nominal Output Voltage}}{\text{Reference Test Current}}$$

The measured output signal should be within 2% of the value given by the formula above. In the event that the error is larger than 2% then the wiring of the Measurement Unit should be carefully checked and the test repeated.

Step 2 - PQSensor™ Calibration

Having verified the output signal in step 1 then the test current should be removed and the PQ-Sensor™ is now ready to be calibrated. Calibration is normally performed at the same time as the calibration of the main CVT outputs. Rated primary voltage is applied to the CVT and the output of the PQSensor™ is adjusted using the output adjust control so that the output voltage is as given by the formula :-

$$\text{Output Voltage} = \frac{\text{Test Voltage x Nominal Output Voltage}}{\text{Nominal Rated Voltage}}$$

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.

Site Installation and Testing of the PQSensor™

Mounting The SCM Enclosure.

The signal conditioning module (SCM) box is a weatherproof IP65 enclosure, with approximate dimensions of 260 mm x 160 mm x 90 mm. 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 earth connection between the SCM enclosure and the earthed 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. In hot climates it is also recommended to mount the SCM in a location that will afford the maximum shielding from direct sunlight. While the PQSensor™ is rated to temperatures up to 65 ˚C, where possible, in warmer climates it is prudent to limit exposure direct sunlight. A canopy is provided for installations in climates where ambient temperature can exceed 40 ˚C. Typical installation photographs can be seen in Appendix V.

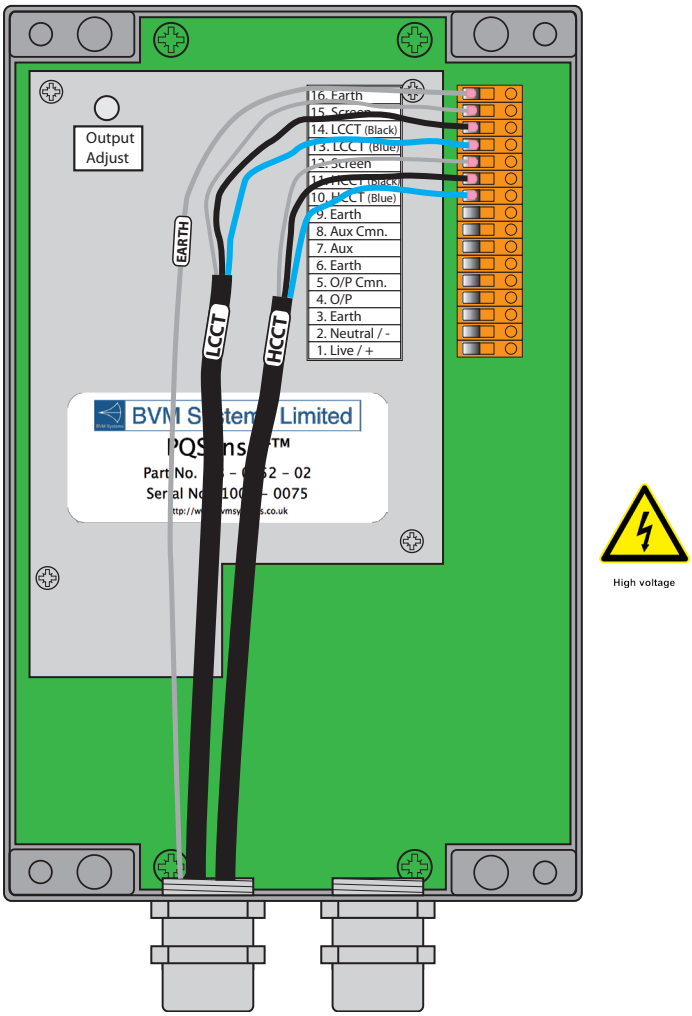


Figure 4

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.

Installing the Interconnecting Cable

The Interconnecting cable is a total of 3m in length and is prepared at both ends for connection to the CVT secondary terminal box and the SCM enclosure. The interconnecting cable should

be installed between the MU in the CVT secondary terminal box and the SCM using the glands supplied. First terminate the connections in the SCM as shown in Figure 4 and the drawing in Appendix IV. Then remove the links on the MU outputs and terminate the other end of the cable as shown in Figure 3.

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.

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 110 - 250V dc. An Earth connection must always be made to pin 3 of the PQSensor™ user connections terminal block.

The nominal output signal from the PQSensor™ is 63.5V 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 63.5V ac present on the output terminals.

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

Site Verification For a Factory Calibrated PQSensor™

It is recommended to repeat the Wiring and Installation validation check as performed in the factory to ensure that field installation has been completed correctly. This involves injecting the Reference Test Current into the test inputs of the MU and verifying that the output of the PQSensor™ is within 2% of the Nominal Output Voltage.

Since the PQSensor™ has been factory calibrated it only remains to verify that the output of the PQSensor™ is consistent with the primary voltage when the CVT is energised. To verify the PQSensor™ output monitor the substation voltage using the most accurate instrument transformer available (e.g. a reference substation CVT or inductive VT) and using a calibrated True RMS meter measure the output of the PQSensor™. Using the formula :-

$$\text{Output Voltage} = \frac{\text{Measured Substation Voltage x Nominal Output Voltage}}{\text{Nominal CVT Voltage}}$$

the measured output voltage should be within 0.5% of the Output Voltage given by the formula. When testing is complete record the substation voltage and output voltage on the label provided inside the PQSensor™.

Site Calibration Of a PQSensor™ being fitted to an existing installed CVT

As a first step install the Measurement Unit and the SCM as described above. Before energising the CVT to perform the site calibration it is recommended to re-check the Wiring and Installation Validation as described above.To perform this calibration check the complete PQSensor™ should be installed as described above and the CVT secondary terminal box securely

closed up before the CVT is energised.

N.B. Before energising the CVT ensure that the earth connections in the C_2 and EMU circuits have been securely established and checked as part of the Measurement Unit installation. Also ensure that the CVT secondary terminal box is securely closed.

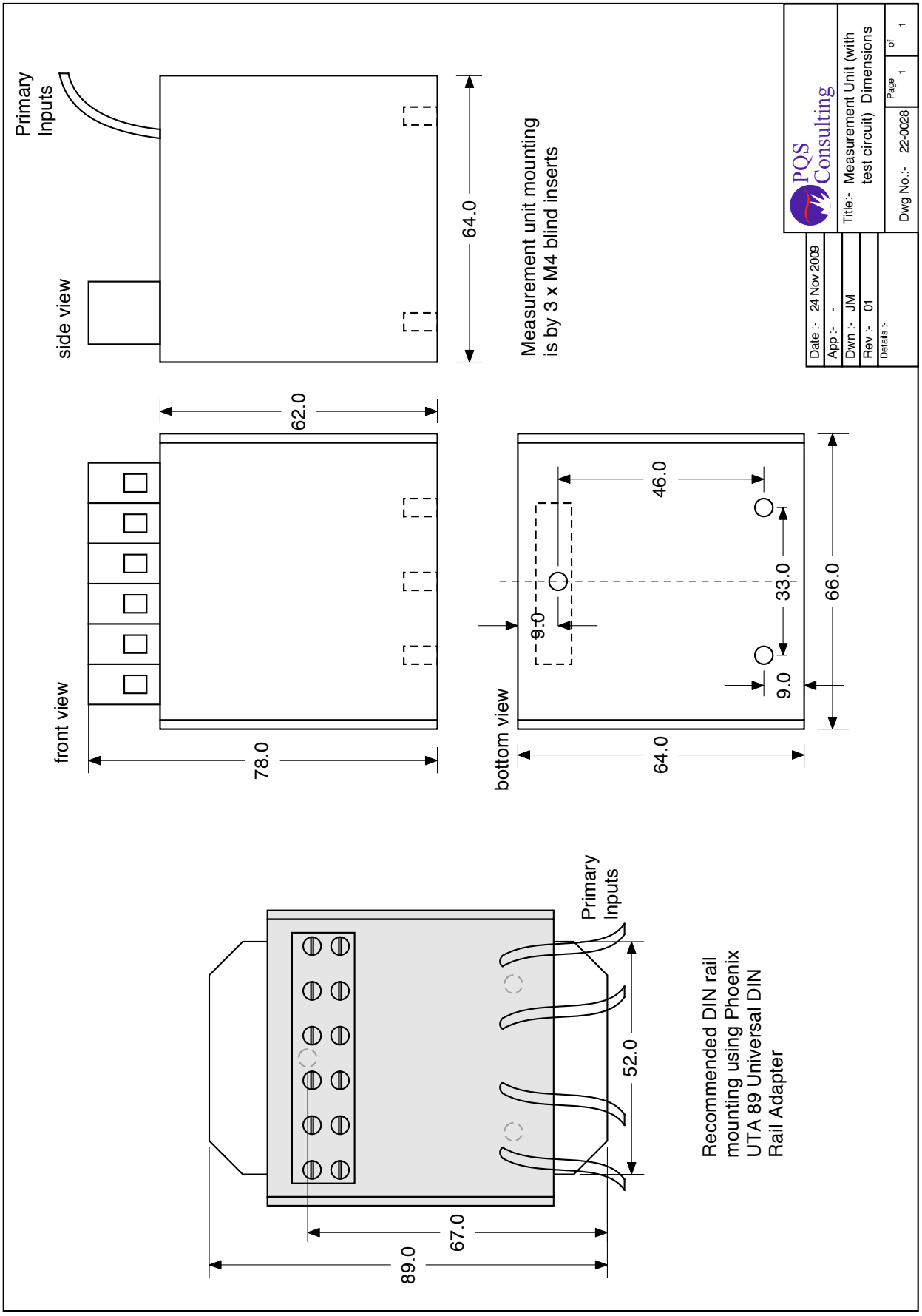
Using an accurately calibrated voltmeter measure the output voltage of the SCM while the CVT is energised . The measured output voltage should be exactly 63.5 V rms for nominal substation voltage. Use the formula below to determine the expected output voltage for substation voltages that differ slightly from the nominal voltage.

$$\text{Output Voltage} = \frac{\text{Measured Substation Voltage x Nominal Output Voltage}}{\text{Nominal CVT Voltage}}$$

Minor adjustments to the calibration of the PQSensor™ can be made by adjusting the gain adjust in the SCM which is accessible through the top panel.
If the error between the measured voltage and the expected voltage is greater than 5% then it is likely that there is an installation problem and the CVT should be de-energized, made safe and the PQSensor™ installation and wiring should be checked.

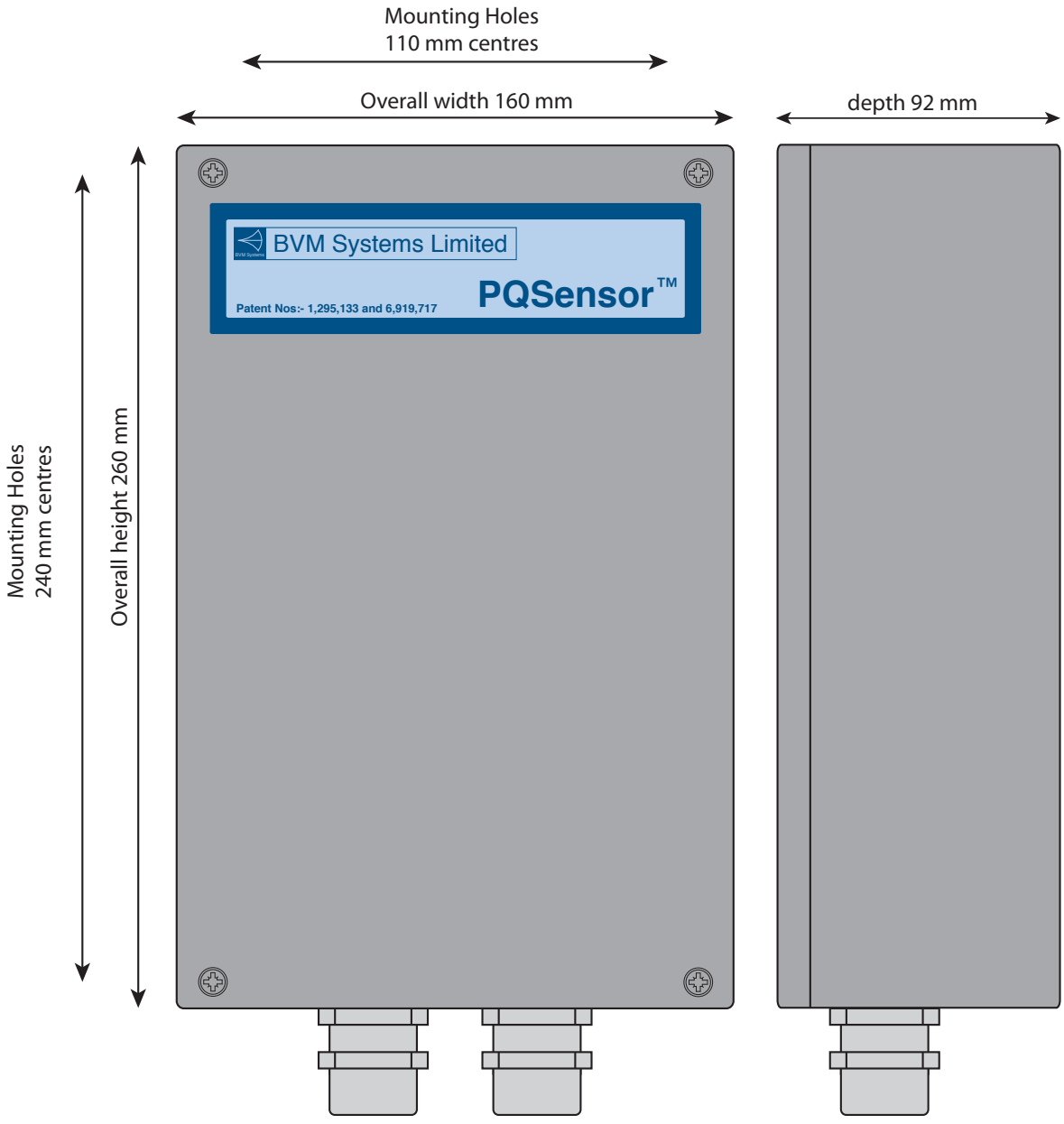
When testing is complete record the substation voltage and output voltage on the label provided inside the PQSensor™.

Appendix I


Primary Inputs
side view
64.0
Measurement unit mounting is by 3 x M4 blind inserts
62.0
front view
78.0
46.0
33.0
9.0
9.0
66.0
bottom view
64.0
PQS Consulting
Date :- 24 Nov 2009
App :- -
Dwn :- JM
Rev :- 01
Details :-
Title:- Measurement Unit (with test circuit) Dimensions
Dwg No.:- 22-0028
Page 1 of 1
Primary Inputs
52.0
67.0
89.0
Recommended DIN rail mounting using Phoenix UTA 89 Universal DIN Rail Adapter

Appendix II

SCM Dimensions



Fixing bolts - M6 x 30mm

Appendix III

PQSensor™ - Sample Test Reports

BVM Systems Limited

Measurement Unit Test Report

Date:- August 6, 2010

Customer:- CVT OEM

Serial Number:- 1007-0209

Input Continuity Check

Test Current (A)	7.89
Resistance (mOhm)	23.18
Result	Pass

Hi-Pot Test (2.5 kV ac)

I/P - O/P (mA)	0.11
I/P - Gnd (mA)	0.08
O/P - Gnd (mA)	0.06
Result	Pass

MU Ratio And Phasing Check

HCCT Ratio Test Error	< 0.25%
LCCT Ratio Test Error	< 0.25%
HCCT & LCCT Phasing	Pass
Result	Pass

Signed _____

BVM Systems Limited

PQSensor Test Report

Date:- June 9, 1946

Customer:- CVT OEM

SCM Serial Number:- 1007-0089

HCCT Injection

Measurement Error (less than)	0.00%
Result	Pass

LCCT Injection

Measurement Error (less than)	0.0%
Result	Pass

Test Injection

Measurement Error (less than)	0.0%
Result	Pass

Frequency Response

Result	Pass
(see attached graph)	

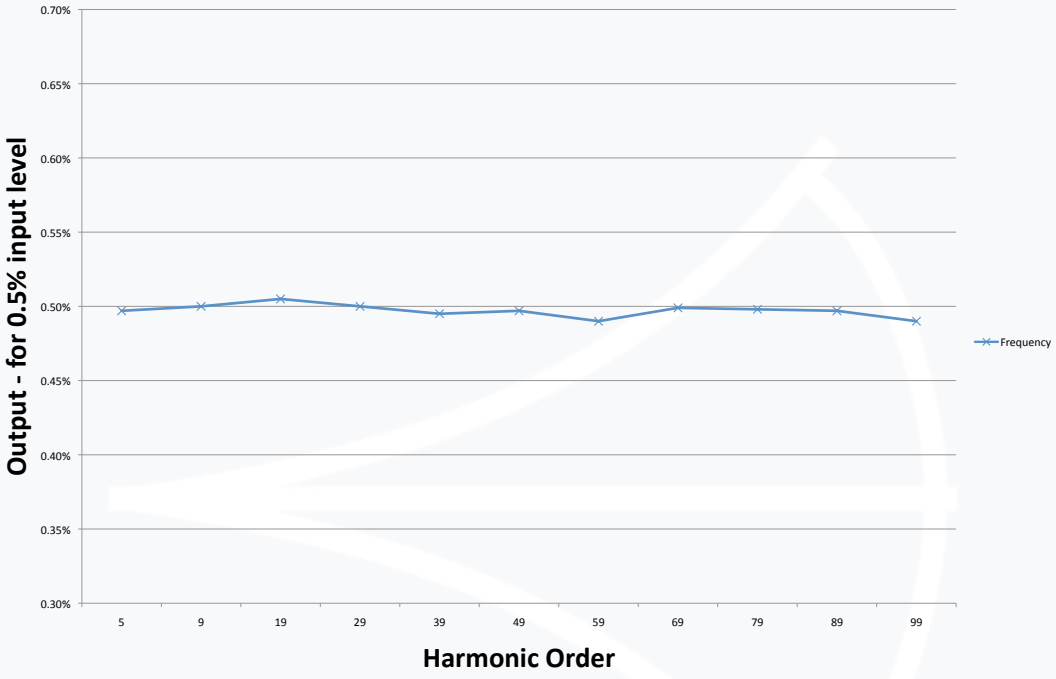
Signed _____

Reference Data

Voltage (kV)	132
C1 (pF)	15500
C2 (pF)	66500
TH	250
TL	125
Nominal Output Voltage	63.5
Reference Test Current (mA)	856.594

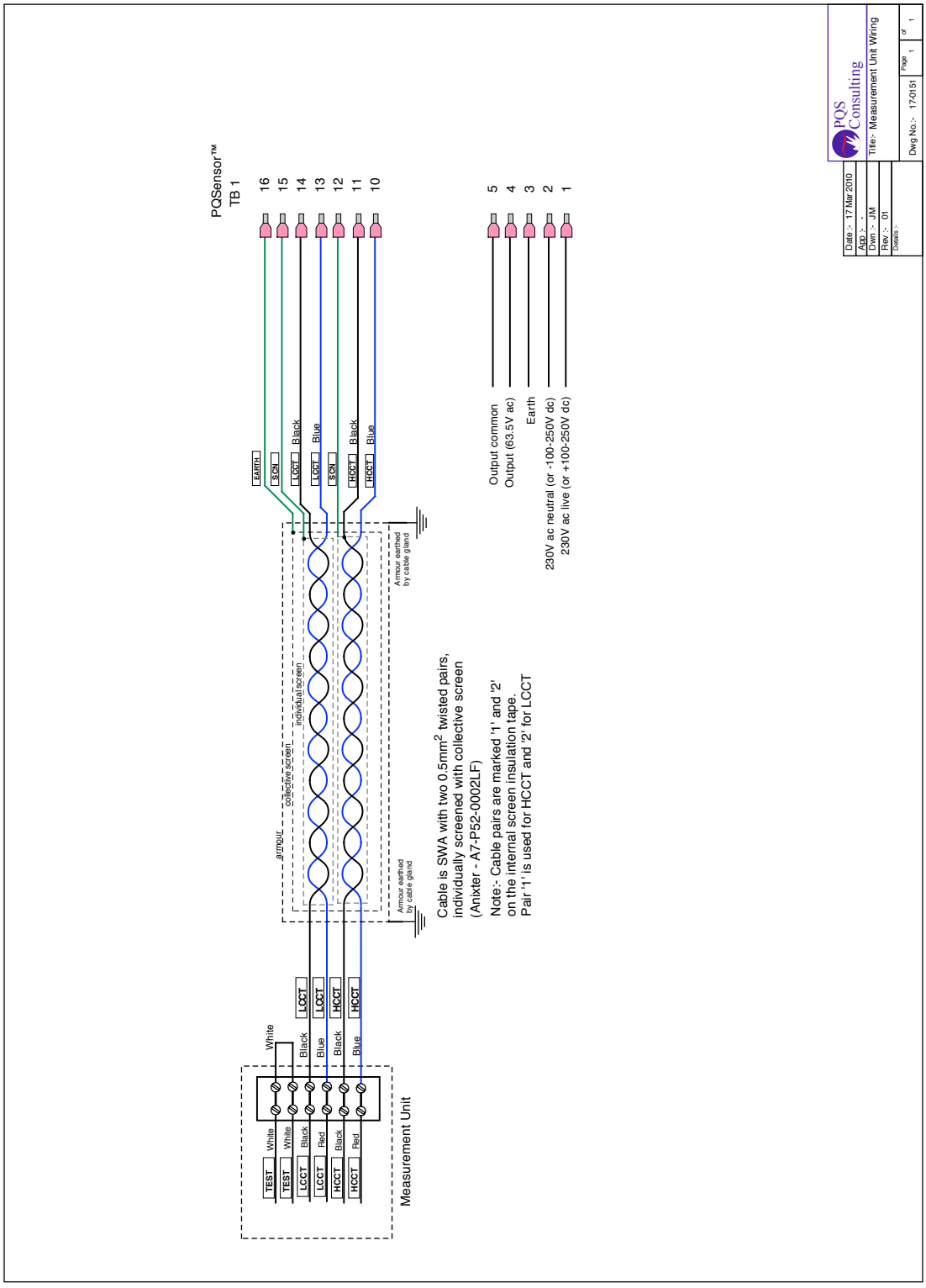
SCM Serial Number - 1007-0089

Frequency Response Report



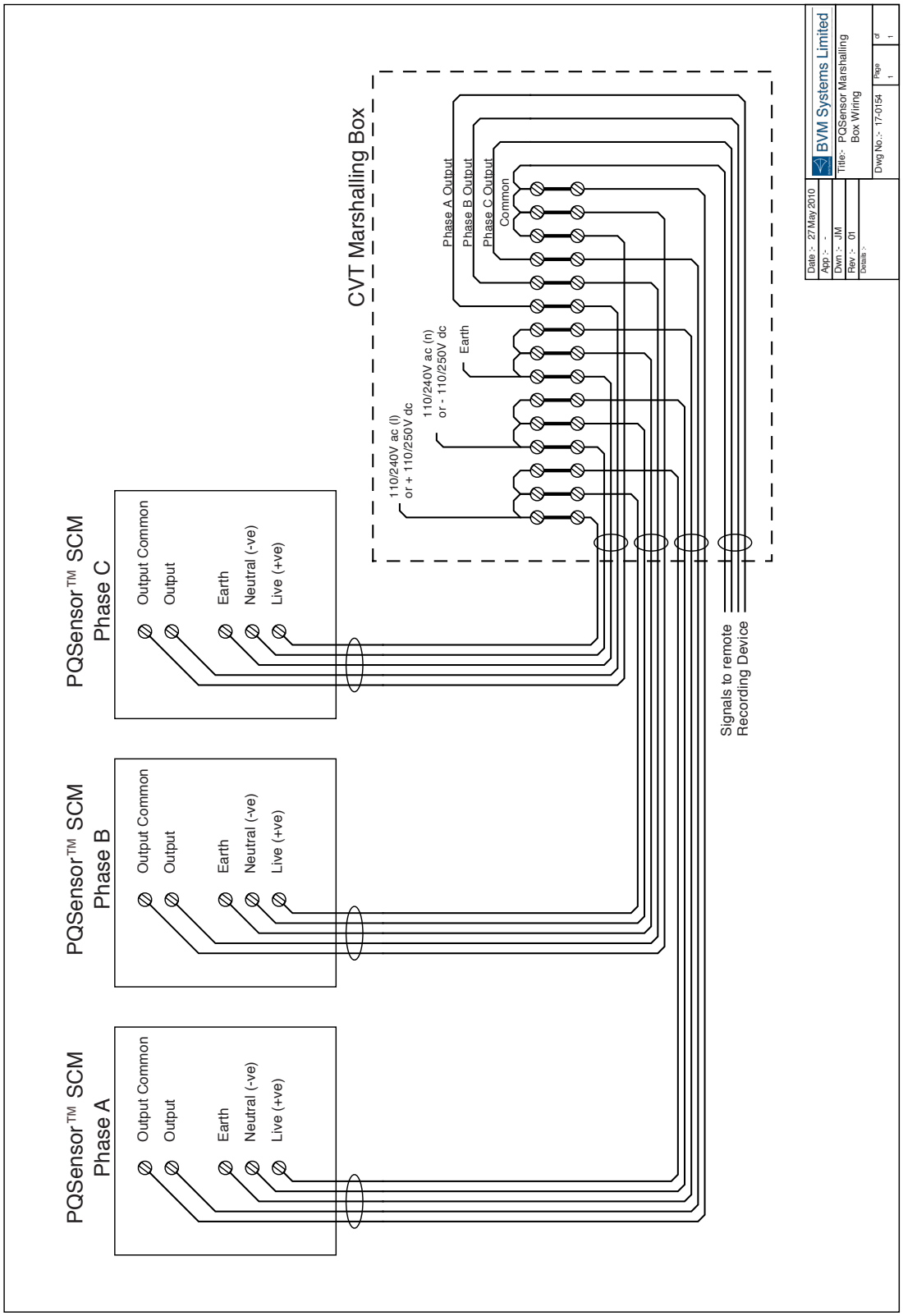
Appendix IV

PQSensor Wiring Diagram



Appendix V

PQSensor Marshalling Box Wiring Diagram



Appendix VI

PQSensor™ Installation Examples