

## **OPERATIONAL METERING**

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### **PURPOSE AND SCOPE**

This document deals with the requirements for the measurement inputs to SCSs (Substation Control Systems) be they direct AC inputs or derived from transducers.

### **PART 1 –PROCEDURAL**

#### **1 CONNECTION OF VT AND CT SIGNALS**

##### **1.1 Current Transformer Inputs**

###### **1.1.1 CT Cores**

Transducers shall only be used in conjunction with measurement/protection cores as defined in TS 3.2.4. Connection to dedicated protection cores is not normally permitted as this may compromise protection performance.

Connection to settlement CTs is generally precluded other than under the precise conditions identified in the Settlement Metering Code of Practice.

###### **1.1.2 CT Ratio Selection**

At least two CT ratios are provided on all current transformers as standard. The selection of CT ratio should be based on the joint measurement and protection requirements, guidance on ratio selection is given in Section 9.7.

###### **1.1.3 Burden on CTs**

Care should be taken to ensure that the total connected burden of the CT (including cabling) does not exceed the rated value as measurement performance is only guaranteed up to the

rated value. Burden assessments should include all connected equipment and cabling. The burden presented by transducers is approximately 1 VA per transducer input.

## 1.2 Voltage Transformer Inputs

1.2.1 Connection to settlement VTs is generally precluded other than under the precise conditions identified in the Settlement Metering Code of Practice.

1.2.2 Care should be taken to ensure that the total burden lies in the range 25 to 100% of rated burden, as transformer performance is only guaranteed over this range. The burden presented by transducers is approximately 0.1 VA per input. Self auxiliary powered transducers present an additional burden of about 3 VA per transducer.

1.2.3 *Informative: The consequence of not observing this requirement will result in gross errors in the measurement of Voltage MW and MVAR.*

## 2 CABLING

### 2.1 General

2.1.1 To avoid undue measurement errors resulting from coupling from external sources, cabling should not be run in close proximity and/or in parallel to primary and auxiliary power circuits. Such circuits should be crossed at right angles wherever possible.

2.1.2 All cabling shall meet the requirements of TS2.19.

### 2.2 VT and CT Input Cabling

2.2.1 All cabling in the measuring transformer secondary circuits should be performed using cores having a cross sectional area of 2.5 mm<sup>2</sup>. For guidance, the resistance of 2.5 mm<sup>2</sup> cross sectional area conductors is approximately 7.41  $\Omega$  per 1000 metres (500 metres loop) and its effect should be considered when ensuring compliance with CT burden requirements (see Section 3.1.3).

2.2.2 In order to minimise VT secondary “volt drop” errors, cabling resistance should be controlled. The table below gives maximum permissible cabling distances for 2.5 mm<sup>2</sup> cores, calculated on the basis of:

- (i) A 0.8 PF connected burden, and
- (ii) A total fuse and link resistance not exceeding 0.6  $\Omega$  (see Section 5.2), and
- (iii) The resultant measurement magnitude error not exceeding 0.5%.

2.2.3 It should be noted from the table that there is a significant advantage in using a common VT neutral for balanced 3 phase loads.

| Total Burden Connected Via VT Input Loop. | Total Permitted Cabling Loop Distance of VT Circuit (metres)             |                                                                                                     |
|-------------------------------------------|--------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|
|                                           | VT cabling loop distance with a separate neutral for each phase (metres) | VT cabling loop distance with a common neutral and a substantially balanced 3 phase burden (metres) |
| 5VA                                       | 300                                                                      | 600                                                                                                 |
| 10VA                                      | 125                                                                      | 250                                                                                                 |
| 15VA                                      | 75                                                                       | 150                                                                                                 |
| 20VA                                      | 45                                                                       | 90                                                                                                  |
| 25VA                                      | 30                                                                       | 50                                                                                                  |
| 30VA                                      | 15                                                                       | 30                                                                                                  |
| 35VA                                      | 10                                                                       | 15                                                                                                  |

**Table 1: VT input loop cable distance**

### 3 TRANSDUCERS

#### 3.1 Output Cabling

- 3.1.1 Cabling between transducers and receiving equipment should utilise twisted pairs of 0.8mm<sup>2</sup> cross sectional area. The maximum permissible cabling distance is determined by the output drive capability of the transducers (500  $\Omega$ ) and the burden of the receiving equipment. For guidance, the resistance of 0.8mm<sup>2</sup> cross sectional area cores is approximately 23  $\Omega$  per 1000 metres.

#### 3.2 Location

- 3.2.1 Where discrete transducers are being used these shall be located as close as is reasonably practicable to the point of measurement. Resistance transducers as used for transformer tap and winding temperature indication should be located at the transformer marshalling kiosk. This approach has the advantages of reduced cabling costs, reduced CT burdens, limiting of volt drop errors, and avoidance of CT/VT signals in close proximity to sensitive receiving equipment.

#### 3.3 Output Types and Usage

- 3.3.1 All approved transducers are of a constant current output type and will not be damaged by either open, or short circuit output conditions. Accuracy is maintained for output burdens of between 0 and 500  $\Omega$ .
- 3.3.2 Transducers having 0 ... 10 and -10 ... 0 ... 10 mA d.c. outputs have a designed over-range measurement capability, dependent on measurement function. Performance is maintained up to 125% overload condition for all transducers types and up to 160% for Watt, VAr and Current transducers.
- 3.3.3 Transducers having 4 ... 20 mA and 4 ... 12 ... 20 d.c. mA outputs have no over-range capability, the receiving equipment will normally determine signals outside of these ranges as error conditions. Transducers of this type are preferred for control applications as a zero measurement condition gives a non-zero output.

Type Registered transducers cover output types as indicated in the following table:

| Output Type              | Usage                                                                                         |
|--------------------------|-----------------------------------------------------------------------------------------------|
| 0 ... 10 mA d.c.         | Unidirectional quantities (V, I etc)                                                          |
| -10 ... 0 ... 10 mA d.c. | Bi-directional quantities (Watts and VArS)                                                    |
| 4 ... 20 mA d.c.         | Unidirectional quantities (V, I etc)                                                          |
| 4 ... 12 ... 20 mA d.c.  | Bi-direction quantities (Watts and VArS, 12 mA corresponds to the zero measurement condition) |

**Table 2: Transducer output types**

### 4 SCS NMV AND TRANSDUCER NMO

- 4.1.1 The required measurement range of a primary system quantity is agreed with Market Operation (MO). The measurement range is defined as 125% of the Nominal Maximum Value (NMV).. The output delivered by transducers at the Nominal Maximum Value (NMV) is termed the transducer Nominal Maximum Output (NMO).
- 4.1.2 The mA signal received from the transducers is normally used to develop a voltage within the receiving equipment, the scaling is chosen on the basis of producing a voltage X at the NMV value, where X is chosen to allow a measurement over-range capability, at least up to 128% of X.

- 4.1.3 Please note that where the over range capability of the receiving equipment is limited to the minimum of 128% appropriate scaling needs to be applied to allow for the over-range requirements stated in the relevant functional requirements of the application. One such example would be the overload threshold for ATCC which can be set at up to 200% (refer to TS3.24.61 section 4.47)

## 5 SCS ANALOGUE INPUT CHANNEL USAGE

### 5.1 Input resolution

- 5.1.1 All Substation Control System (SCS) analogues should be measured using high resolution inputs. These have an effective count range of at least 0 to  $\pm 1023$  bits,  $\pm 800$  bits being the count for an input equivalent to NMV for GI74 and typically 0 - 20,000 for IEC60870-5-101. Please also refer to TGN165 for details on analogue scaling for IEC60870-5-101.

## 6 REQUIRED MEASUREMENTS

- 6.1.1 The following table lists the required provision of measurements for some of the most common applications. Please refer to the relevant level 3 specification of the type of plant/cct for more details.

| Circuit, Station or Function*** | Measurement Type      | Measurement                              |
|---------------------------------|-----------------------|------------------------------------------|
| Generators                      | Voltage               | Per Generator****                        |
|                                 | MW                    |                                          |
|                                 | MVAr                  |                                          |
| Transformer LVs , QBs etc       | Current               | Per Transformer                          |
|                                 | Voltage               |                                          |
|                                 | MW (LV)               |                                          |
|                                 | MVAr (LV, Tert*)      |                                          |
|                                 | Winding Temp (WTI)    | Per transformer winding, see Section 9.6 |
|                                 | Tap Position          | Per transformer, see Section 9.5         |
| Lines                           | Conservator Oil Level | Per Transformer                          |
|                                 | MW                    | Per Circuit                              |
|                                 | MVAr                  |                                          |
|                                 | Current**             |                                          |
|                                 | Voltage               |                                          |
| Series Reactors                 | MVAr                  | Per Circuit                              |
|                                 | WTI                   | Per Plant                                |
|                                 | Oil levels            | Per Plant                                |
| Shunt Compensation              | Current**             | Per Plant                                |
|                                 | MVAr                  | Per Plant                                |
|                                 | WTI                   | Per Plant                                |
|                                 | Oil levels            | Per Plant                                |
| Mesh Station                    | Frequency             | Per Mesh Corner, See section 9.4         |
|                                 | Current               | Per busbar section                       |
| Busbar Station                  | Frequency             | Per busbar section, See section 9.4      |
|                                 | Current               | Per busbar section/bus coupler           |

**Table 3: Required Measurements**

**Notes:**

\* Tertiary MVARS only required where variable reactive compensation equipment is connected.

\*\* Current only required at the SCP.

\*\*\* Please refer to the relevant level 3 specifications for a more details.

\*\*\*\* Requirements for Generators are usually included in the relevant connection agreement.