

ALGORITHM FOR THE COMPENSATION OF THREE PHASE FOUR WIRE SETTLEMENT METERING

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PURPOSE AND SCOPE

This Technical Guidance Note details National Grid requirements for the calculation and application of metering errors / compensations for three phase four wire energy meters as used for Settlement Metering purposes.

This version of the TGN has been produced to cover the National Grid Settlement Metering Upgrade Project (starting in 2013) and for future new metering installations.

The algorithms specified in this document deal with the compensation for errors associated with the measurement circuits external to the meter. The algorithms do not include for the compensation of plant losses (power transformer and/or line losses) where the actual metering point does not coincide with the defined metering point.

National Grid Asset Management (or the National Grid Meter Operator Agent) should be consulted for advice on issues relating to plant loss compensation.

The algorithms will normally be used in a calculation utility (e.g. spreadsheet or similar) which calculates the required errors /compensations for each Metering System (both Main and Check meters) and stores in an associated database the calculated results and relevant source data.

In instances where compensation is not applied to the energy meters (e.g. for very small compensation values) the calculated metering system errors (available from the database) provide part of the evidence that the metering system meets the accuracy requirements of Metering Code of Practice One.

Informative: Metering Code of Practice 1 is an industry standard available on the Elexon web site and with which full compliance is required

The energy meters covered by this document are four quadrant energy meters (combined active and reactive types).

PART 1 – GUIDANCE

1 CALCULATION OF EXTERNAL MEASUREMENT ERRORS

Meter compensation shall take account of the following measurement errors.

- a) Voltage Transformer (VT) errors.
- b) VT lead resistance errors.
- c) Current Transformer (CT) errors.

1.1 VT Errors

Meters shall normally be compensated on a per element basis for the associated VT errors at the nominal working burden of the VT. The actual working burden is that burden presented to the VT by the metering circuit and for special cases any non-metering burden.

This version of the TGN covers the future standard arrangement in which energy meters are provided with a substation dc battery source auxiliary supply and the metering system burden resistors are selected to achieve the nominal VT 25% rated burden test condition. This normally relates to 3.75 VA at upf and is achieved by burden resistors located in the metering cubicle and connected on the VT cable 'auxiliary supply' cores.

Since, in this standard case the only VT burdens other than the burden resistors are the meter measurement input and the VT leads which are both relatively small values, the burden resistor nominal value is selected to achieve the 25% condition. (Typical burden resistor nominal value for a 15 VA rated VT winding is 3,300 ohm using a delta connection.)

The source data to calculate the VT errors is the VT test certificate which provides errors at 25% and 100% of the rated burden. Many installed VTs have test certificate errors at the upf condition and the 25% burden errors available from these can be used without any modification or further calculation. In the case where the certificate only provides errors at 0.8 pf burden (as is the case with VTs supplied in accordance with more recent versions of the National Grid technical specification for Settlement Metering VTs, NGTS 3.2.6) it will be necessary to use the algorithms as detailed below to convert the certificate values to the upf condition.

1.1.1 Calculation of VT Errors at 3.75 VA upf where the certificate data is only available at 0.8 pf burden.

- a) Step 1: Calculation of the VT Errors at 0 VA Burden

The magnitude and phase angle errors for the 3.75 VA and 15 VA 0.8 pf burdens shall be used to deduce the errors for a 0 VA burden condition (C1 & C2)

$$C_1 = B_1 - \left[\left(\frac{A_1 - B_1}{U - L} \right) \times L \right] \qquad C_2 = B_2 - \left[\left(\frac{A_2 - B_2}{U - L} \right) \times L \right]$$

Where: A1 = Magnitude error (in percent) at U VA 0.8 lag burden.
A2 = Phase error (in centiradians) at U VA 0.8 lag burden.
B1 = Magnitude error (in percent) at L VA 0.8 lag burden.
B2 = Phase error (in centiradians) at L VA 0.8 lag burden.
C1 = Magnitude error (in percent) at 0 VA burden.
C2 = Phase error (in centiradians) at 0 VA burden.

U = VT Rated Burden (100%) or upper test burden value in VA.
L = 25% of VT Rated Burden or lower test burden value in VA

b) Step 2: Calculation of the working burden vector at 3.75 VA upf

The magnitude and phase of a new upf vector shall be produced relative to the derived 0 VA point as shown in Figure 1. (This vector is in effect shifted by 36.87 degrees ($\cos^{-1} 0.8$) anti-clockwise to adjust the values to upf.)

The magnitude and phase of the derived vector is:

$$F_1 = \frac{\sqrt{(A_1 - C_1)^2 + (A_2 - C_2)^2} \times E_1}{U} \quad F_2 = D + \tan^{-1} \left(\frac{A_2 - C_2}{A_1 - C_1} \right) + E_2$$

Where: D = (180 + 36.87) degrees.

E1 = Magnitude (in VA) of 25 % VT burden, 3.75 VA for U equal 15 VA

E2 = Phase angle (in degrees) of total VT burden, 0 degrees for this case

F1 = Magnitude (in percent) of working burden vector relative to 0 VA.

F2 = Phase angle (in degrees) of working burden vector relative to zero degrees.

Notes: 1. The specified value of D assumes that A1 is less than C1 which will be true for all practical cases where the angle of the vector AC is in the third angular quadrant. Where A1 is found to be greater than C1 or, where A1 equals C1, or A2 equals C2, then the condition shall be flagged as suspect and the data checked.

2 The above approach assumes that the burden on the two secondary windings of each VT is approximately the same (3.75 VA).

c) Step 3: Calculation of the VT Errors at Working Burden

To determine the VT errors at the working burden the value (F1) and angle (F2) are converted into rectangular coordinates, and to this is added the values of C1 and C2 (percent and centiradians error at the 0 VA point respectively), to produce the resultant magnitude and phase errors for the working burden:

$$G_1 = (F_1 \cos F_2) + C_1 \quad G_2 = (F_1 \sin F_2) + C_2$$

Where: G1 = Magnitude error (in percent) of the VT at working burden.

G2 = Phase error (in centiradians) of the VT at working burden, this angle to be converted to minutes.