# Testing of electricity meters
# with interconnected current and voltage circuits

Dr. Ladislav Grno / Applied Precision Ltd.
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## 1. Introduction

Testing of electricity meters with interconnected current and voltage circuits i.e. closed I-P links is an increasing need for meter manufacturers and meter operators.
The meters that do not allow to open the links between the current and voltage measuring circuits ( I-P links) for test or calibration purposes are increasingly in use. There are several reasons for this but the most important for manufacturers is the lower manufacturing cost of single-phase meters using resistive shunts for current measurement. Provision of facility to isolate the current and voltage paths of these meters would result in significantly higher manufacturing cost. During normal operation, this isolation would not even be technically feasible. Another reason for using meters with non-removable I-P links is to prevent their misuse for fraud. Reason for testing meters with closed links might be reduction of additional work needed for manipulation with the links before and after testing i.e. increasing of testing capacity and reduction of cost at high volume testing sites as well.

## 2. Standard arrangement of test systems for simultaneous testing with opened I-P links

During meter testing the source is normally used as a phantom load to provide test currents and voltages applied to both the meters under test and the reference meter. The test current flowing into current terminal is supplied independently from the test voltage. This test configuration allows simultaneous testing of any number of meters limited only by mechanical and power capacity of the system. The separation of current and voltage circuits at each meter is achieved by opening the link (I-P link) in the terminal block. Disconnection avoids interaction of current and voltage circuits and thus introduction of large unpredictable measurement error.

## 3. Arrangements of test systems for simultaneous testing with closed I-P links

If the meter under test has closed I-P links, then the interconnection between voltage and current circuit should be eliminated beyond the meter. The principle of testing with closed links is based on mutual isolation of individual voltage and current source feeding each meter instead of isolating the voltage and current circuits of the meter. Generally it is possible to isolate the voltage source or the current source.

### 3.1. Voltage source isolation

In traditional approach, special voltage transformer having separate output voltage windings for each meter is used for isolation. In this case the test rack must be equipped with multiple voltages wiring network for individual connection of each meter to respective winding of the common transformer. (The transformer is known generally as a multi-secondary voltage isolation voltage transformer or MSIVT). The number of secondary windings is at least equal to the number of meters under test, plus an additional one for the reference meter connection. These transformers are specifically manufactured and calibrated for this purpose and the windings are typically matched to within 0.1% as reported by some manufacturers of test systems. The additional error introduced by the transformer is unpredictable as it depends on the load impedance created by the tested meters, as the absolute accuracy of the MSIVT is not guarantied.

### 3.2. Current source isolation

The required isolation can be achieved by using transformers in the current circuits with one current transformer per phase for each test position. In this way, each meter under test is supplied with isolated test currents. These transformers advantageously have a current ratio of 1:1 and over the required current range should have amplitude and phase errors small enough as not to introduce significant additional errors. The classic test systems specify the accuracy degradation from 0.5% to 0.1%. Because of non-linearity inherent in standard transformers, the overall accuracy of the system significantly decreases at lower currents. As the current isolation transformers provide an additional load to the current amplifier, the power of the current source needs to be higher then for the system without the current transformers.

## 4. Suitable arrangements for testing

The applicable test arrangement depends on the type of the tested meter.

### 4.1. Test system for single-phase meters

If the test system is dedicated only for Single-phase meters, the isolation of each meter can be realized either using individual isolated voltage source or using individual isolated current source. In both cases each installed meter must be equipped with individual source.

### 4.2. Test system for multi-phase meters

Multi-phase meters for direct connection are also manufactured with closed I-P links. Due to the common neutral connection of three voltage circuits it is not possible to simply utilize voltage transformers with separated secondary windings for isolation of individual meters. Example of arrangement of two three-phase meters with closed links is shown in the Fig. 1.

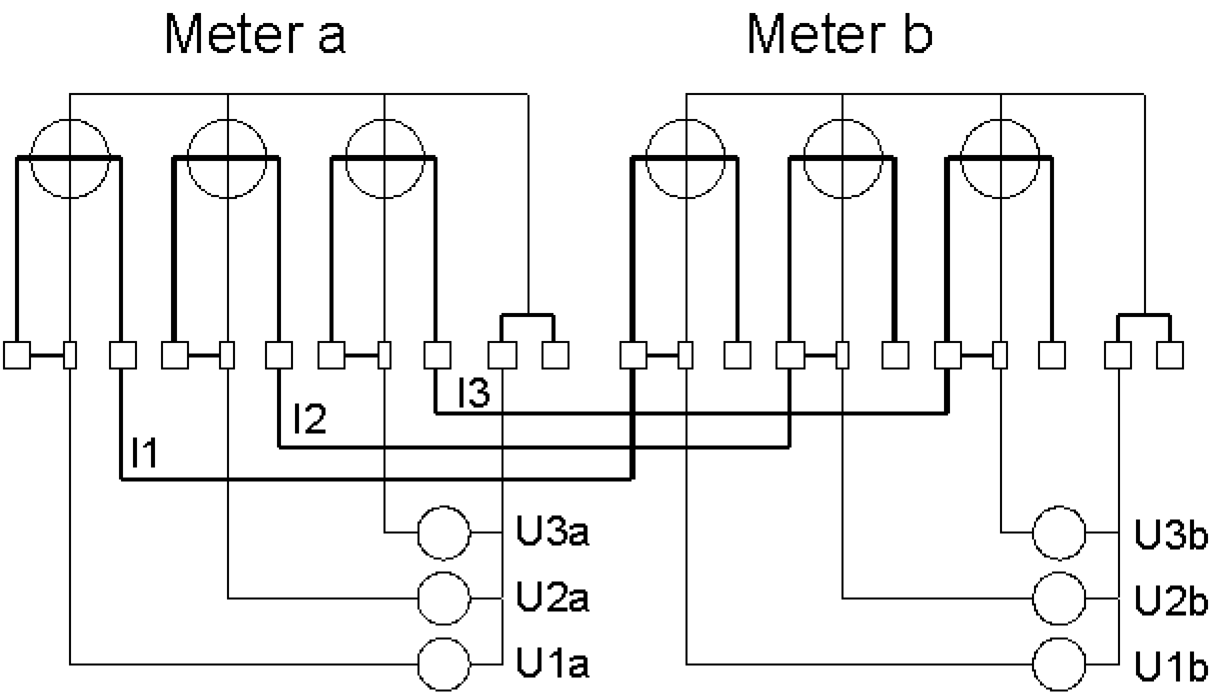


**Fig. 1**

There are three separated voltage sources U1, U2, and U3 for each meter A and B. Via common neutral the three independent sources of each meter are interconnected. The voltage circuits of meter A and meter B are interconnected via closed links, common neutral and current wires I1, I2, and I3. This is the reason for interaction between the voltage and current circuits due to non-equality voltage drops on the current wires due to impedance of the wires and contact resistances. The interconnections cause undefined balance currents destroying the measurement accuracy.

The required isolation of three phase meters with closed links can be achieved only using isolation current transformers in the current circuits fitted with separate current transformer per phase for each test position as shown in the Fig.2

In this case the closed link creates only one interconnection in any isolated current circuit and therefore no current path between current and voltage circuits is closed. Therefore no interaction currents can flow through the circuits and the accuracy is fully maintained.

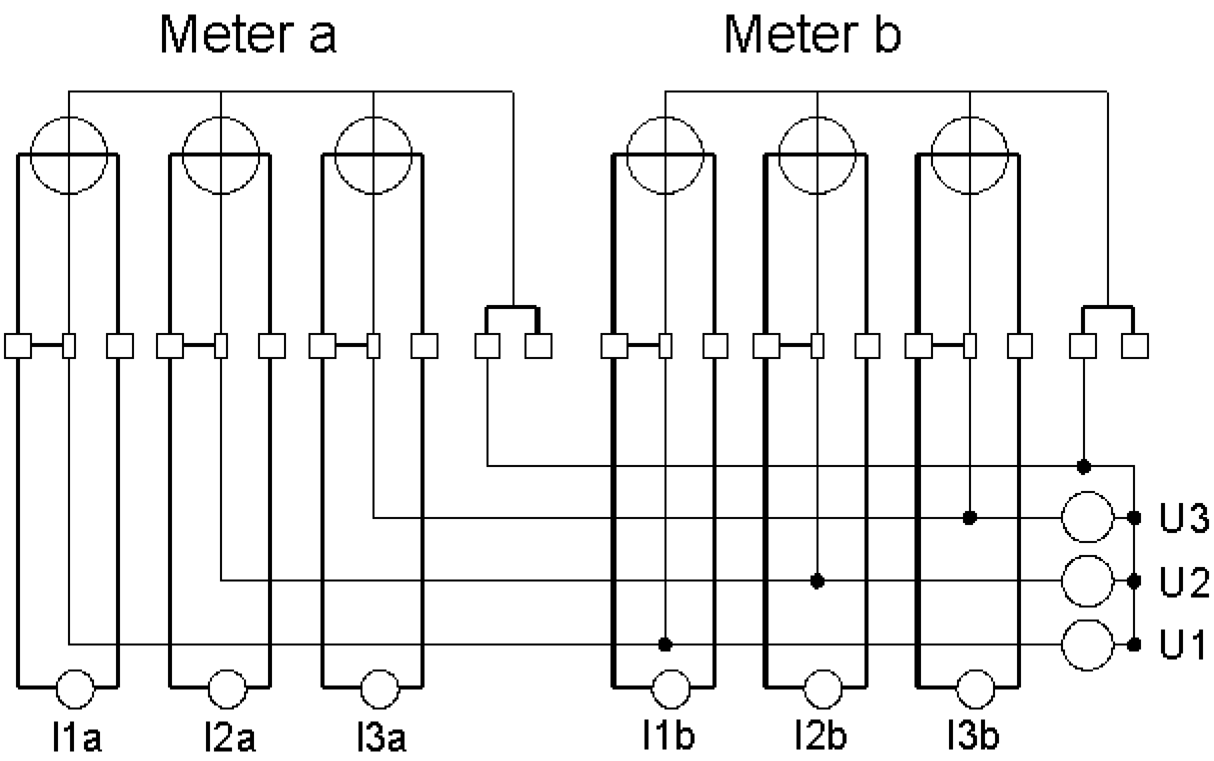


**Fig. 2**

## 5. Solution of Applied Precision Ltd. for simultaneous testing of meters with closed I-P links

Applied Precision Ltd. has developed high precision electronically compensated isolation circuit for voltage or current separation. The devices are assigned as Common Mode Rejecter (CMR) units in the product line of Applied Precision Ltd.
The CMR units are based on internationally patented technical solution using sophisticated core materials and active compensation technique. This approach enables significant size, weight and price reduction compare to the classical approach at non-comparable accuracy and application comfort.
There are two types of CMR units used either for voltage isolation in single-phase systems or for current isolation in three-phase systems:

- The CMR-U unit works as precise 1:1 fully isolated voltage transducer. Typical accuracy of the CMR units is in order of 0.02% in magnitude and 0.02 degree in phase.

- The CMR-I works as 1:1 isolated current transducer with maximum current up to 120A and broad current working range exceeding three decades of amplitude. Typical accuracy is in order of 0.02% in magnitude and 0.02 degree in phase.

The major advantage of the standalone 1:1 CMR approach is that the user can check the functionality and accuracy of the isolation unit easily by simple means. Then there is no need for metrological verification by external body.
The system equipped with appropriate CMR units can be used for either Single-phase or Multi-phase meters with closed links.
The CMR units are fully independent from the test system so they can be used to extend the closed links test capability to any existing system either classic manually operated electromechanical or the latest computer controlled one without any interference.