

White Paper Isolation in Substation Secondary Equipment

Why Isolate?

It is a long established practice for protection and control equipment in substations to be required to have isolation between all inputs, outputs and earth. Standards such as IEC 60255 specify isolation levels for different classes of exposure, up to 2 kV rms for 1 minute.

The reason for the requirement is to minimize the risk of damage and equipment failure, not just during fault conditions, but also while normal high voltage switching operations are in progress.

Problem 1: Output Isolation

Low voltage control signals, such as TTL time sync signals, have traditionally been distributed in a substation using coax cable to ensure adequate noise immunity for the signal. By connecting the coax shield to station earth, external interference coupling into the signal circuit is minimized. The coax cable is then "multi-dropped" to feed multiple devices using BNC "T" connectors in an Ethernet bus-like architecture.

Under normal operating conditions, this works reasonably well; however, there is a problem. When fault currents flow through the station earth grid during a significant event, potential differences arise across the substation earth grid. These cause high instantaneous noise current to flow in the earthed outer shield conductor of the coax, which seriously interferes with the signal.

Furthermore, if the coax cable is inadvertently earthed in more than one place, currents flowing in the shield conductor are likely to damage the cable. Just when its integrity is needed the most, the now corrupted time sync signal is distributed to all connected devices throughout the sync system.



About Tekron

Tekron International is a leading developer of exceedingly accurate GPS clocks and time synchronization solutions for use in industrial applications.

Tekron GPS clocks are simple to install and use and are extremely rugged, attributes that are a prerequisite in the often extreme environments in which the clocks are installed.

Tekron GPS clocks have been installed in thousands of power stations & substations across the globe, where they prove invaluable in assisting power companies to operate efficiently, minimizing downtime and increasing the accuracy of control decisions.

With a Tekron GPS clock you can be confident that you can set it up and walk away.

Imperfect Solutions

One potential solution is to have a clock with multiple outputs to individually feed each device, or group of devices, that need the sync signal. The drawback of this approach is the amount of cabling that would be needed.

A more economical solution is a clock with an isolated output to drive balanced twisted-pair cable. The problem of potential gradients within the earth system is solved because now noise currents cannot flow to earth along the time sync distribution wiring.

In theory, this would allow a twisted-pair multi-drop distribution of sync signals, with associated savings in the amount of wiring. However, there is still a potential problem due to the way in which the isolated outputs are developed in the clock.

Most clocks use opto-isolator devices internally to provide a solid-state "contact closure" or "dry-contact" at their outputs. This is an economical way of providing isolation, but the outputs are asymmetric - that is, they can only control current to the load in one direction, either source or sink, when the output turns on.

The user must provide an external power supply for the time signal circuit. When the clock output switches off the timing signal, wave shape is dependent on; external noise influence, wiring impedance and load impedance. It is no longer controlled by the clock output.

In order to drive multiple devices with the sync signal at any distance from the clock without affecting signal timing and preserve noise immunity, the load must be low impedance to overcome the cable capacitance. However, when the clock output switches "on", it must source (or sink) the high current caused by the low impedance load.

These conflicting design requirements result in a compromised solution; one where poor noise immunity and timing delays caused by cabling capacitance are tolerated as trade-offs against the need for high current sink capability of the opto-isolated outputs. Clock outputs that use this form of isolation circuitry can only drive a single device. With their multiple outputs and consequent wiring overhead, plus compromised noise immunity and timing accuracy, a problem still exists!

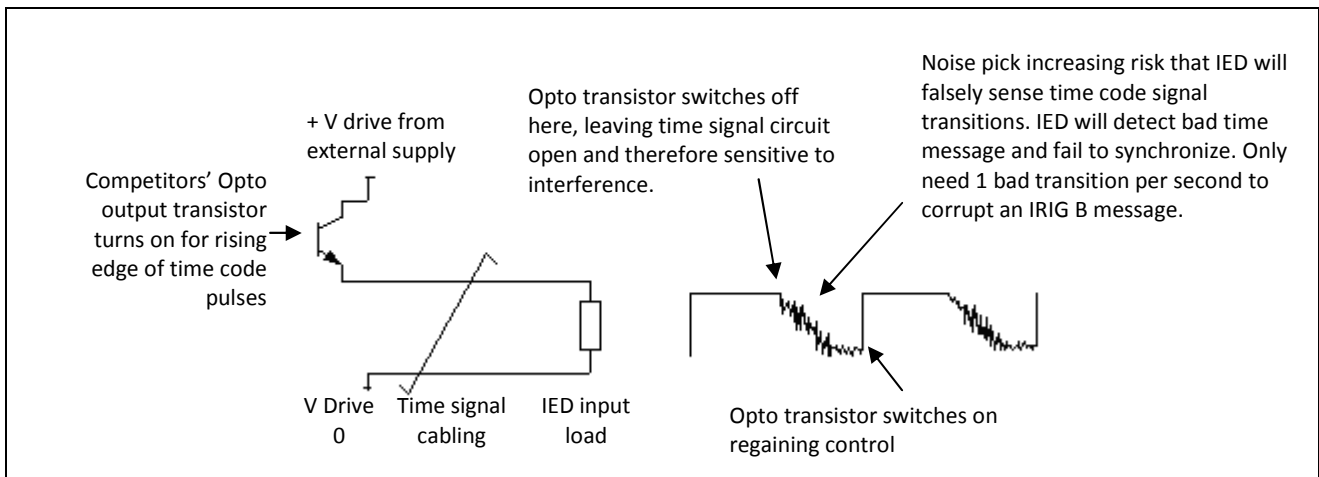


Figure 1: Inferior transistor output

Managed Solution: Tekron's symmetrical isolated outputs

Tekron clocks solve the problem of driving long lines from isolated outputs by using balanced symmetrical outputs that can both source and sink current.

The outputs don't require an external voltage, excellent noise immunity is achieved through good line balance, there are no timing delays, and outputs are capable of driving multiple devices on a "multi-drop" line many metres from the clock.

Typically, each output on the Tekron TCG01 clock can drive 20 or more devices at varying distances from a single cable up to 50 metres or more from the clock! Furthermore, good noise immunity and accurate timing control is maintained.

With Tekron's approach, the design of a synchronizing system is greatly simplified, wiring is minimized, and reliability significantly enhanced. The balanced outputs allow easy-to-use twisted-pair cable for sync distribution around the substation, and yet still maintain good noise immunity. With these features the sync requirements of a whole substation can be catered for. It is rare that more than two clock outputs are required - although the Tekron TCG01 provides four!

For applications requiring isolation between individual devices receiving the time sync signals, Tekron's MOFRs (Multi Function Output Repeaters) can be installed to supply signal to a device or group of devices. As we have seen, the MOFR can also provide signal and protocol conversion if required by specific devices.

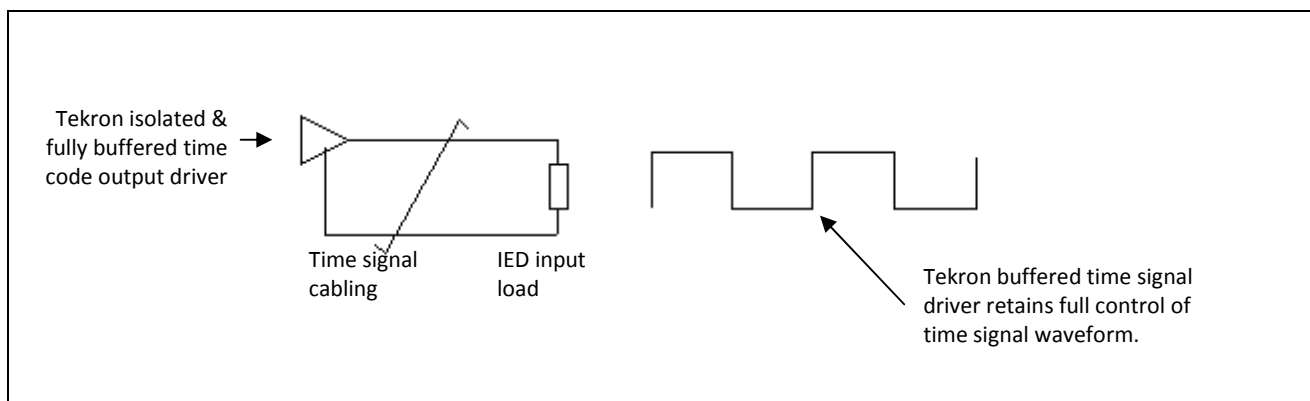


Figure 2: Tekron buffered output

Problem 2: Power supply isolation

Substations usually have a variety of secure battery based power supplies available. A 24 volt or 48 (50) volt supply may be available for communications equipment. Common telecommunications industry practice is for this to be grounded on the positive side. A similarly rated supply may be available for supervisory and remote control equipment. This is likely to be floating and fitted with earth fault detection. The main dc supply for control and protection is commonly approximately 125 Vdc or 250 Vdc, floating and fitted with earth fault detection. Standards vary within the industry and within companies due to the wide range of ages of assets.

Power supplies used for control purposes have cabling running to primary plant in high voltage switchyards therefore any equipment, located anywhere in the substation, that is connected to those supplies is exposed to disturbances and earth potential differences that occur in a substation during fault conditions and during normal operation of primary plant.

Unless the clock is purpose designed for a substation environment, its power supply is unlikely to have a sufficiently high isolation rating to ensure reliable operation and robustness during fault conditions. Clocks that provide no isolation are likely to ground the negative side of the supply input.

This arrangement is incompatible with the common floating battery bank and earthed positive configurations described above. Use of clocks with insufficient, or non-existent isolation in a substation requires installation of an additional power supply to provide the required level of isolation. This arrangement requires more space, makes installation more expensive and reduces overall reliability.

The Solution: Tekron's isolated power supplies

The Tekron TCG01 and TTM01 are designed for the high voltage substation environment.

They are available with a choice of 3 built in and isolated power supplies to cover supply requirements from 24 volts dc through to 250 volts dc. The high voltage version (90 - 300 Vdc) is fully isolated to in excess of 2 kV for use directly from substation primary dc supplies to maximize installation reliability and minimize total life time cost of ownership.

Tekron clocks have been designed, right from the first prototype, to be "Fit for Purpose" in a substation environment.

If you have any questions on this white paper, or would like to discuss any part of it, please email information@tekroninternational.com.