AN001

Benefits of a Relay Barrier in an In-System Programming Equipment

Adding a relay barrier between an in-system programmer and the target system increases the flexibility of a programming/testing equipment. This Application Note explains how to implement and control a relay barrier together with the WriteNow! series of in-system programmers.

In-System Programming in a Testing Context

In-System Programming (ISP) is the capability of modern microcontrollers, memories and other programmable devices to be programmed while already installed in a system, rather than requiring the chip to be programmed prior to mounting it into the board. A problem a test engineer must solve is that of integrating In-System Programming (ISP) in an existing test system. Usually, an Automatic Test Equipment (ATE) performs parametric and functional tests on the Unit Under Test (UUT) that is placed inside a custom, unit-specific test fixture. The fixture routes several ATE test lines to the various test points on the UUT. The same fixture is used to in-system program the target device(s) (or DUP, Device Under Programming) in the UUT. In-system programming usually takes place after the component parametric test and before the functional test (Fig. 1).

Fig. 1

The parametric or in-circuit test (ICT) consists of checking the correct values/placement of capacitors, resistors, diodes, and other components, and the search for unwanted open and short circuits. This is done through the bed of nails inside the fixture, which contacts the UUT in the right places. The in-system programming phase uses the same fixture to in-circuit program the DUP. After the programming phase, a functional test is usually performed. It's extremely important that the in-system programmer lines (that are connected to the DUP) don't introduce unwanted impedances that may affect the ICT measurements (Fig. 2).

In other cases, the programmer should not be connected to the UUT during the ICT or functional test

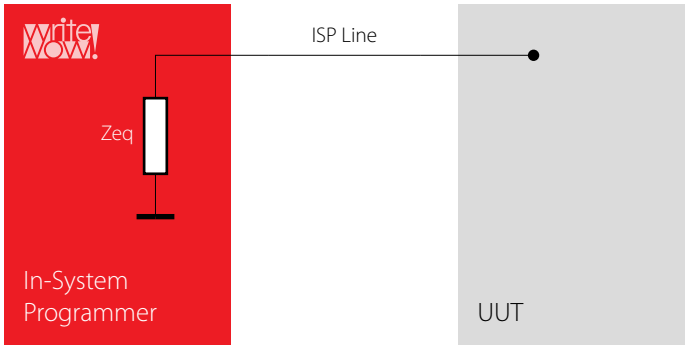

Fig. 2

because (for example) of different ground domains. For these and other reasons, a galvanic isolation of the ISP lines is often required. This can be obtained through a relay barrier that connects the ISP lines only during programming, and disconnects them when necessary (Fig. 3).

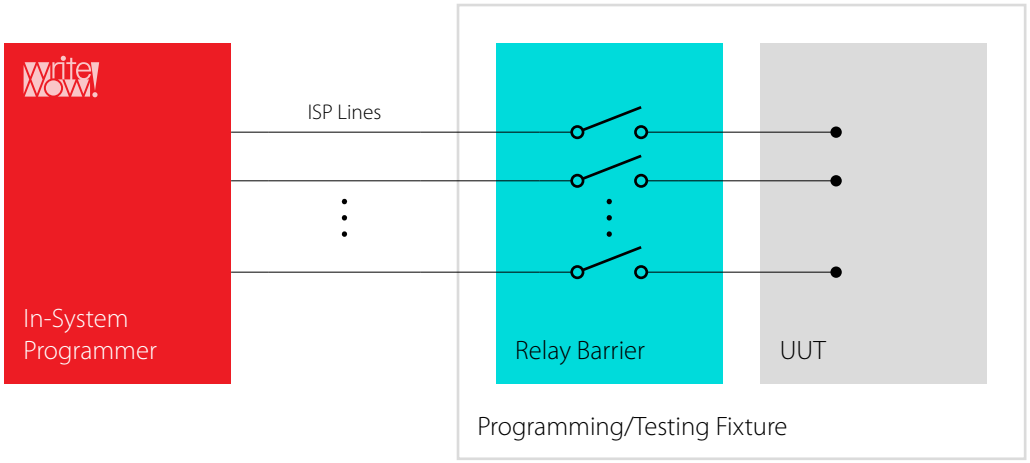

Fig. 3

Isolation of ISP Lines in Commercial Programmers

In-system programmers on the market employ two ways for obtaining high impedance on their ISP lines:

- Driving them to tri-state (using a solid state semiconductor like a line buffer);
- Using relays to disconnect them from the target system.

Driving ISP lines to tri-state (Fig. 4) is easier and cheaper to design than the relay approach. On the other hand, the high impedance obtained this way may not be enough to isolate it from the UUT. The Zeq impedance has a relevant parasitic capacitance component, in the order of 50-100pF, that may affect ICT measurements. The leakage current can easily be in the order of 1-5µA.

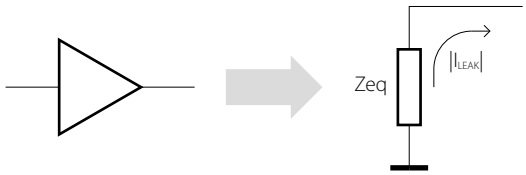

Fig. 4

Using relays helps keeping a higher Zeq impedance; in particular, the parasitic capacitance is lower than in the above approach (1-5pf), while the leakage current is 0. Some in-system programmers in the market (including the WriteNow! single-site programmer) have built-in relays; however, multiple-site in-system programmers do not have built-in relays.

Implementing a Relay Barrier on WriteNow! Programmers

The multi-site WriteNow! models (WN-PRG04A and WN-PRG08A) do not have built-in relays, but have nonetheless a dedicated line and software instructions for driving an external relay barrier that can therefore be easily added, as explained here in detail.

ISP Connector(s)

The ISP connector(s) have, for each programming site, a line dedicated to directly drive the coils of the external relays. Fig. 5 shows the two ISP connectors present in the 8-site WriteNow! version.

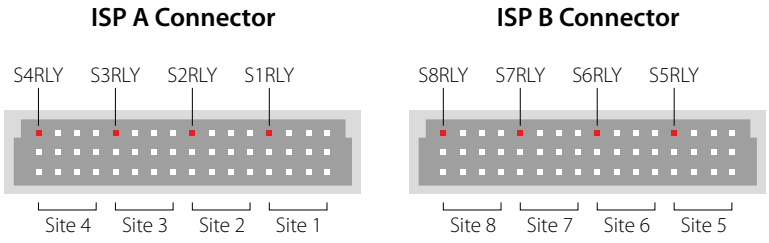

Fig. 5

SxRLY are open-drain lines with a weak internal pull-up to 5.5V. Each SxRLY line has a clamp diode, making it suitable for switching inductive loads, and can provide 500mA to the relay coil. Fig. 6 shows how to connect the external relay barrier. All ISP lines for a programming site are shown but, depending on the particular

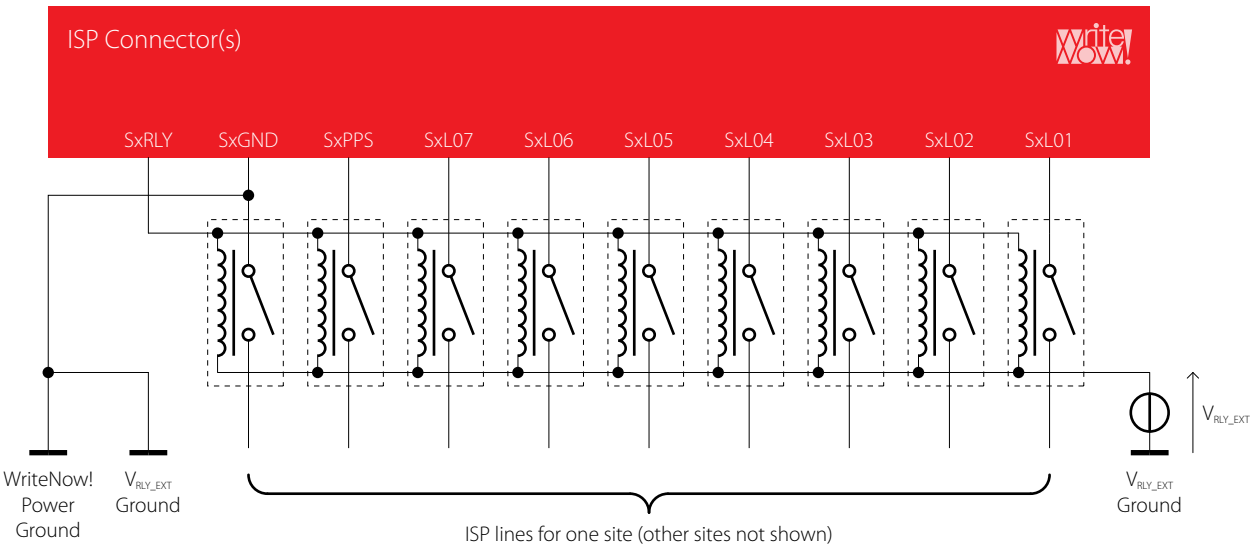

Fig. 6

case, only the actual lines used to program the DUP need to be connected. Note that even the SxGND line, that is the ground of the ISP site represented, goes through a relay. Usually this is not necessary, but in some circumstances, during the ICT or functional test, the ground potential of the UUT can not be "shared" with the programmer's ground. Also note that, although WriteNow! allows to drive the external relays through its dedicated SxRLY lines, an ATE can drive the relays by itself.

The VRLY_EXT voltage is usually the nominal voltage of the relays. External snubbers are not necessary, since each SxRLY features a built-in free-wheeling diode. However, it is up to the test engineer the use of external snubbers. The same goes for resistors to be placed in series to the relays coils; their presence and values depend on the relays chosen. Please note that SxRLY lines are not current limited.

Powering the Relay Barrier

The correct powering for the relay barrier must be chosen based on the nominal voltage of the relays and on the bias current necessary to drive them. The ground of the power supply of the relay barrier must be the same of that of the programmer. The two grounds must therefore be connected together. The ground of the programmer can be found on the SxGND line of any ISP site or on the C5 pin of the "Low-Level Interface"

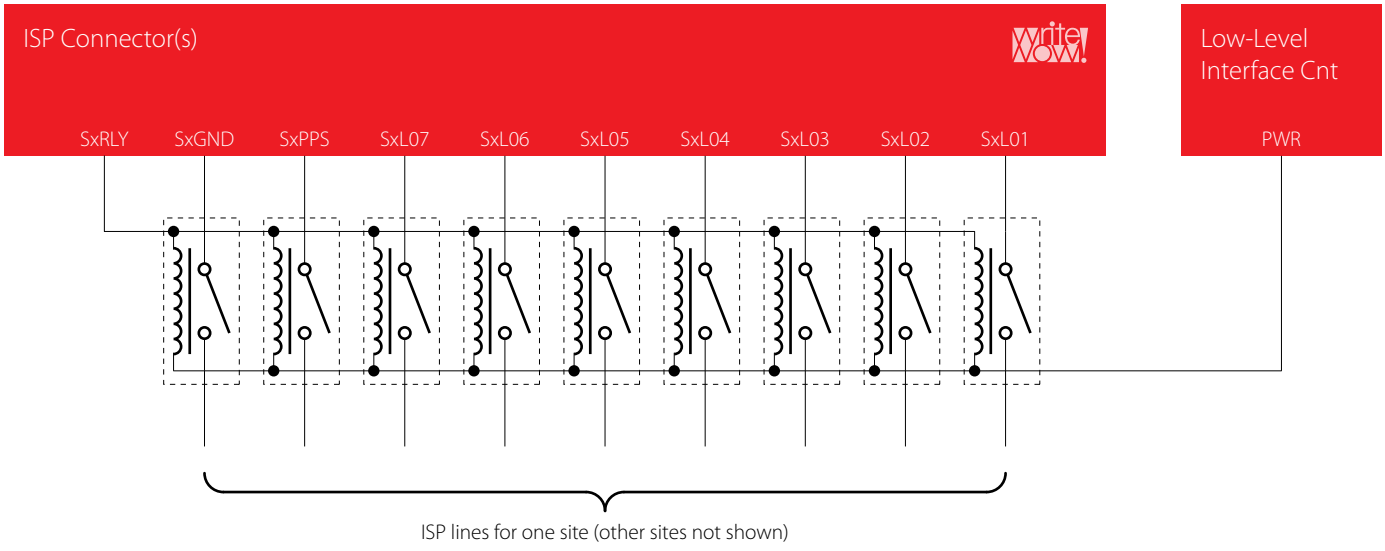

Fig. 7

connector, and is the same ground of the power plug.

If the WriteNow! supply voltage (15V when using the provided AC adapter) is adequate for powering the relay barrier, it is possible to use it instead of the external power supply. As Fig. 7 shows, in this case the power supply voltage for the relay barrier can be taken directly from the "Low-Level Interface" connector. When powering the relay barrier externally, make sure to power on WriteNow! before the relay barrier is powered on; and to power off the relay barrier before powering off WriteNow! Doing otherwise may cause a temporary malfunction of the instrument.

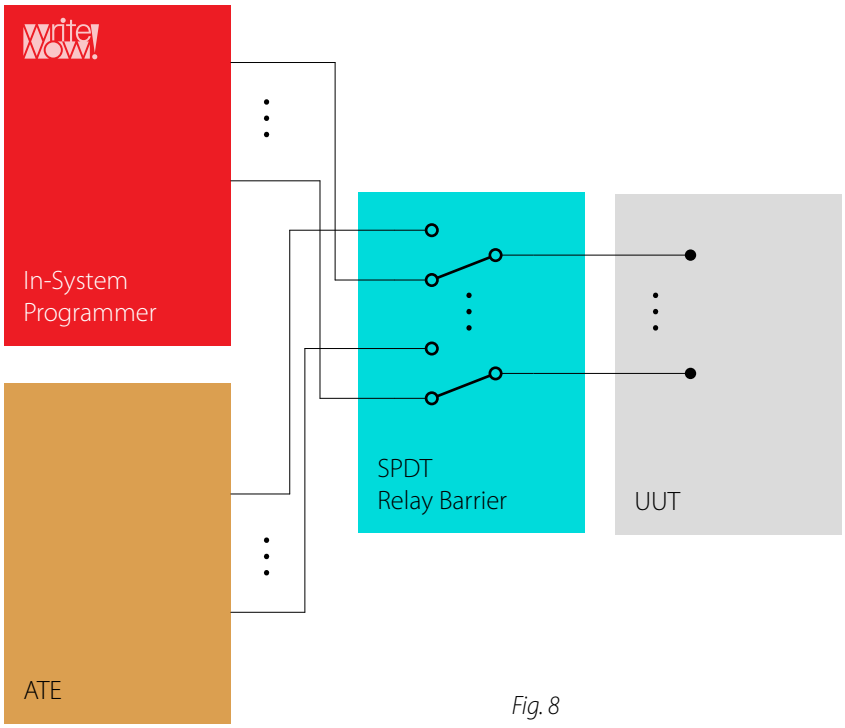

Fig. 8

The relays shown are SPST (Single Pole, Single Throw) relays, but SPDT (Single Pole, Double Throw) relays can be used instead—for example, when the ATE needs control over the ISP lines of the DUP, outside of the programming phase (Fig. 8).

In order to minimize cross-talk interferences generated by the parasitic capacitance of the relay contacts over long connection lines during the ICT phase, the relay barrier should be placed as near as possible to the bed of nails inside the fixture.

SxRLY Timing

The SxRLY lines on each of the enabled ISP sites are automatically driven by WriteNow! during programming (when creating a programming Project, the Project Generator utility automatically inserts the relay close and relay open commands at the beginning and end of the Project, respectively). The lines, which in idle are tied to 5.5V through a weak pull-up, are driven low (that is, to the ISP ground) about 50ms before the programming starts, and released at the end of programming (Fig. 9). Manual relay driving can be accomplished through the **`#relay -o open`** and **`#relay -o close`** commands.

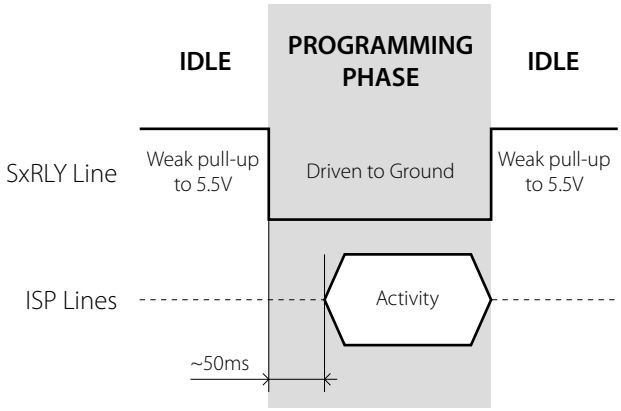

Fig. 9

Choosing the Right Relays

We suggest using relays that are specific for ATE. These relays offer a voltage drop between the contacts lower than 250µV. Carry current should be 600mA or higher. Working voltage for the coils must not exceed 25V, the maximum voltage rating for the SxRLY lines. Relays must not be of the latch type, since the SxRLY lines are bi-stable. The following table lists some suggested relays.

Manufacturer	Model	Description
Meder	SIL15-1A72-71D	15V coil, SPST, SIL package
Meder	SIL05-1C90-51L	5V coil, SPDT, SIL package
Tyco Electronics	V23100-V4505-A000	5V coil, SPST, SIL package
Tyco Electronics	V23100-V4312-C000	12V coil, SPDT, DIL package

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