Chroma Turnkey Test & Automation Solution Provider

APPLICATION NOTE

Guarding

Enhance DC Transmission Speed for very Low-current Measurement

Key Words: SMU, Guarding, Shielding, Guard, Force, Cable Capacitance, Settling Time, Measure Current, Charging Delay, very-low Current Measurement,

Product Family: Model 52400 series SMU (Source Measure Unit)

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Scope

Guarding- A technique that reduces **leakage current** error and decreases **settling time**. It keeps the potential of the guard connector at the same potential as the force conductor, so current does not flow between the force and guard conductors. It also eliminates the cable capacitance between source measure unit (SMU) and DUT for faster and accurate measurements. This document describes how to reduce settling time for very-low current measurement. For more information about leakage current, please refer to the related document: AN-52400-01V1.00.

Cable Capacitance & Charging Delay

Cable Capacitance is the capacitance between Shield and Force/Guard. If a charged conductor is close to the test circuit, that charge will attract or repel in the test circuit and cause momentary current flow.

However, the charging time required is related to the RC constant of the cable where the R is the isolation resistance and C is the cable capacitance. The charging of C yields the exponential curve shown in Figure-1. After one time constant (τ= RC), the measured voltage rises up to 63% of its final value; final values for various time constants summarized in Table-1.

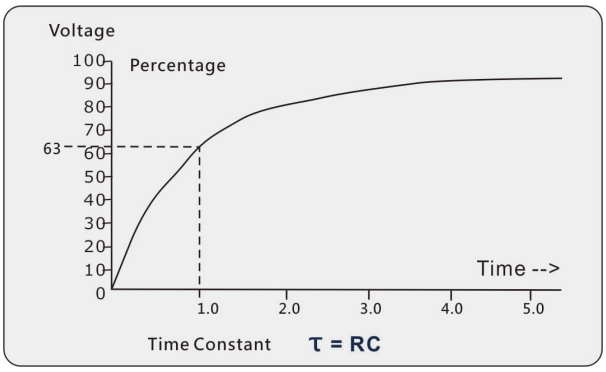


Figure-1 Exponential Response of Voltage across Capacitance

Time Constant (τ *)	Percent of Max. Value
1	63%
2	86%
3	95%
5	99.3%

Table-1 Settling Times to Percent of Final Value

*** τ =RC, where R=resistance (Ohms), C=capacitance (Farads)**

Example: Assume R = 1GΩ and C=1000pF. This combination results in an RC time constant of one second. Thus, it would take five second for the circuit to settle to within less than 1% of final value.

Reduce Charging Delay by Using Guarding

For SMU operates under current mode with very-low current (below 1 nA), a regular coax cable's capacitance dominates over the DUT (device under test) capacitance and has greatly impact to the settling time. What you see is cable charging current. I = C (dv/dt) where dv/dt is the rate of change of SMU voltage from one step to the next of a coax cable with no guard. C is the total capacitance of the cable.

Cable capacitance and shield surfaces between the SMU and DUT must be charged which will introduce an added current. The driven guard effectively eliminated the parasitic capacitance by isolating the signal line. Then, the guarding can be used to reduce the charging, the guard buffer significantly reduces the cable capacitance.

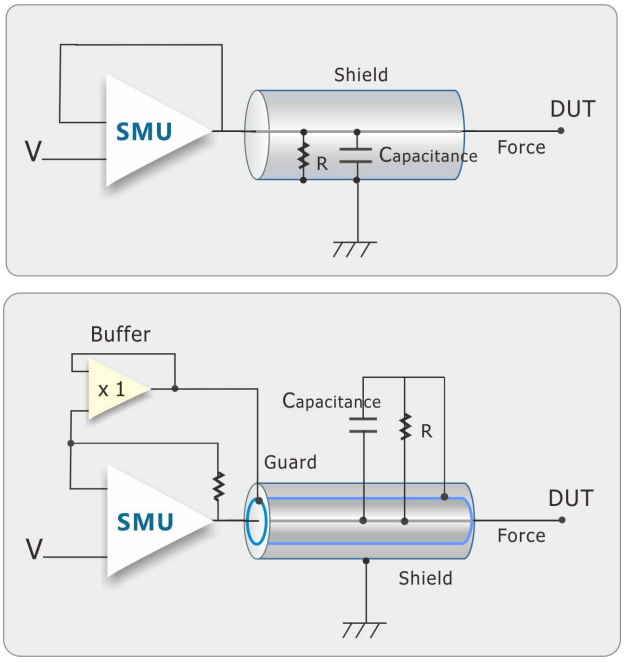


Figure-2 Guard Connection: Cable Capacitance is eliminated with Triaxial Cable

The Figure-2 shows how the cable capacitance is eliminated with a triaxial cable. The guard is driven at the same voltage as the force center conductor. The buffer amplifier (x1) keeps the potential of the guard connector at the same potential as the force conductor. Guard and force are isolated by the buffer amplifier. [NOTE: They CAN'T be shorted together].

Settling Time on Measurement Speed

It is important to consider the effect of both settling time and transient response on the accuracy of measurement. To ensure accurate measurements, sufficient settling time must be allowed for taking the reading.

Take an example of wafer chuck test. Due to big chuck surface, the chuck capacitance tends to be high and chuck isolated resistance tends to be low. For a standard check (none guarded), the settling time will be very long. Even when the chuck capacitor is charged, there is leakage current caused by the chuck resistance (detail please refers to AN-52400-01V1.00). This limits how low the current can be to meet application needs. In contrast, for a guarded chuck, the chuck capacitance can be eliminated with sufficient settling time with minimal leakage current (AN-52400-01V1.00). Therefore, with guarded chuck, the significantly lower leakage current enables to be use under very low current applications.

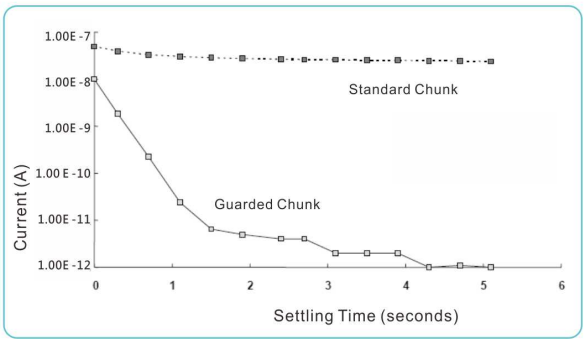


Figure-3 Guarding for IV Measurement Speed

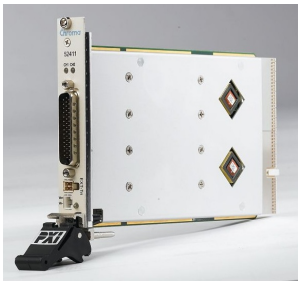
Figure-3 shows the relationship of a typical wafer chuck applied current and the settling time required for different current level. It can be clearly seen for standard chuck, it has limitation in how low the current can go (when leakage current is higher than applied current), While for guarded chuck, by giving sufficient settling time, we can push the applied current down to pico-Amp level or even lower.

Summary:

Guarding eliminates the cable capacitance and thus decreases the RC time constant or settling time of the measurement.

Chroma 5240 Series SMU

The Chroma 52400 family has two fully isolated SMUs allowing testing or measure; such as, FET or BJT IV sweeping. No additional piece of equipment is necessary. Kelvin remote sense connections for precise voltage/sense at the DUT as well as +/-Guard signal to suppress unwanted leakage current are available.



Model 52400 series SMU

Other features, such as hardware sequencer for precise output profile control, two isolated channels in one compact PXI slot are capable to meet most demanding test requirements.

For more detailed information about Chroma 52400 series SMU & other Chroma solutions, please visit Chroma's website at: www.chromaate.com

PXI™ Systems Alliance

www.pxisa.org

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