±500 Volt Protection Circuit

Introduction

A ±500V protection circuit for low voltage high impedance measuring instruments is shown in Figure 1. The protection is accomplished by limiting the amount of current going into the measuring instrument. The circuit will protect against destructive high voltages inadvertently connected to the probes (V_{MEAS}) of up to 500VDC of positive and negative polarity.

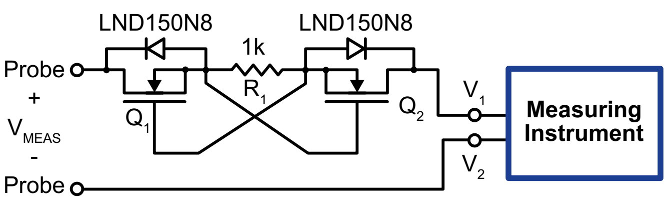

Figure 1

Circuit Description

The circuit consists of two transistors, Q_1 and Q_2, and one resistor, R. Both Q_1 and Q_2 are Supertex LND150N8, 500V N-channel depletion mode MOSFETs with gate-to-source ESD protection in a SOT-89 surface mount package. Q_1 and Q_2 are configured back-to-back as two constant current sources with a nominal value of 1.0mA. Resistor R sets the current limiting value. Figure 2 is a typical low voltage high impedance measurement instrument. Figure 3 is a simplified equivalent circuit showing the protection scheme.

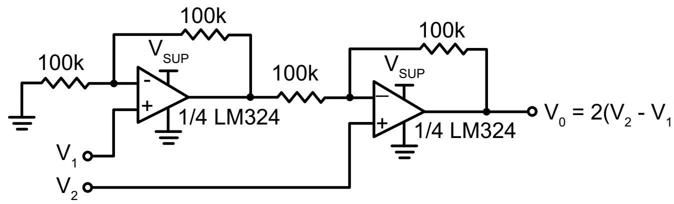

Figure 2

Under normal operation, the absolute value of V_{MEAS} is less than the supply voltage of the circuit. Q_1 and Q_2 will be fully on with a maximum guaranteed R_{DS} of 1.0kΩ. Since the instrument's input impedance is typically very high, say above 10MΩ, the additional 2.0kΩ series resistance from Q_1 and Q_2 will not affect measurement accuracy.

Under the fault condition, the absolute value of V_{MEAS} is greater than the supply voltage, Q_1 limits the current to 1.0mA against large positive voltages and Q_2 limits the current to -1.0mA against large negative voltages across V_{MEAS}.

For example, if V_{MEAS} is connected to ±500V, Q_1 and Q_2 will limit the input current to ±1.0mA causing the input voltage to the measurement instrument to clamp to 1.3V above its supply voltage (when R = 600Ω) and 0.7V below ground.

Typically the measuring instrument has ESD protection diodes connected from both probes to its power supply and ground. The ESD protection diodes can usually handle 1.0mA continuously. In case there are no ESD diodes provided, external diodes D_1, D_2, D_3, and D_4 can be added.

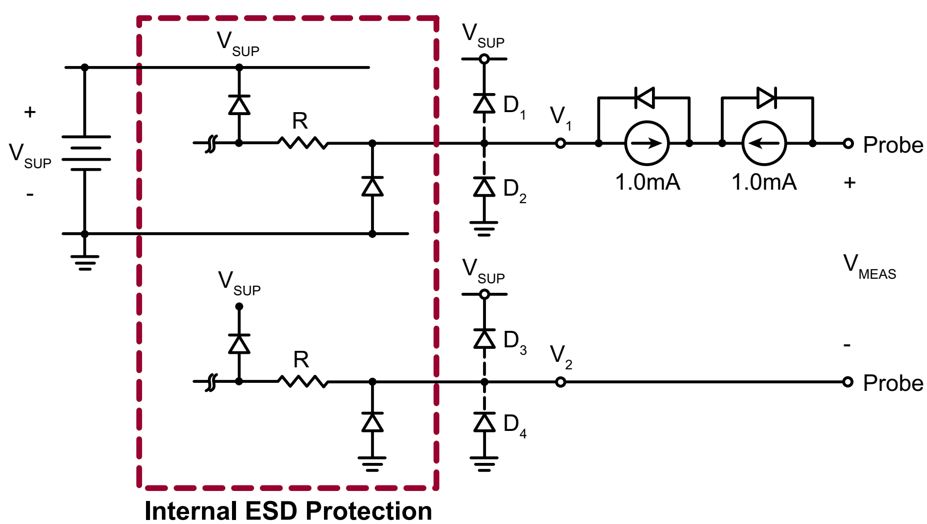

Figure 3

Calculation for Resistor Value

For a current limiting value of ±1.0mA, R can be approximated by the following equation:

$$R_1 = \frac{V_{GS(OFF)}}{I_D} \bullet \left(\sqrt{I_D / I_{DSS}} - 1 \right)$$

where,

I_D = *desired constant current value,*
$V_{GS(OFF)}$ = *pinch-off voltage, and*
I_{DSS} = *saturation current at* $V_{GS} = 0V$.

$V_{GS(OFF)}$ and I_{DSS} are device characteristics and will vary from lot to lot. Actual constant current values are not critical as long as the power dissipation of the LND1 is less than 600mW.

P_{DISS} = *600mW = (constant current value)(max. input voltage)*

Figures 4A and 4B are pictures of current due to V_{MEAS} vs. V_{MEAS} voltage of the actual circuit. R_1 was chosen to be 1.0kΩ.

Conclusion

The high voltage protection circuit is ideal for both bench measurement and handheld measurement instruments. It is simple, reliable and cost effective. It eliminates the possibility of input damage to very sensitive and expensive high impedance devices within the measurement instrument.

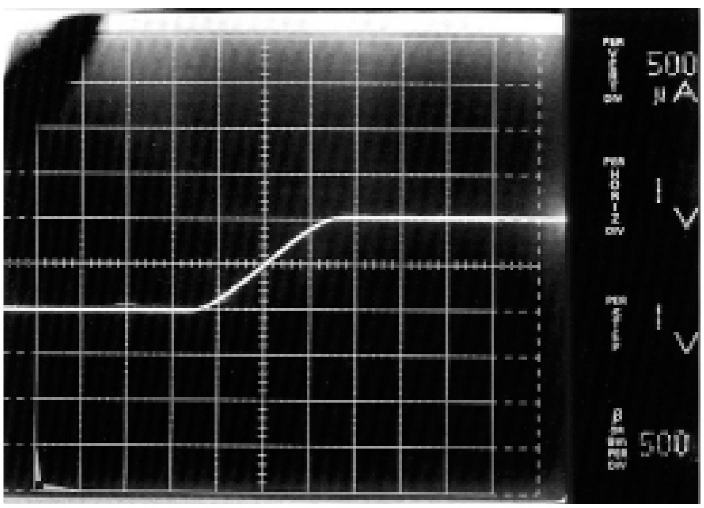

Figure 4A

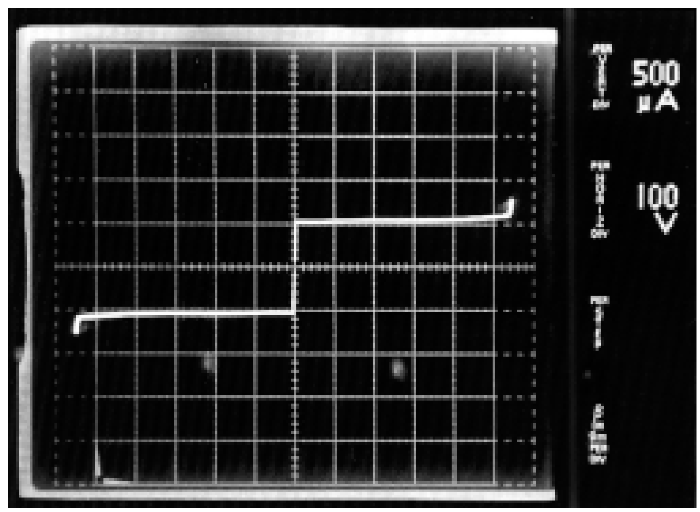

Figure 4B

Supertex inc.
1235 Bordeaux Drive, Sunnyvale, CA 94089
Tel: 408-222-8888
www.supertex.com