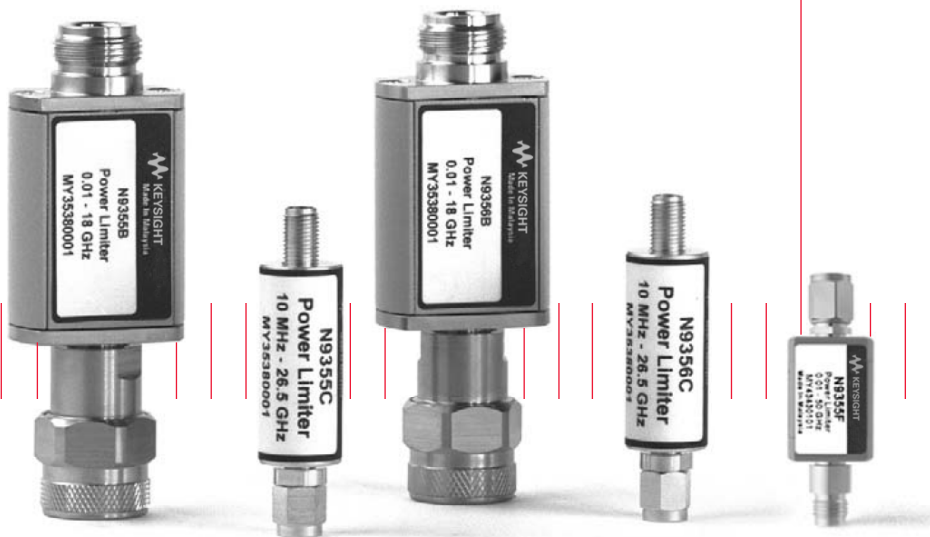


Keysight Technologies

N9355/6 Power Limiters

Application Note



Abstract

Many receivers are often at risk of having their front ends burned out by high power RF and microwave stray signals. The same applies for sensitive microwave components such as detectors, mixers and amplifiers. These instruments and devices are also easily damaged by electrostatic discharge (ESD). This paper outlines application considerations and the latest limiter technologies available from Keysight Technologies, Inc.

Introduction

Microwave and RF receivers, as well as many instruments and components are susceptible to damage from high power CW and pulsed microwave signals, with amplitudes exceeding certain danger levels. For some instruments, this danger level may be as low as one watt (+30 dBm). These types of sensitive instruments and components are traditionally protected by a power limiter. The limiter should have the following characteristics for maximum protection:

- Provide very low insertion loss to signals with amplitude below the limiting threshold
- Offer very high loss to signals which exceed the limiting threshold
- Possess very fast response time, providing protection within nanoseconds of the arrival of a damaging signal

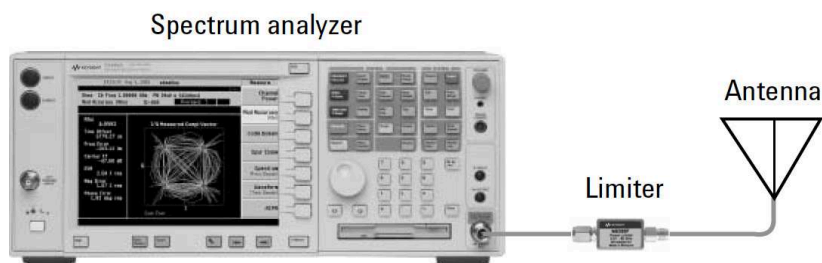


Figure 1. Typical application of power limiters

Limiter Basics

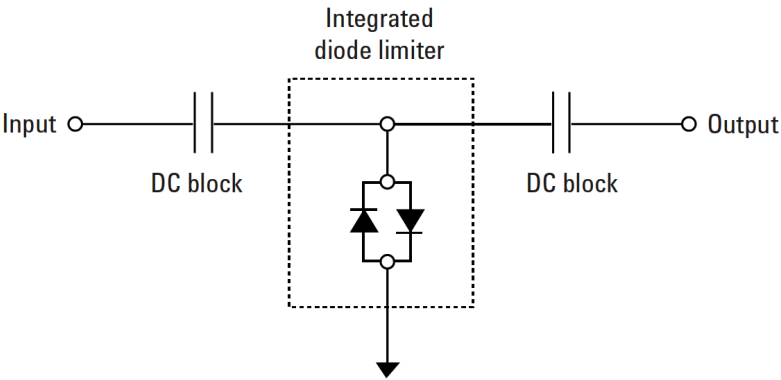


Figure 2. Block diagram for N9355 and N9356

The Keysight N9355/6 series of limiters consists of DC blocking capacitors at both input and output ports, and an integrated diode limiter circuit. The integrated circuit contains either Planar-Doped-Barrier (PDB) or Schottky diodes mounted in shunt across a 50 ohm transmission line.

For incoming signals which are below the limiting threshold in amplitude, the signal passes with relatively low power loss. Insertion loss and return loss (VSWR) are defined in this region. As the incident signal exceeds the limiting threshold power level, the RF power causes the integrated diode in the limiter to self-bias. This decreases the forward resistance of the diodes, and results in the incident signal being attenuated. The limiting threshold (or 1 dB compression point) is defined as the incident power level at which the output power level is attenuated by 1 dB, excluding transmission line losses.

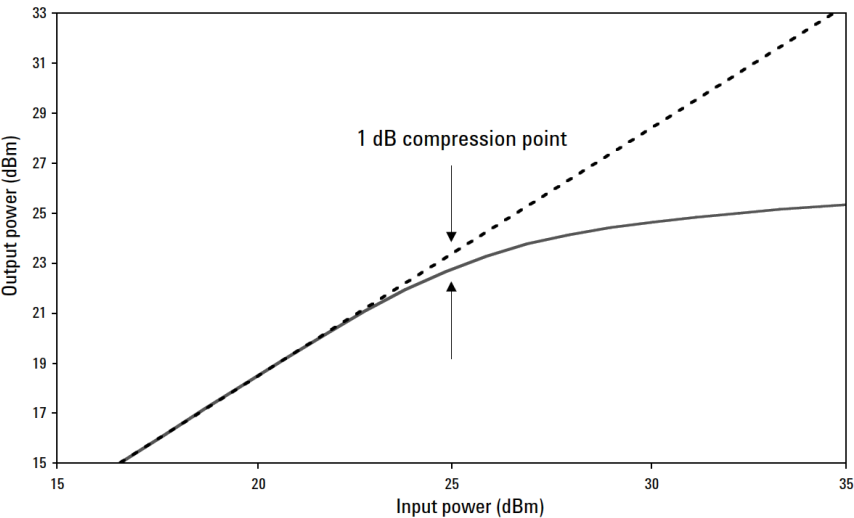


Figure 3. Typical limiting curve for N9356B

As the incident power level increases, the attenuation level also increases until the diodes reach their saturation point. Beyond this point, the limiter provides almost constant attenuation, and the output power level will begin to increase proportionally with the input power level until the diodes burn out. The input power level at which the diodes burn out is dependent on frequency, and it decreases with higher frequencies. Thus, the maximum power level of the N9355/6 limiters are specified at their highest frequency of operation. At lower frequencies, the maximum input power level will be higher.

With an RF input pulse, the output pulse is shown in Figure 4.

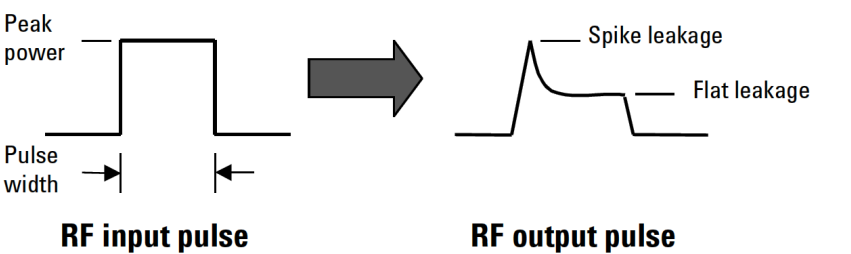


Figure 4. RF input pulse vs. RF output pulse

This is only true when the RF input pulse has a faster rise time than the turn-on time of the limiter. In the event when the limiter turns on faster than the rise time of the pulse, there will be no spike leakage, only flat leakage. The N9355/6 limiters have an extremely fast turn-on time of less than 100 ps, thereby also preventing any spike leakage from damaging the subsequent instrument or component it is protecting. Figure 5 and Figure 6 show the measured turn-on time of the N9355B/C and N9356B/C limiters, which is below 100 ps.

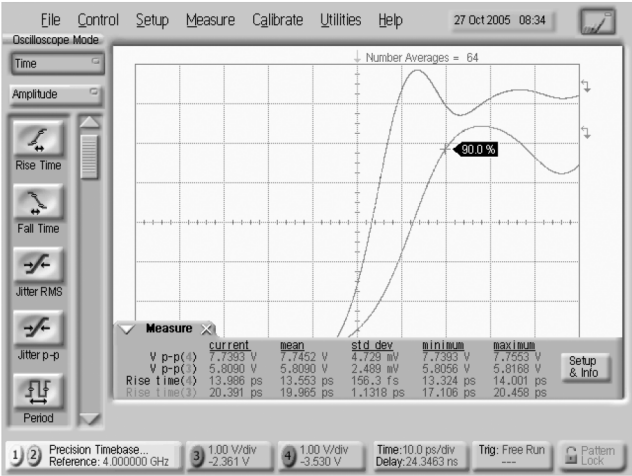


Figure 5. Turn-on time for N9356B/C

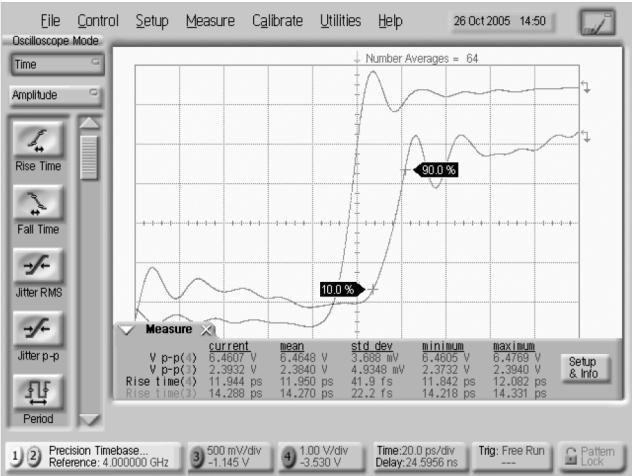


Figure 6. Turn-on time for N9355B/C

ESD

ESD is a high voltage pulse with a very fast rise time. Although very little energy is contained within an ESD pulse, the extremely fast rise time coupled with high voltage can cause failures in unprotected semiconductors inside instruments and devices. Catastrophic destruction can occur immediately as a result of arcing or heating. Even if catastrophic failure does not occur immediately, the device may suffer from parametric degradation, which may result in degraded performance. The cumulative effect of continuous exposure can eventually result in a complete failure. Figure 7 shows the ESD pulse waveform as specified in MIL-STD-883B (Human Body Model) method 3015.7. The rise time of the pulse is less than 10 ns, with the total duration of the pulse less than 500ns.

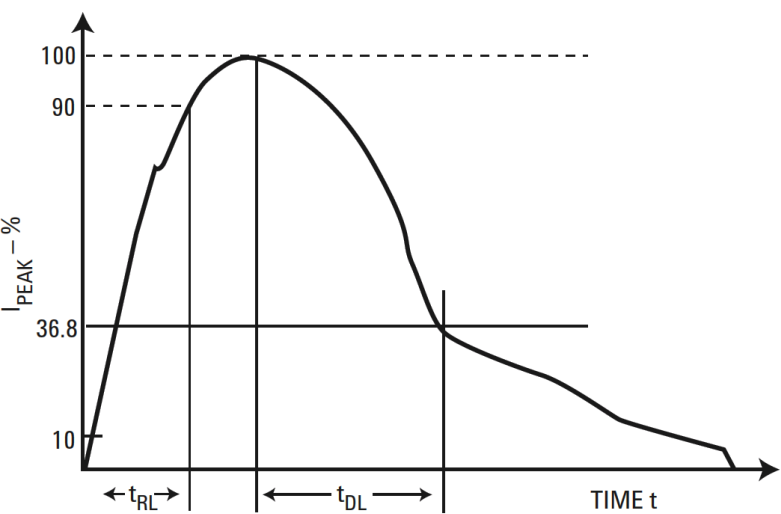


Figure 7. Human body model (MIL-STD-883B) ESD pulse waveform

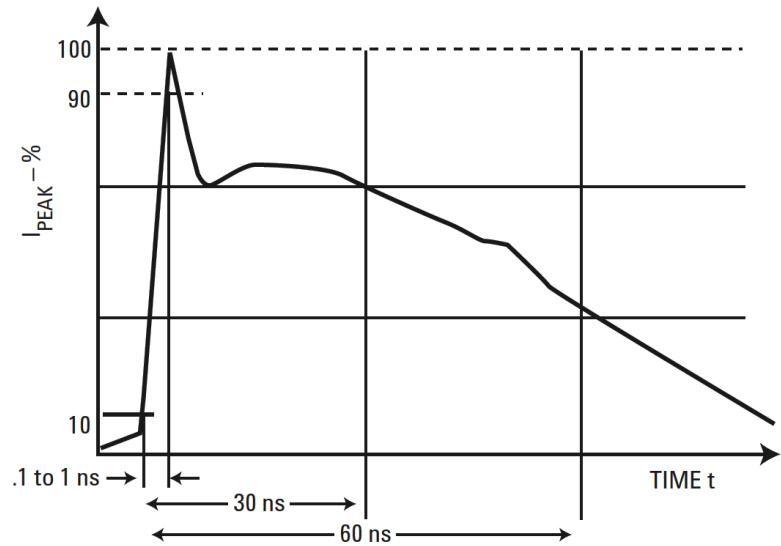


Figure 8. IEC61000-4-2 ESD pulse waveform

Figure 8 shows the ESD pulse waveform as described in IEC61000-4-2. The rise time of the pulse is less than 1 ns, with the total duration of the pulse less than 100 ns. Thus, any device that offers ESD protection must have a rise time of less than 1ns. The Keysight N9355/6 family of limiters all have a rise time of less than 100 ps, thus, offering some level of ESD protection in event of an ESD discharge. However, if the ESD discharge voltage is higher than the ESD susceptibility of the limiters, it is possible that the limiters will be permanently damaged

Related Product Literature

1) *N9355/6 Power Limiters* Technical Overview, literature number 5989-3637EN

2) *N9355/6 Power Limiter* Flyer, literature number 5989-3740EN

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