Single Event Testing of the IS-1009RH Voltage Reference

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Introduction

The intense heavy ion environment encountered in space applications can cause a variety of transient and destructive effects in analog circuitry, including single-event latchup (SEL), single-event transient (SET) and single-event burnout (SEB). These effects can lead to system-level problems including disruption and permanent damage. For reliable space system operation, these components have to be characterized as to their SEE response, with specific design changes if needed. This report discusses the results of single-event effects (SEE) testing of the IS-1009RH Voltage Reference.

Product Description

The IS-1009RH is a monolithic precision voltage reference fabricated using the Intersil Corporation dielectrically isolated EBHF process. The process features complementary bipolar devices and laser-trimmable NiCr thin film resistors, making it well suited for reference applications. The device is single-event latchup (SEL) immune by construction and is hardened to a total dose level of 300krad(Si). The DI process enables vertical PNP and NPN devices, resulting in greatly improved enhanced low dose rate effects (ELDRS) performance.

Functionally, the IS-1009RH is a 2.5V shunt regulator designed to provide a stable 2.5V reference over a wide current range. It operates at a lower minimum current level than commercial 1009 types and features 0.2% reference tolerance achieved by on-chip laser trimming. An adjustment terminal is provided for calibration of system errors.

SEE Test Objectives

This device was tested for single-event transient (SET), single-event latchup (SEL) and single-event burnout (SEB) in order to validate its design and construction, and determine any SEE-related applications restrictions.

SEE Test Procedure

Testing was conducted at the Texas A&M University Cyclotron Institute heavy ion facility. This facility is coupled to a K500 super-conducting cyclotron and is

capable of providing a wide range of test particle fluxes and energies for advanced radiation testing.
Figure 1 shows the schematic of the test fixture used to test the IS-1009RH. The fixture enables selection of device bias and output filtering. For this testing sequence we used gold (Au) at a linear energy transfer (LET) of 80MeV/mg/cm^2 and a fluence of 1x10^6 p/cm2 for investigation of both destructive and transient effects.

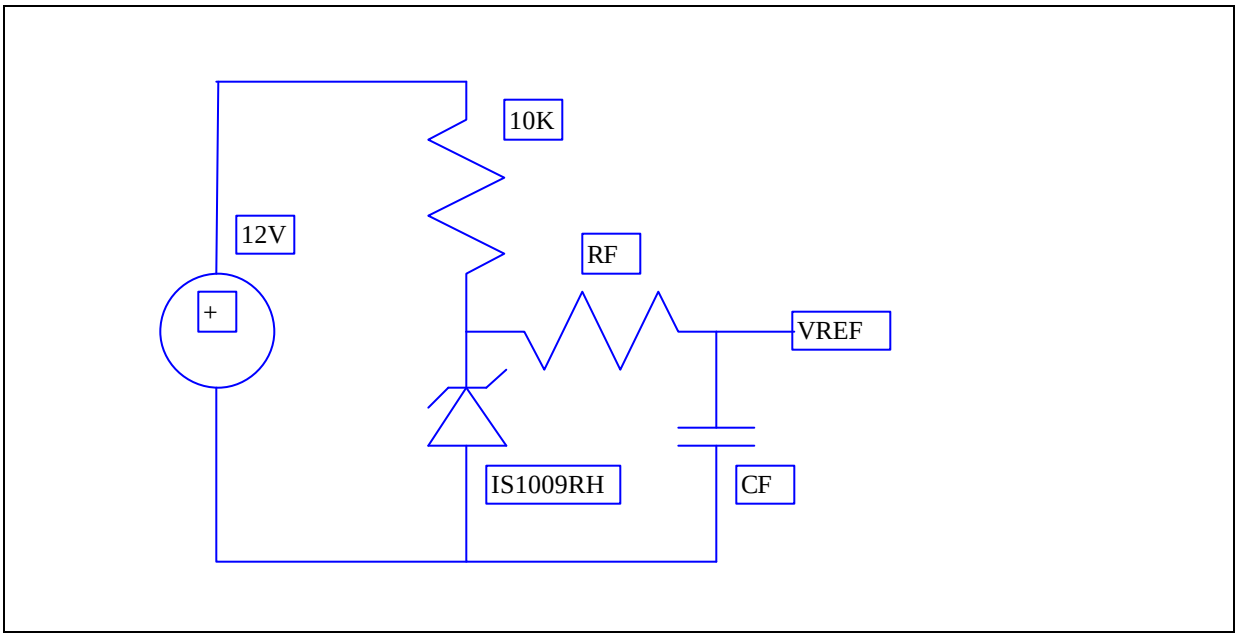

Figure 1: SEE test fixture schematic.

SEE Testing Results

An initial run was made with the filter resistor RF at zero ohms and with the filter capacitor CF removed. In Figure 2 we show the fixture output voltage of 2.5V with no particle flux applied. Figure 3 shows the part's response under Au irradiation at LET=80MeV/mg/cm^2, with no external filtering of the output. The reference voltage was significantly perturbed from its steady-state value. Counts of 363 to 445 pulses were recorded at the test fluence of 1x10^6 p/cm2 for an approximate cross section of 4x10^{-4} cm^2. Most of the transients observed were narrow pulses, but a significant number were full-scale deflections stretched out by saturation effects in the device. Both positive- and negative-going output pulses were observed, with negative ones predominating. Transient effects observed ranged from 10 nanoseconds to 50 microseconds.

A series of runs was then made for several combinations of output filter components. The use of such filtering is a common SET mitigation technique for voltage references, which are DC parts in which fast AC response is not of great

importance. RC combinations investigated and the corresponding responses of the voltage reference for each set of filter conditions are outlined in Table 1.

Filter Resistor	zero	1 Kohm	1 Kohm	10 Kohm	zero	zero
Filter Capacitor	none	0.01uF	0.1uF	0.01uF	10uF	100uF
Maximum Error	2V	1.5V	zero	zero	500mV	500mV
Maximum Pulse Width	45usec	60usec	NA	NA	<10ns	<10ns

Table 1: Filter combinations evaluated during testing.

In Figure 4 we show device response with the 1000 ohm / .01 microfarad external network; this improves the error term, but stretches out the recovery to 60 microseconds. Further improvement (Figure 5) is provided by the second filter combination; here, the error voltage nearly disappears, as it does in the third filter combination (Figure 6). Finally, we show the results (Figures 7 and 8) for capacitive-only filtering, in which we see a moderate error term of 500mV and very quick recovery.

Destructive effects or latchup were not observed during any of these tests, nor did the reference voltage show any permanent change.

Conclusions

The IS-1009RH voltage reference was tested at the highest LET available at the TAMU facility (LET=80MeV/mg/cm^2, Au ions) and was found to be free of destructive latchup and burnout effects. The part was found to display single-event transient (SET) effects at this LET, with the magnitude of the SET pulse dependent on the external filter parameters. These SET effects introduce an applications dependence; in most cases the reference will be used to drive a buffer amplifier, and this enables the use of significant resistance in the output RC filter, thus reducing the SET pulse to a few millivolts.

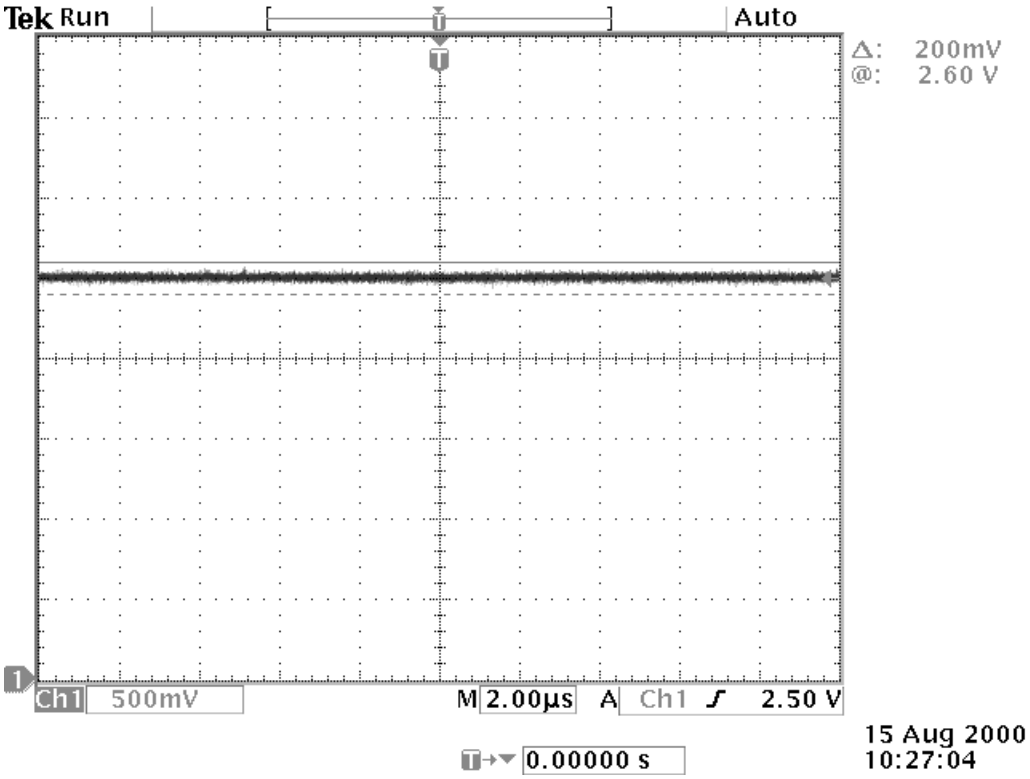

Figure 2: Reference with no particle flux.

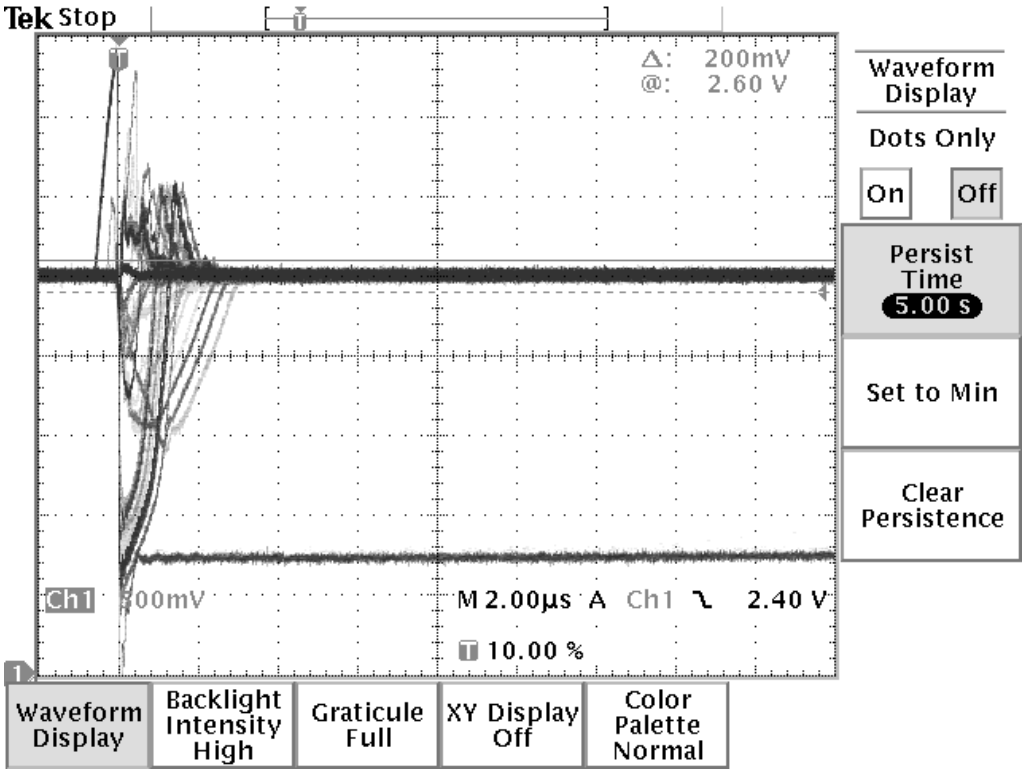

Figure 3: Bare reference, LET=80 Au ions.

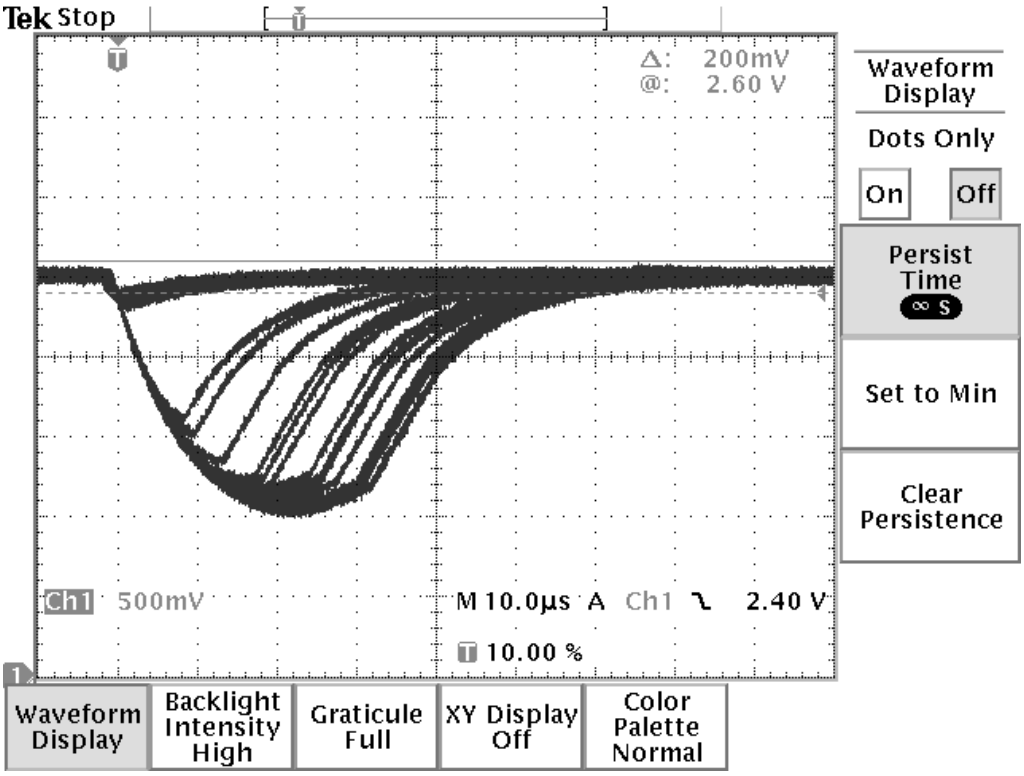

Figure 4: 1Kohm / 0.01uF external filter network. Error max width increases to approx. 60us, error max voltage decreases to -1.5V.

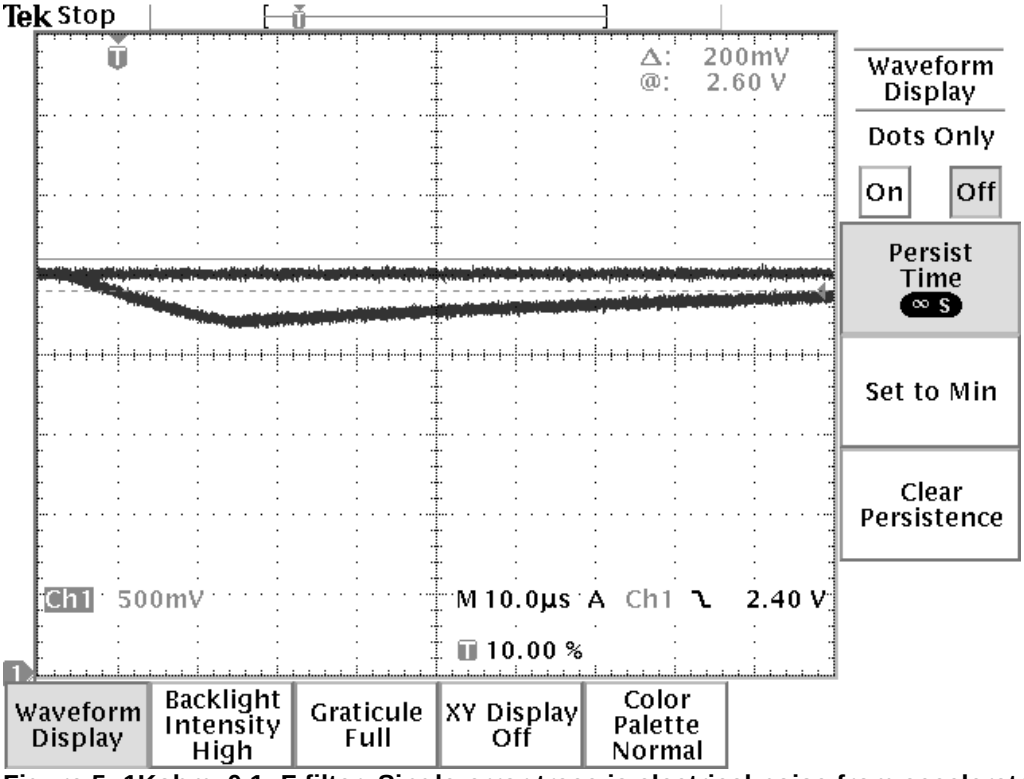

Figure 5: 1Kohm, 0.1uF filter. Single error trace is electrical noise from accelerator shutter electronics. No SEE transients observable exceeding initial accuracy window.

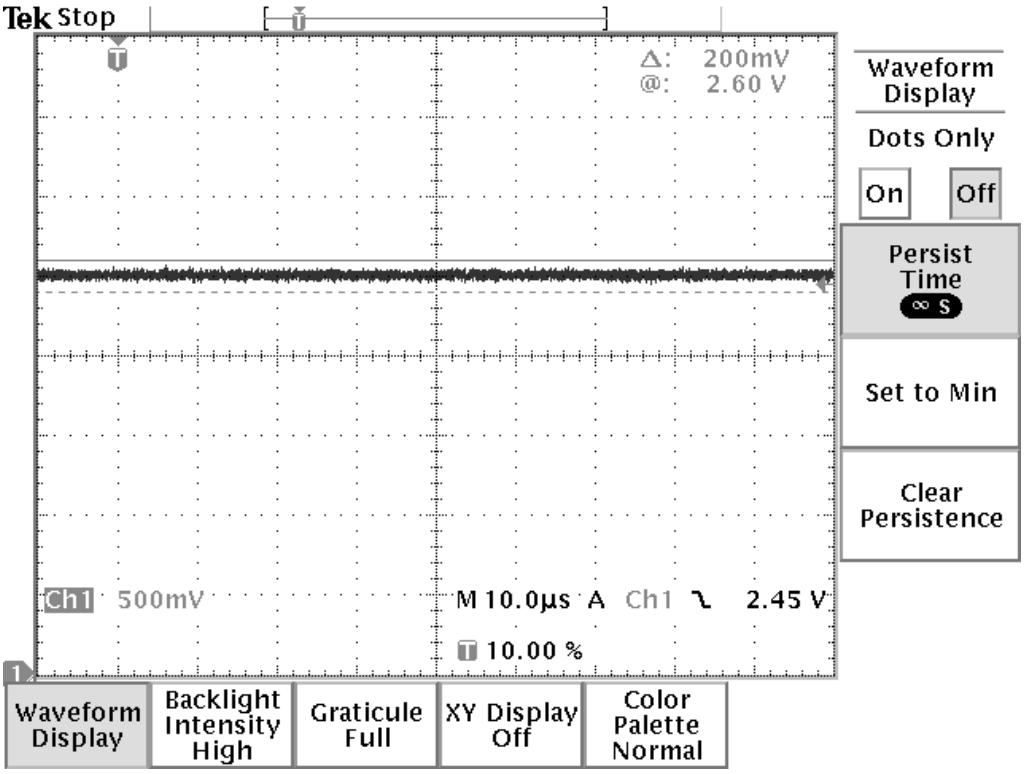

Figure 6: 10Kohm, 0.01uF filter. Acquire started after beam shutter open, no visible transients.

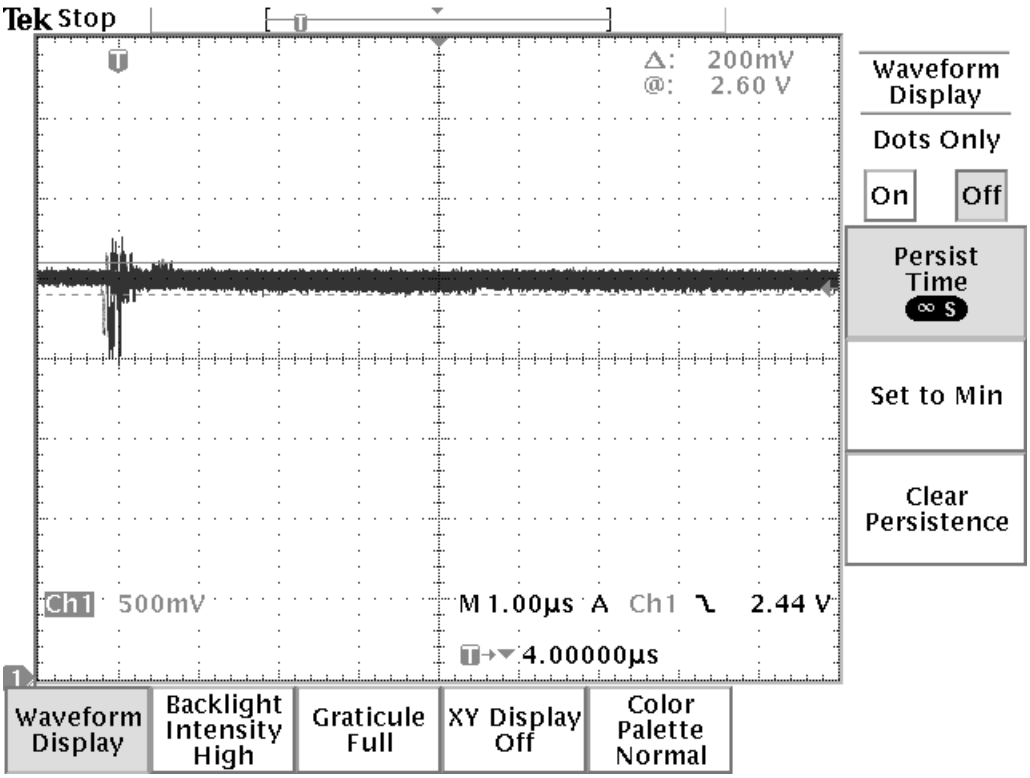

Figure 7: 10uF bypass capacitor (Ta). 500mV, few-ns glitching observed. Believe capacitor ESR inadequate to suppress reference output current spike entirely.

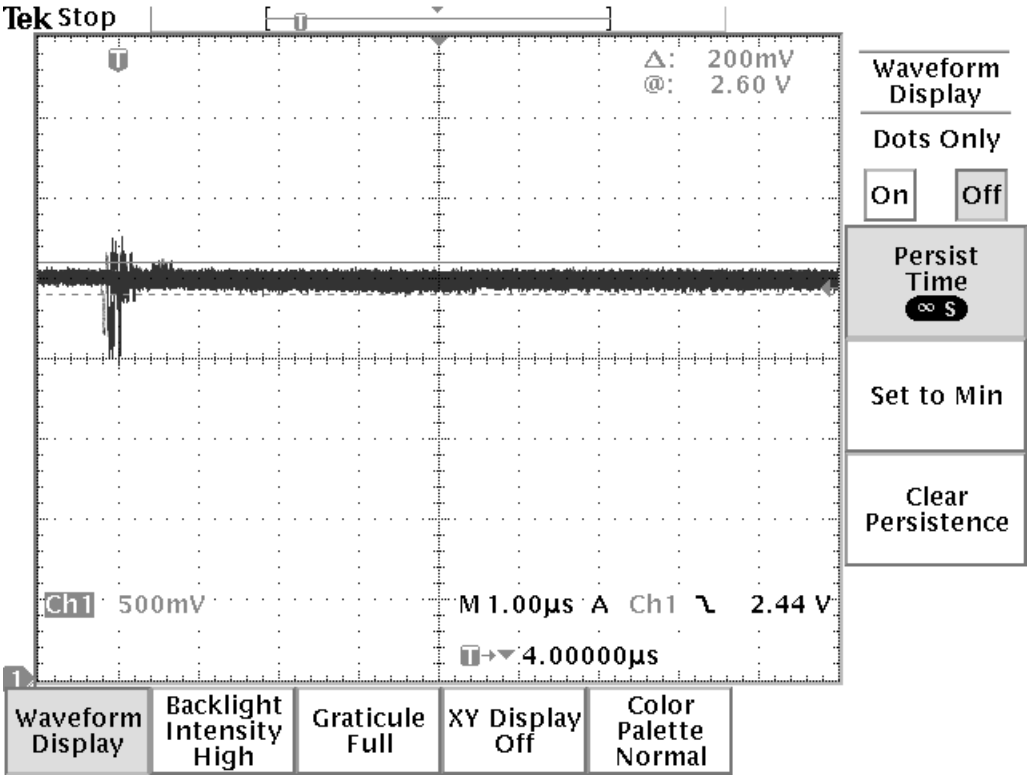

Figure 8: 100uF bypass cap (Ta). 500mV output spikes, capacitor ESR provides limited impulse suppression.