Technical Note

Proper Bias-T Usage to Avoid PPG Damage

Signal Quality Analyzer-R MP1900A
Signal Quality Analyzer MP1800A

Contents

1. Introduction

It is sometimes necessary for chip / module vendors to bias devices under test (DUTs) using an external Bias-T. These useful tools provide a dynamic method for engineers to vary both RF and DC conditions applied to the input of their DUTs. However, both simulations and empirical data have demonstrated that voltage transients can be produced under certain conditions that may be damaging to PPG outputs.
This document offers several recommendations by Anritsu's R&D team for the safe usage of Bias T's with Anritsu PPGs.

2. Precautions for using Bias-T

Figure 1 illustrates a typical Bias-T application with a Pulse Pattern Generator (PPG) driving the DUT.

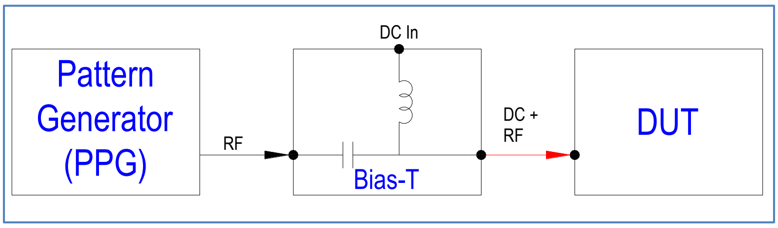

Figure 1. Typical Bias-T Usage

The voltage transients are likely to occur if the connection at the Bias-T's **DC+RF** port (the red connection in Figure 1) is shorted to ground while DC is being applied to the **DC In** port. The likelihood of this accidental occurrence may be greater if a probe is being used to make the red connection rather than typical coaxial connections, although it is still possible to short the center pin while making a coaxial connection. Simulations have also determined that excessive transients are also possible even when a separate DC block is used between the Bias-T and the PPG output.

Anritsu strongly recommends the following precautions be taken when using Bias-T's at PPG outputs for biasing DUTs:

I. **If possible, add series resistance between the power supply and Bias-T DC input to avoid / reduce possible voltage transients.**

II. **Set the current compliance level on the Bias-T power supply to a level suitable for the DUT.**

III. **Keep the Bias-T power supply turned OFF while connections are being made the between the PPG, Bias-T and the DUT.**

IV. **Turn the Bias-T power supply ON ONLY AFTER all connections to the measurement system have been established.**

V. **Turn the Bias-T power supply OFF BEORE DISCONNECTING the PPG, Bias-T or the DUT.**

3. Simulation Data

This model's objective was to reveal the voltage and current transients potentially seen by PPG output when the probe in the simulation is shorted to ground. This shorting action represents the inadvertent situation where a connection to the DUT is being attempted while DC power is being applied to the Bias-T's **DC In** port.

Model Elements (Figures 2 & 3):

- PPG output is represented by a 50Ω resistor
- DUT input is represented by a 50Ω resistor
- Bias-T RF capacitor is 0.1 uF
- Bias-T DC network is 1000 uH inductor in series with 6Ω series resistance
- Bias-T DC input is 0.5 V (without series resistor) and 1.0 V (while using series resistor)
- A switch is used to simulate shorting the DC+RF connection of the Bias-T to ground

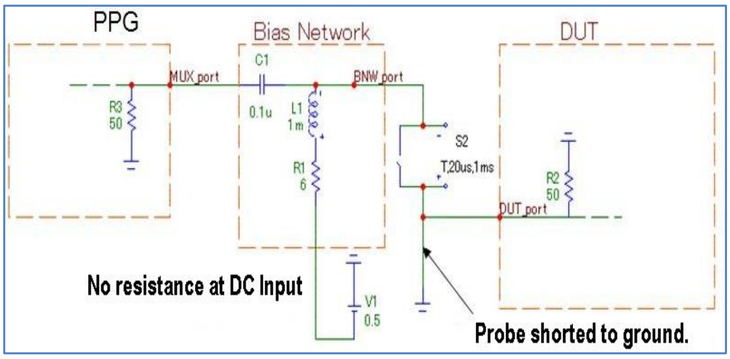

Figure 2. Model with no resistance at Bias-T DC In

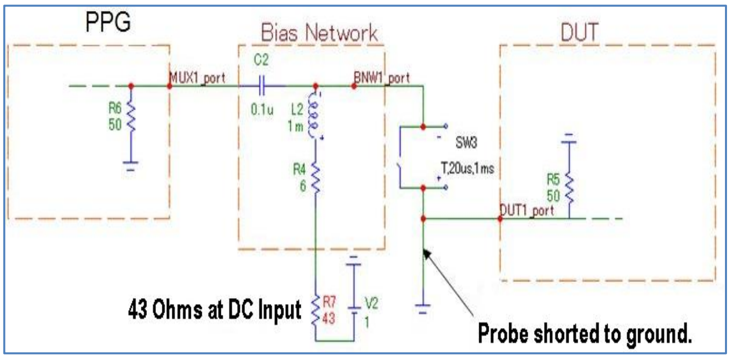

Figure 3. Model with 43Ω at Bias-T DC In

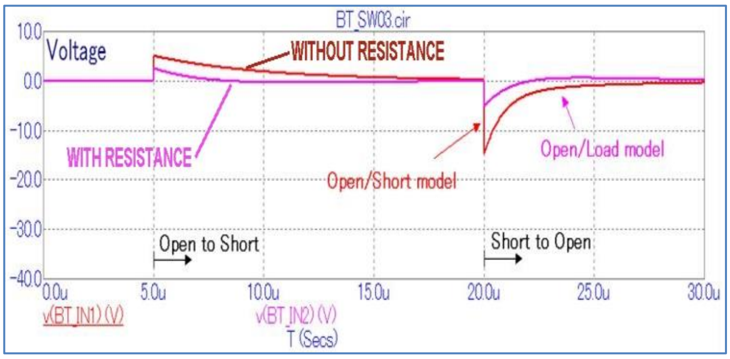

Figure 4. Simulated voltage at PPG output

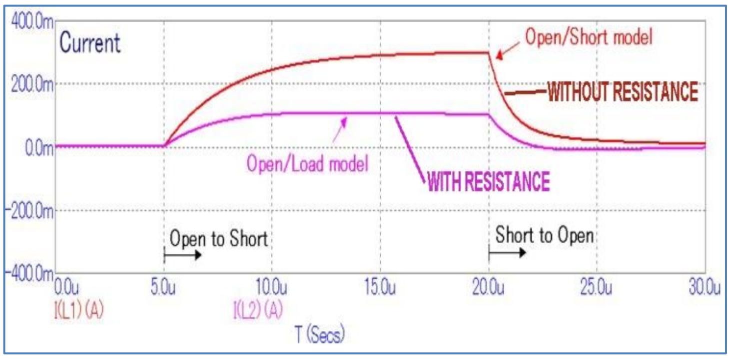

Figure 5. Simulated current at PPG output

Figures 2 and 3 show the modeled circuit with (2) and without (3) an external resistor at the Bias-T's **DC In** port. The simulated behavior of these circuits provided in Figures 4 and 5 show a significant difference between the magnitude of transients **with resistance** and **without resistance** applied at the Bias-T's **DC In** port. Similar observations were made for both voltage and current transients. Without resistance, the PPG is exposed to a potentially damaging voltage transient exceeding -10V. Simulations show that the magnitudes of the voltage and current transients are reduced by applying external series resistance to the Bias-T's **DC In** port, even when DC supply has been increased to compensate for the drop across the resistor.

4. Empirical Data

The same circuit as shown in the model was implemented on the bench during an attempt to reproduce the simulation data. The block diagram of this setup is shown in Figure 6. The actual implementation is shown in Figure 7.

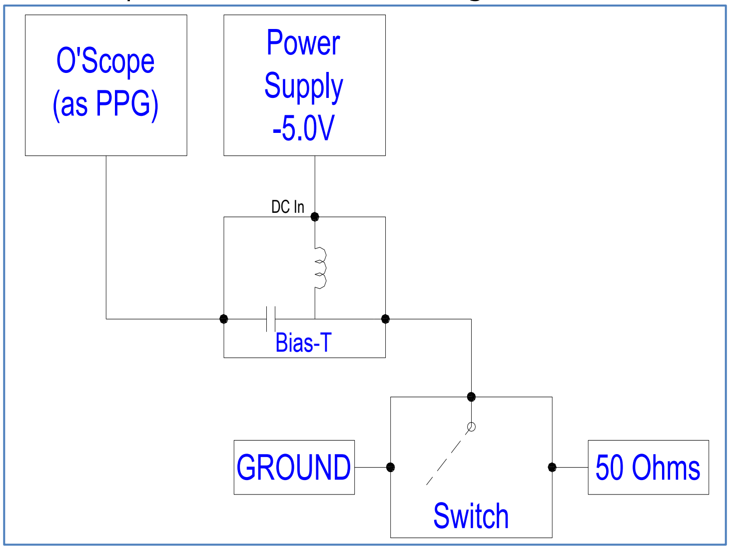

Figure 6. Bench setup block diagram

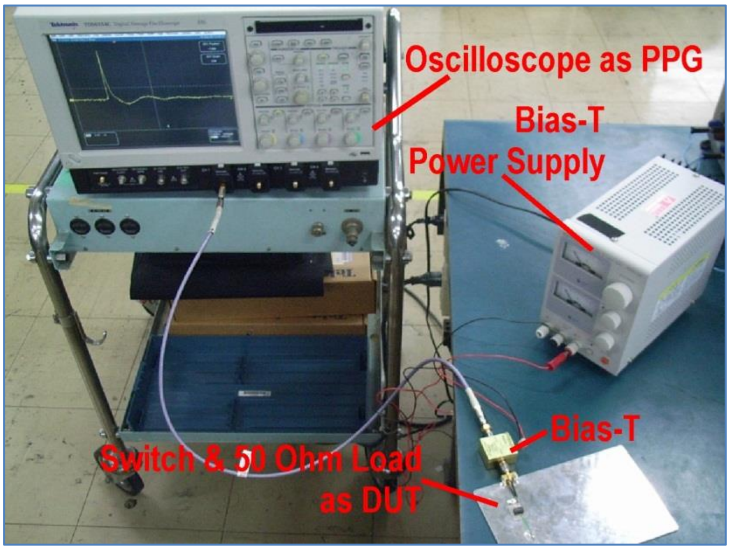

Figure 7. Bench setup photo

In this test system, the 50Ω input of the O'Scope represents the 50Ω output of a PPG. This simplifies the setup and allows the O'Scope to trigger on and observe the same transients that would otherwise appear at the PPG output. The screen captures below reveal the induced transients when the output is switched from open to short (Figure 8) and from short to open (Figure 9) while DC is being applied to the Bias-T's **DC In** port.

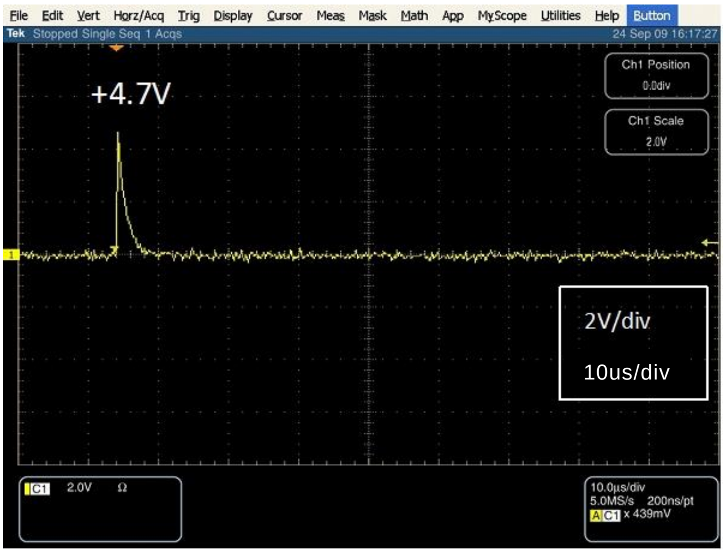

Figure 8. Probe OPEN to SHORT

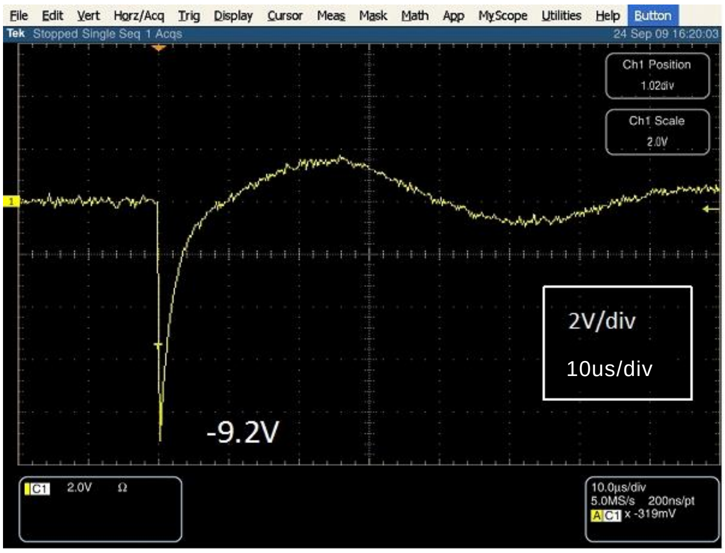

Figure 9. Probe SHORT to OPEN

It should be noted that transients will also occur even when going from an open state to a 50Ω condition while DC is applied to the Bias-T's **DC In** port. This would represent a condition when the Bias-T's **DC+RF** port makes a direct connection to the DUT input without accidentally shorting to ground first. The following screen captures reveal the induced transients when the Bias-T output is switched from open to 50Ω (Figure 10) and from 50Ω to open (Figure 11) while DC is being applied to the Bias-T's **DC In** port.

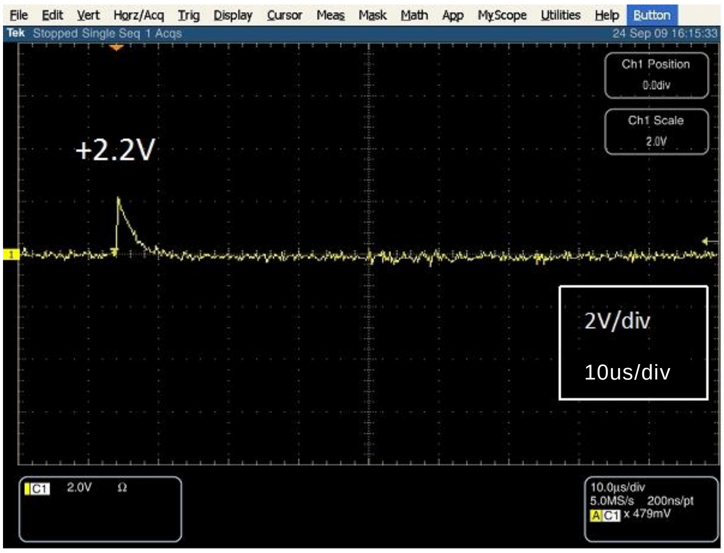

Figure 10. Probe OPEN to 50Ω

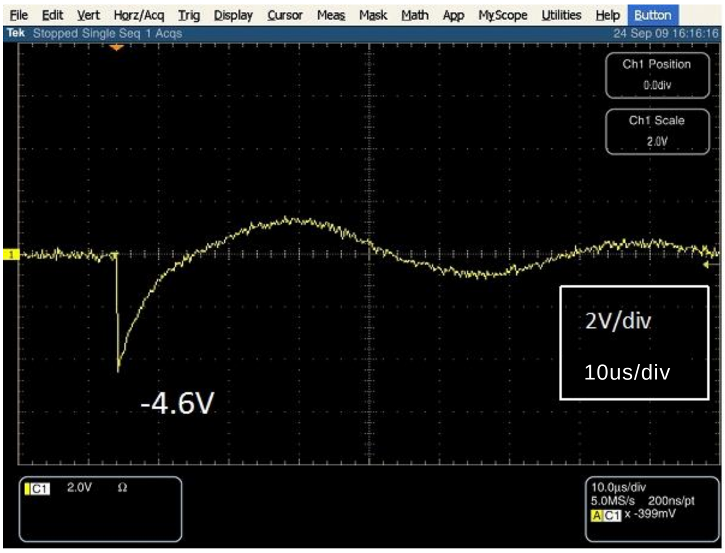

Figure 11. Probe 50Ω to OPEN

5. Conclusion

Based on the simulation and test results, a potential difference is caused by the Bias-T inductor due to changes in the current flow. Because the Bias-T capacitor's reactance is small compared to 50Ω, the potential is generated at the PPG output. This voltage can be excessive if the current fluctuation is sufficiently large. The possibility of PPG output damage exists if the PPG's absolute maximum ratings are exceeded during such an event.

To avoid potential PPG damage, Anritsu recommends that users take the necessary precautions as outlined on page 1 of this document when using Bias-T's.

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