APPENDIX D

Measuring Probe-Oscilloscope Response

Verifying the rise time limit of wideband test equipment set-ups is a difficult task. In particular, the end-to-end rise time of oscilloscope-probe combinations is often required to assure measurement integrity. Conceptually, a pulse generator with rise times substantially faster than the oscilloscope-probe combination can provide this information. Figure D1's circuit does this, providing a 1ns pulse with rise and fall times inside 350ps. Pulse amplitude is 10V with a 50Ω source impedance. This circuit, built into a small box and powered by a 1.5V battery, provides a simple, convenient way to verify the rise time capability of almost any oscilloscope-probe combination.

The LT1073 switching regulator and associated components supply the necessary high voltage. The LT1073 forms a flyback voltage boost regulator. Further voltage step-up is obtained from a diode-capacitor voltage step-up network. L1 periodically receives charge and its flyback discharge delivers high voltage events to the step-up network. A portion of the step-up network's DC output is fed back to the LT1073 via the 10M, 24k divider, closing a control loop.

The regulator's 90V output is applied to Q1 via the 1M-2pF combination. Q1, a 40V breakdown device, non-destructively avalanches when C1 charges high enough. The result is a quickly rising, very fast pulse across R4. C1

discharges, Q1's collector voltage falls and breakdown ceases. C1 then recharges until breakdown again occurs. This action causes free running oscillation at about 200kHz.[1,2] Figure D2 shows the output pulse. A 1GHz sampling oscilloscope (Tektronix 556 with 1S1 sampling plug-in) measures the pulse at 10V high with about a 1ns base. Rise time is 350ps, with fall time also indicating 350ps. There is a slight hint of ring after the falling edge, but it is well controlled. The figures may actually be faster, as the 1S1 is specified with a 350ps limit.[3]

Q1 may require selection to get avalanche behavior. Such behavior, while characteristic of the device specified, is not guaranteed by the manufacturer. A sample of 50 Motorola 2N2369s, spread over a 12 year date code span, yielded 82%. All good devices switched in less than 650ps. C1 is selected for a 10V amplitude output. Value spread is typically 2pF-4pF. Ground plane type construction with

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Note 1: This method of generating fast pulses borrows heavily from the Tektronix type 111 Pretrigger Pulse Generator. See References 8 and 25.

Note 2: This circuit replaces the tunnel diode based arrangement shown in AN13, Appendix D. While AN13's circuit works well, it generates a smaller, more irregularly shaped pulse and the tunnel diodes have become quite expensive.

Note 3: Just before going to press the pulse was measured at Hewlett-Packard Laboratories with a HP-54120B 12GHz sampling oscilloscope. Rise and fall times were 216ps and 232ps, respectively. Photo available on request.
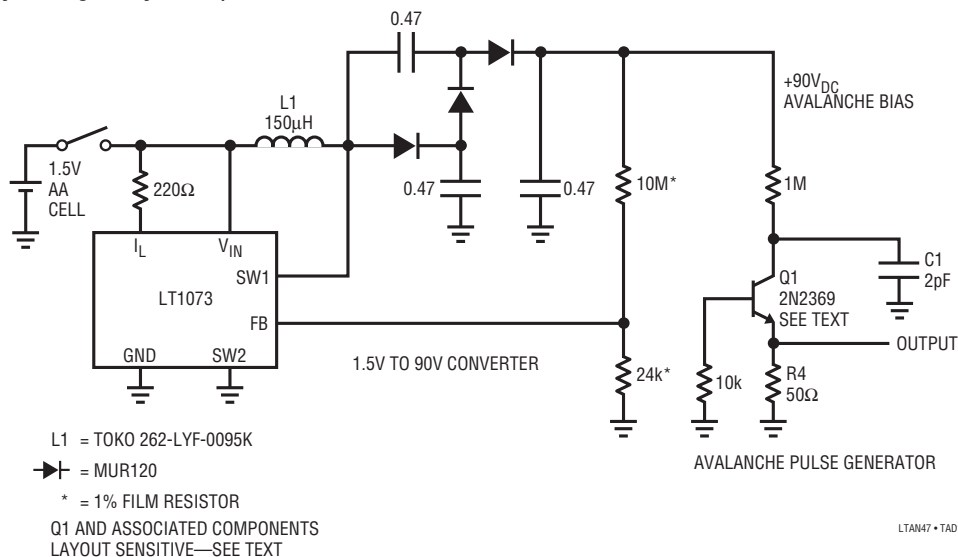

L1 = TOKO 262-LYF-0095K
➤ = MUR120
* = 1% FILM RESISTOR
Q1 AND ASSOCIATED COMPONENTS
LAYOUT SENSITIVE—SEE TEXT

LTAN47 • TAD1

Figure D1. 350ps Rise/Fall Time Avalanche Pulse Generator

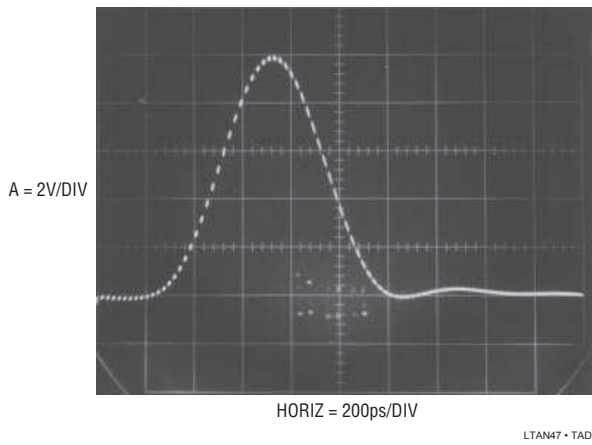A = 2V/DIV

HORIZ = 200ps/DIV

LTAN47 • TAD2

Figure D2. The Avalanche Pulse Generator's Output Monitored on a 1GHz Sampling Oscilloscope

high speed layout techniques are essential for good results from this circuit. Current drain from the 1.5V battery is about 5mA.

Figure D3 shows the physical construction of the actual generator. Power, supplied from a separate box, is fed into the generator's enclosure via a BNC connector. Q1 is mounted *directly* at the output BNC connector, with grounding and layout appropriate for wideband operation. Lead lengths, particularly Q1's and C1's, should be experimented with to get best output pulse purity. Figure D4 is the complete unit.
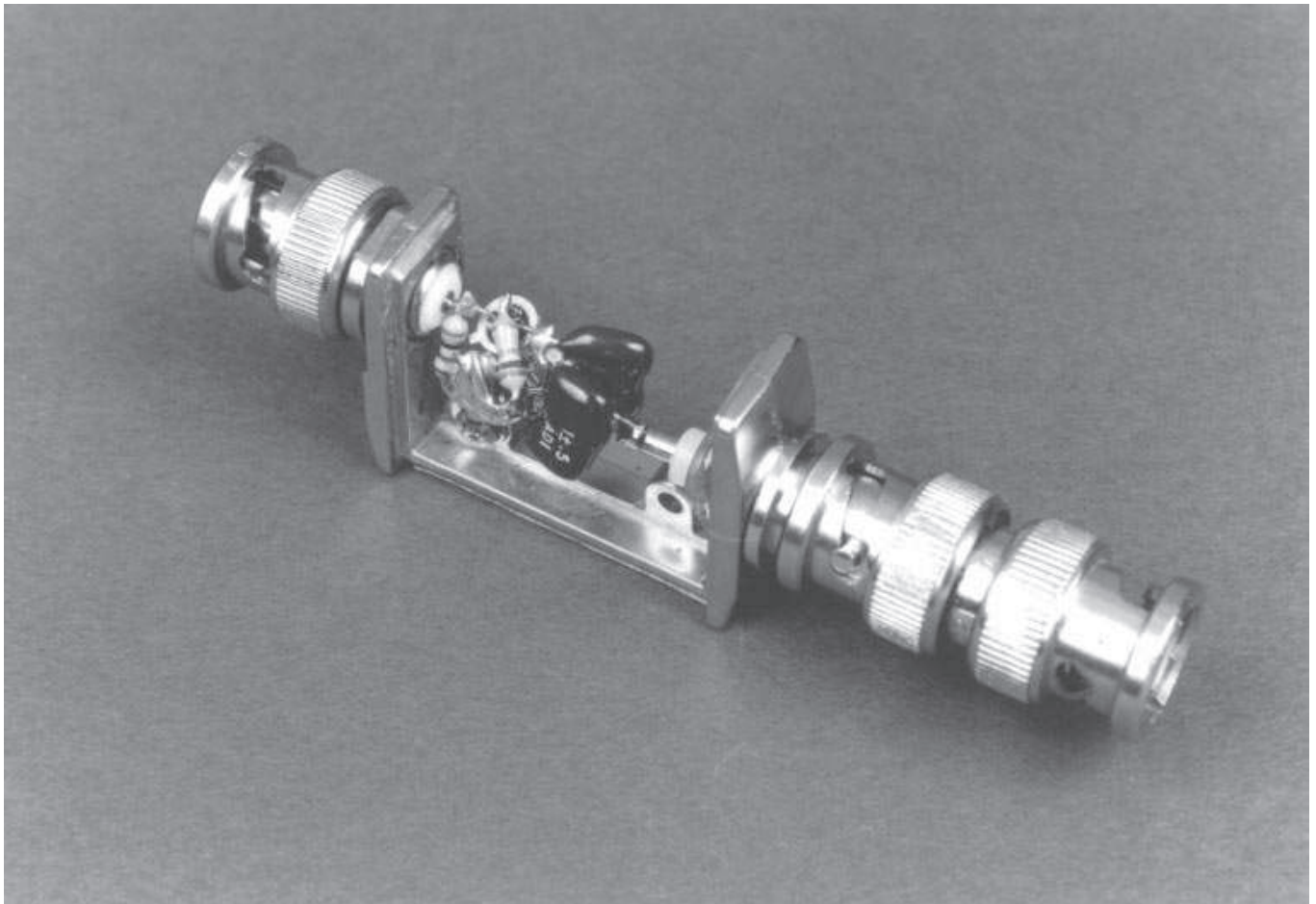

LTAN47 • TAD3

Figure D3. Details of the Avalanche Pulse Generator's Head. 90V$_{DC}$ Enters at Lower Right BNC, Pulse Exits at Top Left BNC. Note Short Lead Lengths Associated with Output

LTAN47 • TAD4

Figure D4. The Packaged Avalanche Pulser. 1.5V-90V Converter is in the Black Box. Avalanche Head is at Left