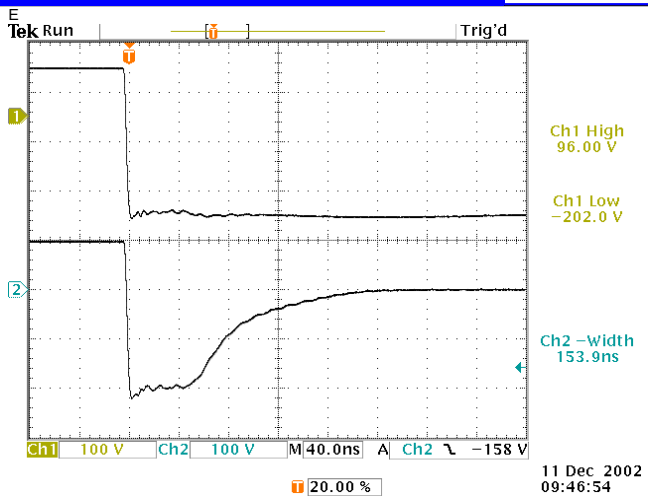
AVR-EB SERIES

t_{RR} & t_{FR} TEST GENERATORS FOR DIODE SWITCHING TIME TESTS INCLUDING METHODS 4031.1 & 4026.2



Top: AVR-EB4-B output. (100V/div, 40 ns/div)
Bottom: Reverse recovery of 1N4937 rectifier (+2A, -4A)

- Ideal for diode switching time tests (t_{RR}, t_{FR})
- Models for forward and reverse recovery testing
- MIL-STD-750E Method 4026.3
- MIL-STD-750E Method 4031.4 Conditions A and B
- Customized test jigs available
- IEEE-488.2 GPIB and RS-232 interfaces included
- Ethernet port for VXI-11.3 support

The AVR-EB series was designed for MIL-STD-750E diode switching time tests, including Method 4026.3 forward recovery time tests and Method 4031.4 reverse recovery time tests (Conditions A & B1-B4).

Method 4031.4 Condition B Reverse Recovery Tests

Models AVR-EB4-B, AVR-EB5-B and AVR-EB7-B are provided for Condition B reverse recovery tests of MIL-STD-750E Method 4031.4. The AVR-EB4-B is intended for reverse recovery testing of high-speed power rectifiers. The similar AVR-EB5-B is intended for more specialized reverse recovery testing of long-lifetime high-voltage PIN diodes, and the AVR-EB7-B is intended for low-current small-signal diodes.

The AVR-EB2A-B is intended for Method 4031.4 Condition A reverse recovery tests of low current switching diodes.

Models AVR-EBF6-B is intended for Method 4026.3 forward recovery tests.

For reverse-recovery tests of high-speeds rectifiers, the AVR-EB4-B generates a forward pulse up to +100V/+2A, which is then immediately followed by a reverse-bias pulse of up to -200V/-4A. The forward and reverse amplitudes and pulse widths are independently variable. The forward-to-reverse switching time is < 4.5 ns (10%-90%).

The current waveforms generated by this instrument are suitable for MIL-STD-750E Method 4031.4 Test Condition B tests. In the terminology of this standard, V3 = 0 to +200V, V4 = 0 to -200V, RF = 50 Ohms, R4 = 50 Ohms, and RR ≈ 0. These values differ from the values suggested in the standard, but the use of 50 Ohm resistances allows common coaxial cabling to be used for flexible connection arrangement, and greatly reduces the τ = L / R time constants that plague measurement systems based on the suggested values. As a result, the measurements are more accurate and more repeatable. (For additional information about the rationale behind the approach, please refer to Avtech Technical Brief 15, “A Comparison of Reverse Recovery Measurement Systems”, available at http://www.avtechpulse.com/appnote.) The values of I_F, I_{RM}, and $i_{R(REC)}$ produced by this instrument are suitable for the MIL-STD-750E Method 4031.4 Test Conditions B1-B4. (B4 is not recommended by Avtech, however, because the high I_{RM} / $i_{R(REC)}$ ratio will make the results more sensitive to parasitic effects.) See the online manual for a selection of typical waveforms obtained with different diode types.

Standard AVR-EB4-B models include one AVX-TRR-MIX diode test jig. The instrument mainframe is connected to the test jig using one coaxial cable and one DB-9 control cable. This test jig contains a variety of pin sockets, which may be used to hold the diode device under test (DUT). The test jig has a hinged lid, which must be fully closed to protect the user from high voltages. The output will be automatically disabled if the lid is left open. The standard AVX-TRR-MIX test jig will accommodate TO-220AC (2 lead) packages, DO-style packages with (leads bent at 90°), and standard and reverse-polarity TO-3 packages. The AVR-EB4-B may also be provided with different or additional a customized test jigs, to meet particular customer package requirements. The standard test jig may be replaced with one that accepts DO-41 and Type E axial packages without the need for lead-bending by specifying the appropriate option. Additional test jigs can be ordered separately.

The breakdown voltage of diodes tested by the AVR-EB4-B must exceed I_{RM} x 50Ω. For instance, for tests with I_{RM} = -1A, V_{BR} must exceed 50V.

The AVR-EB5-B is also similar, except that it is intended for use with diodes which have much longer recovery times (hundreds of microseconds), such as high-voltage PIN diodes. The switching times are slower than for the AVR-EB4-B, and the forward bias current is programmable in the range of +10 mA to +4A. In contrast to the AVR-EB4-B, the forward pulse is programmed in terms of the desired current (+10 mA to +4), rather than the applied voltage. The internal output impedance auto-ranges to achieve the desired current amplitude.

Model AVR-EB7-B is optimized for lower-current small-signal diodes (10 - 200 mA). The switching time is < 2.5 ns.

Method 4031.4 Condition A Reverse Recovery Tests

The above models are used for Condition B tests outlined in MIL-STD-750E Method 4031.4. Model AVR-EB2A-B is for Condition A tests, which use a slightly different test arrangement more suited for low-current small-signal diodes (10 - 100 mA). The switching time of the pulse generator is less than 500 ps (but the inductance of the device under test and the test jig typically increase the measured transition times to 750 ps, approximately). Model

AVR-EB2J-B is similar, with slightly slower switching times (< 1.5 ns). This slower variant is generally not subject to the same governmental export controls that normally apply to models with 500 ps rise/fall times (US ECCN 3A230).

Method 4026.3 Forward Reverse Recovery Tests

Model AVR-EBF6-B is intended for forward recovery tests, as per MIL-STD-750E Method 4026.3. This pulse generator provides a +5V to +50V output amplitude, with 50 Ohm output impedance (for back-matching) to drive 50 Ohm load impedances. Forward currents as high as +1A can be obtained. The mainframe output rise time is < 5 ns (10%-90%). An accessory coaxial rise time filter should be connected to the output to provide the rise time required for the test – typically 8, 10, or 12 ns (10%-90%). The 10 ns filter is included as a standard accessory, and the 8 and 12 ns filters are available as options. The pulse width is adjustable over the range of 200 ns to 10 us. Standard AVR-EBF6-B models include one AVX-TFR-MIX diode test jig. The instrument mainframe is connected to the test jig using one coaxial cable and one DB-9 control cable. The standard test jig contains a variety of pin sockets, which may be used to hold the diode device under test (DUT). The test jig has a hinged lid, which must be fully closed to protect the user from high voltages. The output will be disabled if the lid is left open. The standard AVX-TFR-MIX test jig will accommodate DO-41 packages, the Microsemi axial "E" package, DO-201AD, TO-220AC and similar packages. Lead bending is required for axial packages. The AVR-EBF6-B may also be provided with different or additional customized test jigs, to meet particular requirements. Different rise times can also be provided.

Other Tests

Avtech can also provide test systems other tests. Contact the factory (*info@avtechpulse.com*) for more details.

Test Jigs

The test jigs supplied with all models are specially designed to minimize the effects of parasitic inductance as well as transmission line reflections. This helps improve the accuracy and repeatability of the tests. Contact the sales engineering staff at Avtech (info@avtechpulse.com) for guidance on selecting the most appropriate jigs for your selection of DUT packages.

Other

All models are controlled by a front-panel keypad, adjust knob, and LCD display, or by programming commands sent via the included IEEE-488.2 GPIB and RS-232 ports. Each model also includes a rear-panel Ethernet connector, allowing an instrument to be remotely controlled using the VXI-11.3, ssh, telnet, and web protocols. In particular, the VXI-11.3 features allows software like LabView to control an instrument using standard VISA communications drivers and network cabling, instead of using older-style GPIB cabling and GPIB controller cards. For details, see http://www.avtechpulse.com/options/vxi.

Several relevant application notes are available on the Avtech web site, at http://www.avtechpulse.com/appnote. See application notes TB9, TB15, and TB16 in particular.

More Information

The operating manuals for most instruments are available for download from their online product pages, available at http://www.avtechpulse.com/semiconductor. These manuals contain a wealth of information, including actual test results.

INSTRUMENT MAINFRAME

Reverse Recovery Models

Model[1]:	AVR-EB4-B		AVR-EB5-B		AVR-EB7-B		AVR-EB2A-B AVR-EB2J-B	
Recovery type:	Reverse recovery		Reverse recovery		Reverse recovery		Reverse recovery	
Intended application:	High-speed rectifiers		Long-lifetime PIN diodes		High-speed small-signal diodes		High-speed small-signal diodes	
Basic waveform:	A positive pulse followed immediately by a negative pulse		A positive pulse followed immediately by a negative pulse		A positive pulse interrupted by a negative pulse		Positive DC interrupted by a negative pulse	
Pulse polarity:	-	+	-	+	-	+	DC	-
Voltage output[2,4,6]: (to R_L = 50Ω)	-2V to -200V	+5V to +100V	-2V to -200V	N/A	-0.2V to -20V	+0.1V to +10V	+10V to +100V	-1V to -24V
Corresponding diode current[2,4] (approx., depends on V_{DIODE}):	-40 mA to -4A	+100 mA to +2A	-40 mA to -4A	+10 mA to +4A	-10 mA to -200 mA	+10 mA to +200 mA	+10 mA to +100 mA	-10 mA to -100 mA
Pulse width (FWHM):	2 us - 20 us		0.2 ms to 1 ms		200 ns	500 ns[7]	DC	200 ns
Maximum duty cycle:	N/A		0.25%		N/A		N/A	
Rise time, at mainframe pulse output: (10%-90%)	< 4.5 ns	< 1 us	< 50 ns	< 1 us	< 2.5ns[8]	< 20 ns	AVR-EB2A-B: < 500 ps (without test jig), typically 750 ps[9] with jig and DUT installed. AVR-EB2J-B: < 1.5 ns, but > 0.6 ns[10]	
Output impedance during pulse (inside the mainframe):	≤ 2 Ohm	50 Ohms	≤ 2 Ohm	varies	50 Ohms		50 Ohms	
Maximum PRF:	100 Hz		10 Hz		5 kHz		10 kHz	
Variable delay (sync out to main out, unless noted):	Follows + pulse	0 to ±1s, variable	Follows + pulse	0 to ±1s, variable	500 ns after start of +pulse[5]	0 to ±1s, variable	0 to ±1s, variable	
Included test jig[3]:	See tables on later pages.							
Connectors:	Mainframe pulse output, TRIG, GATE, SYNC: BNC Jig pulse input: SMA				Mainframe pulse output, Jig pulse input: SMA TRIG, GATE, SYNC: BNC			
GPIB & RS-232:	Standard on -B units. See http://www.avtechpulse.com/gpib for details.							
Ethernet port, for remote control using VXI-11.3, ssh, telnet, & web:	Included. Recommended as a modern alternative to GPIB / RS-232. See http://www.avtechpulse.com/options/vxi for details.							
Settings resolution:	The resolution of the timing parameters (pulse width, delay, period) varies, but is always better than 0.15% of (|set value| + 20 ns). The amplitude resolution is < 0.1% of the maximum amplitude.							
Settings accuracy:	Typically ± 3% after 10 minute warmup, for timing parameter. For high-accuracy applications requiring traceable calibration, verify the output parameters with a calibrated oscilloscope[4,11].							
Trigger modes:	Internal trigger, external trigger (TTL level pulse, > 10 ns, 1 kΩ input impedance), front-panel "Single Pulse" pushbutton, or single pulse trigger via computer command.							
Sync output:	> +3 Volts, > 50 ns, will drive 50 Ohm loads							
Gate input:	Active high or low, switchable. Suppresses triggering when active.							
Power requirements:	100 - 240 Volts, 50 - 60 Hz							
Dimensions:	H x W x D: 100 mm x 430 mm x 375 mm (3.9" x 17" x 14.8")							
Chassis material:	cast aluminum frame and handles, blue vinyl on aluminum cover plates							
Temperature range:	+5°C to +40°C							

1) -B suffix indicates IEEE-488.2 GPIB and RS-232 control of amplitude, pulse width, PRF and delay (see http://www.avtechpulse.com/gpib).
2) For operation at amplitudes of less than 10% of full-scale, best results will be obtained by setting the amplitude near full-scale and using external attenuators on the output.
3) Customized jigs available upon request.
4) The amplitude settings should not be relied upon for any degree of accuracy, because the dynamics of the device under test can affect the actual generated waveforms. Amplitude settings should always be verified by oscilloscope measurements.
5) Thus the diode must come to forward steady-state within 500 ns.
6) The diode must have a breakdown voltage exceeding these amplitude limits. Contact Avtech for special arrangements if $I_{MAX} \times 50\Omega > V_{BR}$.
7) The full forward pulse width is 2 us, but the reverse pulse is super-imposed on the forward pulse 500 ns after the start of the forward pulse.
8) Increases to 4.5 ns for units with the -DIPFP option, due to the switching relay inductance.
9) Depends on the parasitic inductance of the DUT and its leads.
10) Model AVR-EB2A-B is subject to export controls (US ECCN 3A230, Canada ECL 4-5.B.6) due to its fast switching times. The AVR-EB2J-B is not subject to these controls, due to its slower switching times.
11) These instruments are provided with a basic calibration checksheet, showing a selection of measured output parameters. These measurements are performed with equipment that is calibrated on a regular basis by a third-party ISO/IEC 17025:2005 accredited calibration laboratory. However, Avtech itself does not claim any accreditation. For applications requiring traceable performance, use a calibrated measurement system rather than relying on the accuracy of the pulse generator settings.

Forward Recovery Models

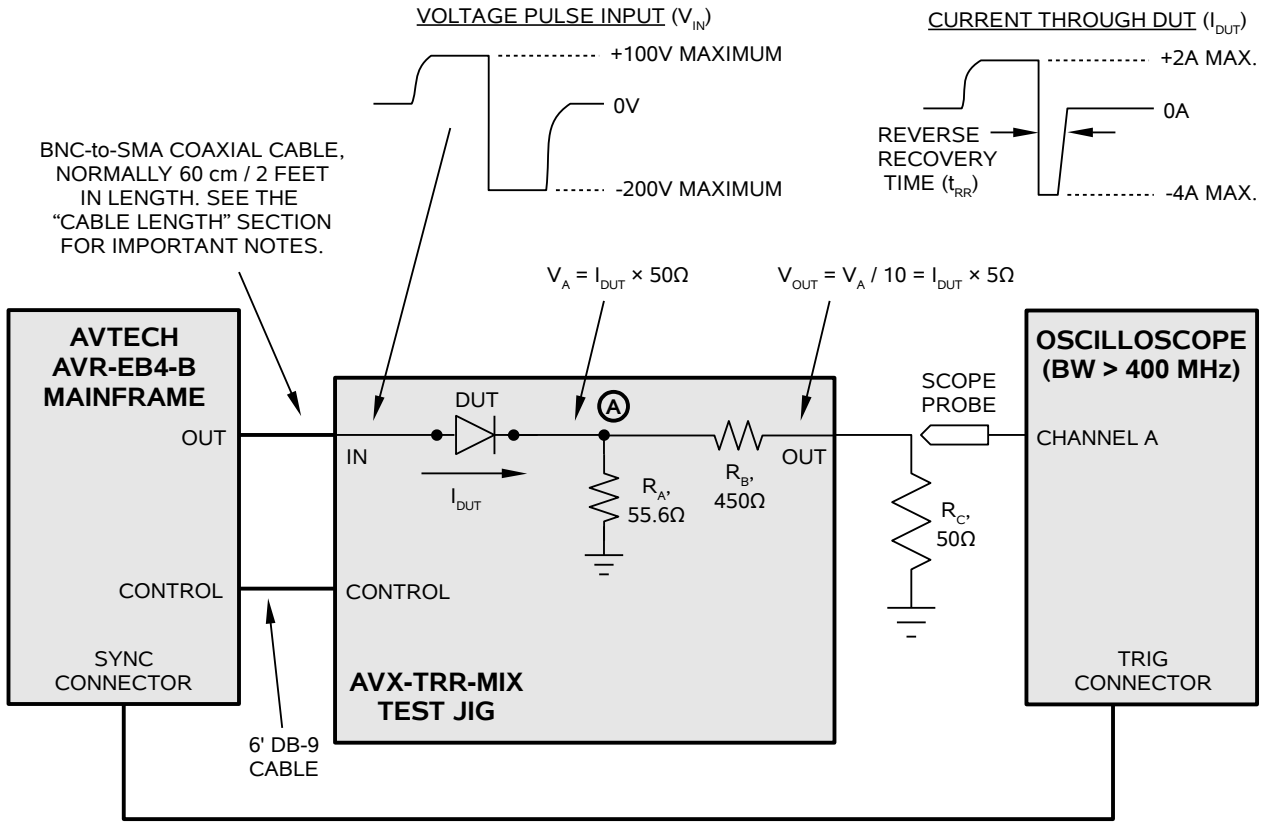
Model[1]:	AVR-EBF6-B
Recovery type:	Forward recovery
Intended application:	High-speed rectifiers
Basic waveform:	A positive pulse
Pulse polarity:	+
Voltage output[2,5]: (to R_L = 50Ω)	+2.5V to +50V
Corresponding diode current[2,5] (approx., depends on V_{DIODE}):	+50 mA to +1A
Pulse width (FWHM):	200 ns to 10 us[7]
Maximum duty cycle:	0.2%
Rise time: (10%-90%)	No filter < 5 ns. Standard filter[4]: 10 ns Optional filters[4]: 8 ns, 12 ns, 20 ns
Output impedance during pulse (inside the mainframe):	50 Ohms
Maximum PRF:	10 kHz
Variable delay (sync out to main out, unless noted):	0 to ±1s, variable
Included test jig[3]:	See tables on later pages.
Connectors:	Mainframe pulse output, jig pulse input: SMA TRIG, GATE, SYNC: BNC
GPIB & RS-232:	Standard on -B units. See http://www.avtechpulse.com/gpib for details.
Ethernet port, for remote control using VXI-11.3, ssh, telnet, & web:	Included. Recommended as a modern alternative to GPIB / RS-232. See http://www.avtechpulse.com/options/vxi for details.
Settings resolution:	The resolution of the timing parameters (pulse width, delay, period) varies, but is always better than 0.15% of (|set value| + 20 ns). The amplitude resolution is < 0.1% of the maximum amplitude.
Settings accuracy:	Typically ± 3% after 10 minute warmup, for timing parameter. For high-accuracy applications requiring traceable calibration, verify the output parameters with a calibrated oscilloscope[5,8].
Trigger modes:	Internal trigger, external trigger (TTL level pulse, > 10 ns, 1 kΩ input impedance), front-panel “Single Pulse” pushbutton, or single pulse trigger via computer command.
Sync output:	> +3 Volts, > 50 ns, will drive 50 Ohm loads
Gate input:	Active high or low, switchable. Suppresses triggering when active.
Power requirements:	100 - 240 Volts, 50 - 60 Hz
Dimensions:	H x W x D: 100 mm x 430 mm x 375 mm (3.9” x 17” x 14.8”)
Chassis material:	cast aluminum frame and handles, blue vinyl on aluminum cover plates
Temperature range:	+5°C to +40°C

1) -B suffix indicates IEEE-488.2 GPIB and RS-232 control of amplitude, pulse width, PRF and delay (see http://www.avtechpulse.com/gpib).
2) For operation at amplitudes of less than 10% of full-scale, best results will be obtained by setting the amplitude near full-scale and using external attenuators on the output.
3) Customized jigs available upon request.
4) The 10 ns (10%-90%) rise time filter is included as a standard feature. To add an 8 ns filter, add the -F8NS option to the model number. To add a 12 ns filter, add the -F12NS option to the model number. To add a 20 ns filter, add the -F20NS option to the model number. The rise time filter rise time accuracy is ±20%.
5) The amplitude settings should not be relied upon for any degree of accuracy, because the dynamics of the device under test can affect the actual generated waveforms. Amplitude settings should always be verified by oscilloscope measurements.
6) Depends on the parasitic inductance of the DUT and its leads.
7) Maximum pulse width is reduced to 500 ns for units with the -DIPFP option.
8) These instruments are provided with a basic calibration checksheet, showing a selection of measured output parameters. These measurements are performed with equipment that is calibrated on a regular basis by a third-party ISO/IEC 17025:2005 accredited calibration laboratory. However, Avtech itself does not claim any accreditation. For applications requiring traceable performance, use a calibrated measurement system rather than relying on the accuracy of the pulse generator settings.

Common Test Jigs for “Condition B” Reverse Recovery Tests (AVR-EB4-B, AVR-EB5-B, AVR-EB7-B)

Option Code	Included Jig	Description
standard	AVX-TRR-MIX	Includes a mix of pin sockets. Will accept TO-220AC (2 lead) packages, DO-style packages[3] (DO-15, DO-35, DO-41, DO-201AD, etc.) with leads bent at 90°, and standard and reverse-polarity TO-3 packages. Lead bending is required for axial packages.
-AXPOST	AVX-TRR-AXPOST	Jig with easy-to-use spring-loaded push-posts for axial packages with body length of up to 0.25” (and diameters up to 0.5”), including DO-35, DO-41 and Microsemi Axial Type E packages (0.185" x 0.135" body, max). Lead bending is NOT required to insert these packages. (Recommended as a superior replacement for earlier AVX-TRR-ANB and AVX-TRR-LORAX designs.)
-SOD123	AVX-TRR-SOD123	Accepts SOD123 packages. A clamp presses the DUT down against upwards-facing spring pins.
-SOD123W	AVX-TRR-SOD123W	Accepts SOD123W packages. A clamp presses the DUT down against upwards-facing spring pins.
-SOD128	AVX-TRR-SOD128	Accepts SOD128 packages. A clamp presses the DUT down against upwards-facing spring pins.
-SQMELF	AVX-TRR-SQMELF	Square MELF jig. Accepts Microsemi Type A (D-5A) and Microsemi Type E (D-5B) “square MELF” packages. It also accepts Microsemi Type B (D-5D) and Microsemi Type G (D-5C) packages, although the fit is less optimal.
-STUD	AVX-TRR-STUD	Stud jig. Accepts DO-4 and DO-5 stud packages.
Custom	Custom	Customized test jigs are routinely provided. Contact Avtech with your specific requirements.

Typical Test Arrangement – “Condition B” Reverse Recovery Tests

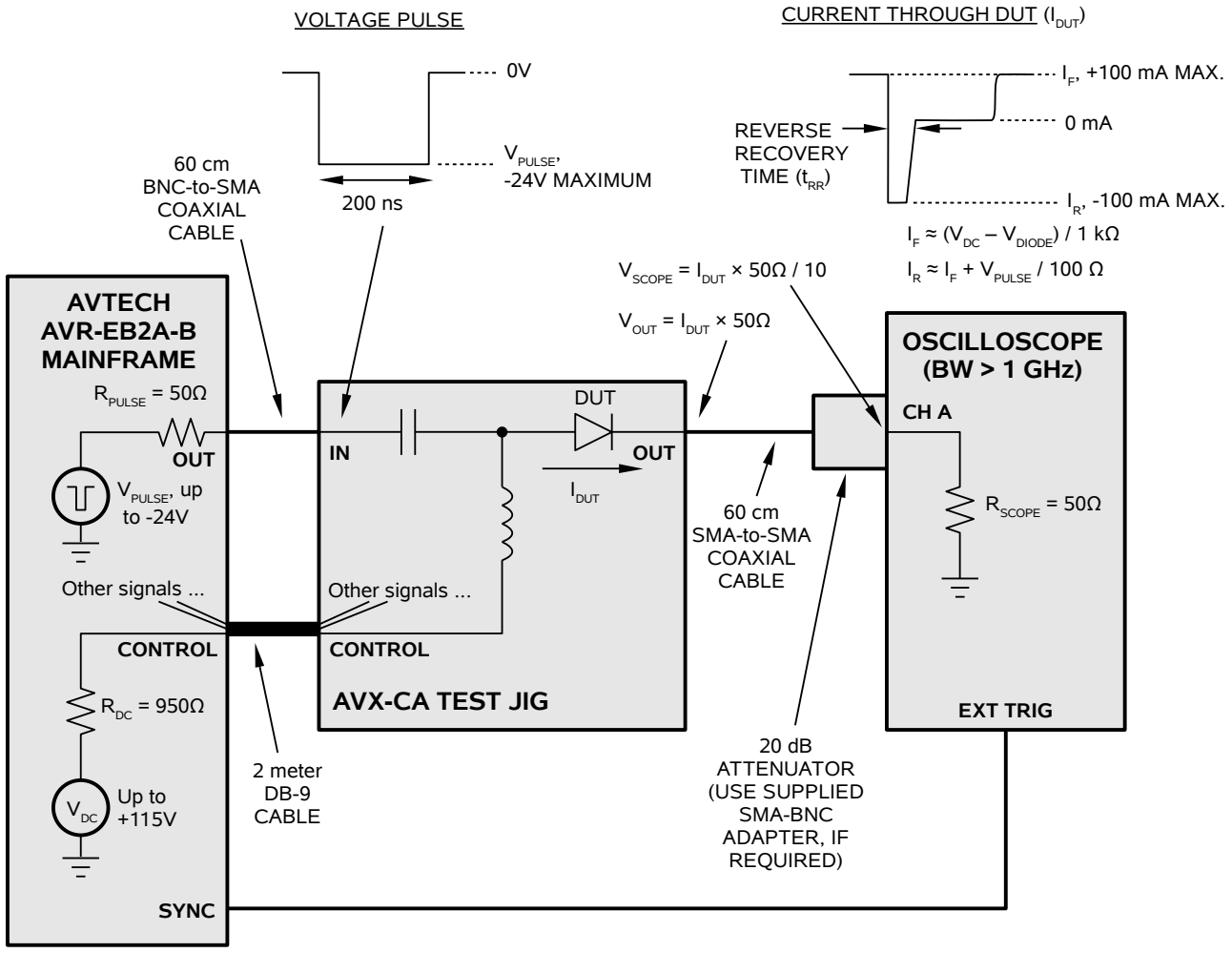


Common Test Jigs for “Condition A” Reverse Recovery Tests (AVR-EB2A-B, AVR-EB2J-B)

Option Code	Included Jig	Typical Parasitic Inductance[1], Description	
standard	AVX-CA-AXPOST	< 20 nH	Jig with easy-to-use spring-loaded push-posts for axial packages with body length of up to 0.25” (and diameters up to 0.5”), including DO-35, DO-41 and Microsemi Axial Type E packages (0.185" x 0.135" body, max). Lead bending is NOT required to insert these packages.
-SOD123	AVX-CA-SOD123	< 20 nH	Accepts SOD123 packages. A clamp presses the DUT down against upwards-facing spring pins.
-SOD123W	AVX-CA-SOD123W	< 20 nH	Accepts SOD123W packages. A clamp presses the DUT down against upwards-facing spring pins.
-SOD128	AVX-CA-SOD128`	< 20 nH	Accepts SOD128 packages. A clamp presses the DUT down against upwards-facing spring pins.
Custom	Custom	< 20 nH	No-solder jigs for various SMT packages (SOD-123, etc) can be provided as needed. Contact Avtech with your specific requirement.

1. The parasitic inductance of the jig (L) will degrade the switching speeds based on the inductive time constant L/R, where R = 50 Ohms. For the above jigs, this means the switching speeds at the hig are degraded by a < 0.4 ns time constant compared to the waveform at the mainframe output.

Typical Test Arrangement – “Condition A” Reverse Recovery Tests



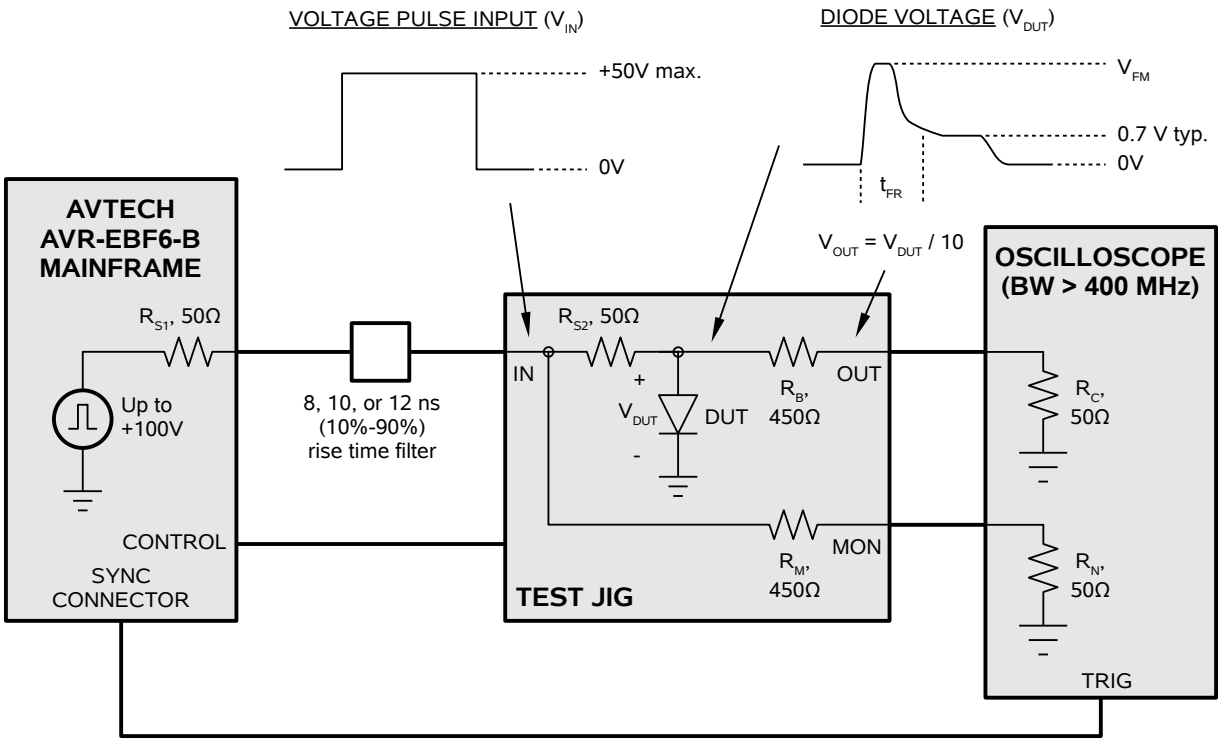
Avtech frequently customizes equipment to meet particular test requirements.
Call us today with your special application!

Common Test Jigs for Forward Recovery Tests (AVR-EBF6)

Option	Included Jig	Typical Parasitic Inductance[1], Maximum Current, Description	
Preferred Jigs			
-MIX	AVX-TFR-MIX	7 nH, 1A	Standard on AVR-EBF6-B. Includes a mix of pin sockets. Will accept TO-220AC (2 lead) packages, DO-style packages[3] (DO-15, DO-35, DO-41, DO-201AD, etc.) with leads bent at 90°, and standard and reverse-polarity TO-3 packages. Lead bending is required for axial packages.
-HPOST	AVX-TFR-HPOST	7 nH, 10A	High-current (up to 10A) jig for DO-41 packages (0.205" x 0.107" body, max) and Microsemi Axial Type E packages (0.185" x 0.135" body, max). Unlike the standard jig, bending is NOT required to insert these packages. This jig will not accept any other type of package.
-SOD123	AVX-CA-SOD123	7 nH, 1A	Accepts SOD123 packages. A clamp presses the DUT down against upwards-facing spring pins.
-SOD123W	AVX-CA-SOD123W	7 nH, 1A	Accepts SOD123W packages. A clamp presses the DUT down against upwards-facing spring pins.
-SOD128	AVX-CA-SOD128	7 nH, 1A	Accepts SOD128 packages. A clamp presses the DUT down against upwards-facing spring pins.
-SQMELF	AVX-TFR-SQMELF	7 nH, 1A	Square MELF jig. Accepts Microsemi Type A (D-5A) and Microsemi Type E (D-5B) “square MELF” packages. It also accepts Microsemi Type B (D-5D) and Microsemi Type G (D-5C) packages, although the fit is less optimal.
-STUD	AVX-TFR-STUD	TBD, 1A	Stud jig. Accepts DO-4 and DO-5 stud packages.

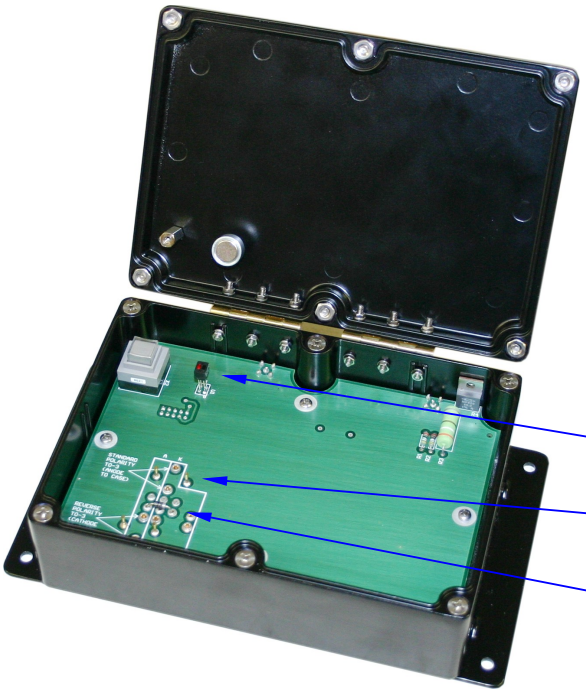
2. The parasitic inductance of the jig (L) will increase the measured V_{FM} value by L × I_{FM} / Rise Time, so it should be minimized as much as possible in order. Forward recovery tests are much more sensitive to parasitic inductance than reverse recovery tests.

Typical Test Arrangement – Forward Recovery Tests



TEST JIGS

The standard AVR-EB4-B, AVR-EB5-B, and AVR-EB7-B models include the **AVX-TRR-MIX** test jig, shown below. (The AVX-TFR-MIX jig for forward recovery tests is similar.)



The input, output, and control cables connect to the rear, shown below:

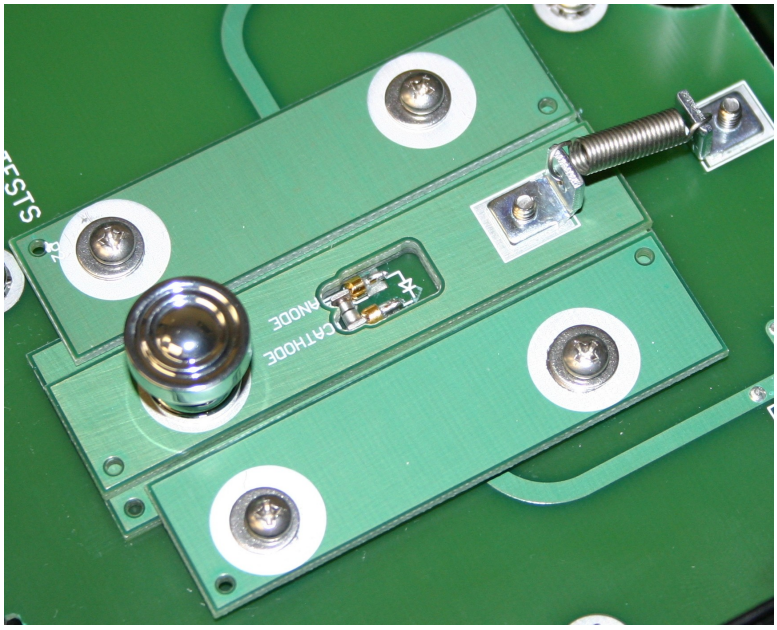
Safety interlocks

Pin sockets, to accommodate a range of leaded devices (DO-41, TO-220, TO-3, etc).

An installed device under test. DO-41 package.

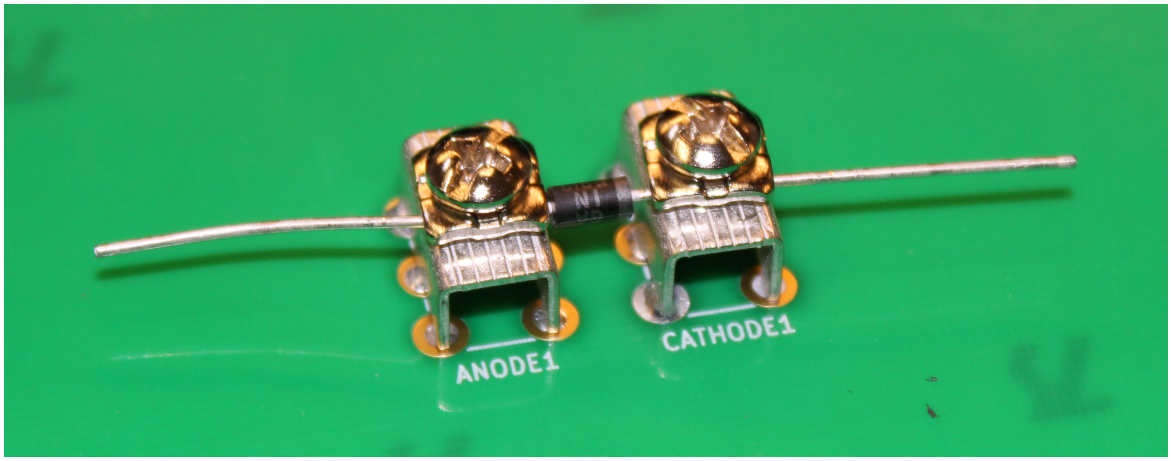
Each test jig is specially designed to minimize the parasitic inductance that can distort results, while maintaining ease of use.

Specialized test jigs can be provided. For instance, the **-SQMELF** jigs accommodates surface-mount SQMELF packages, with an easy-to-use sliding device holder:

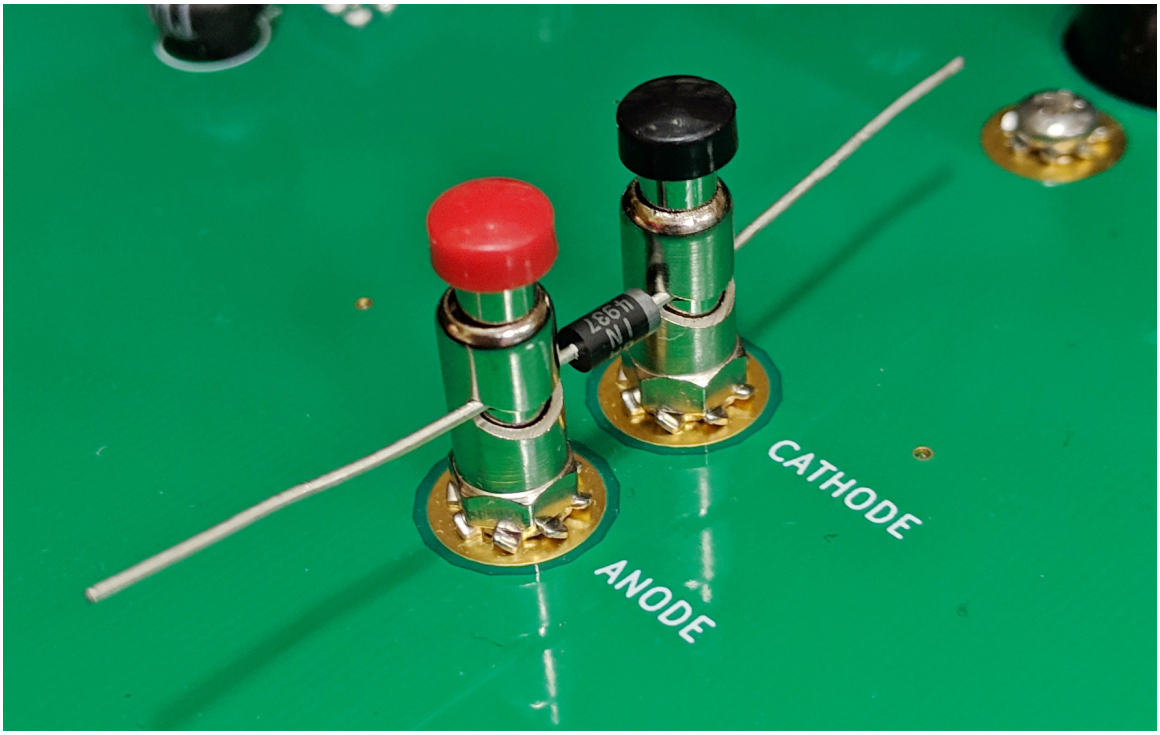


A number of different jigs are available for axial devices.

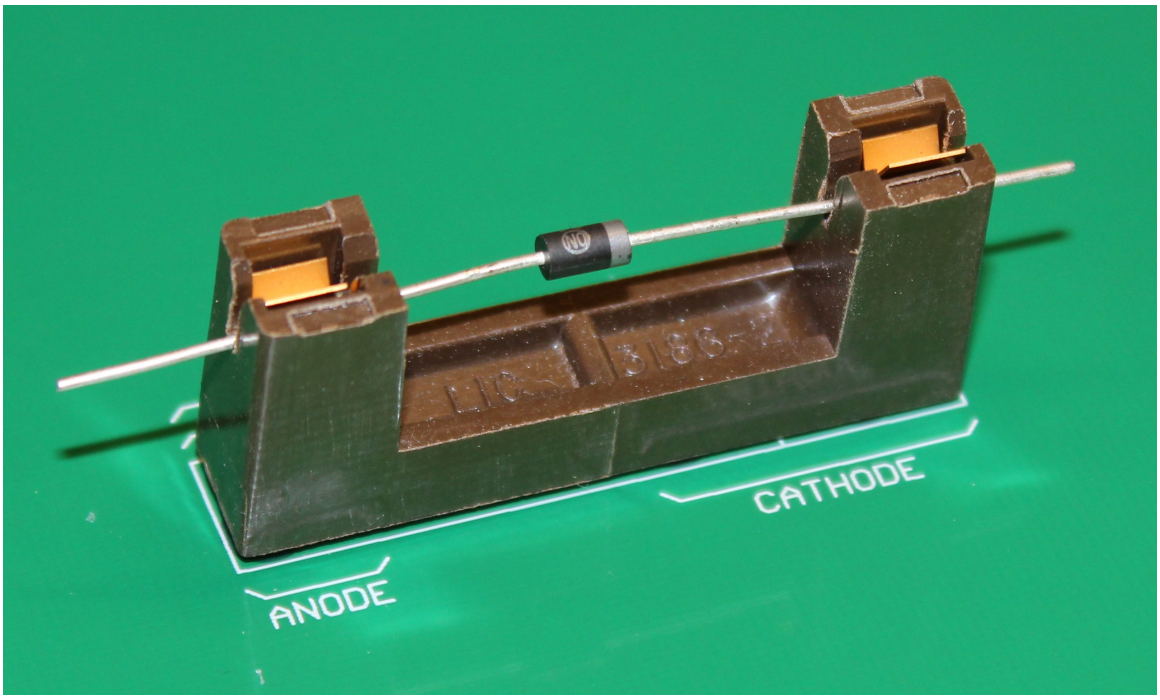
The **-HPOST** test jigs provide lowest-inductance high-current screw terminals for high-current diodes:



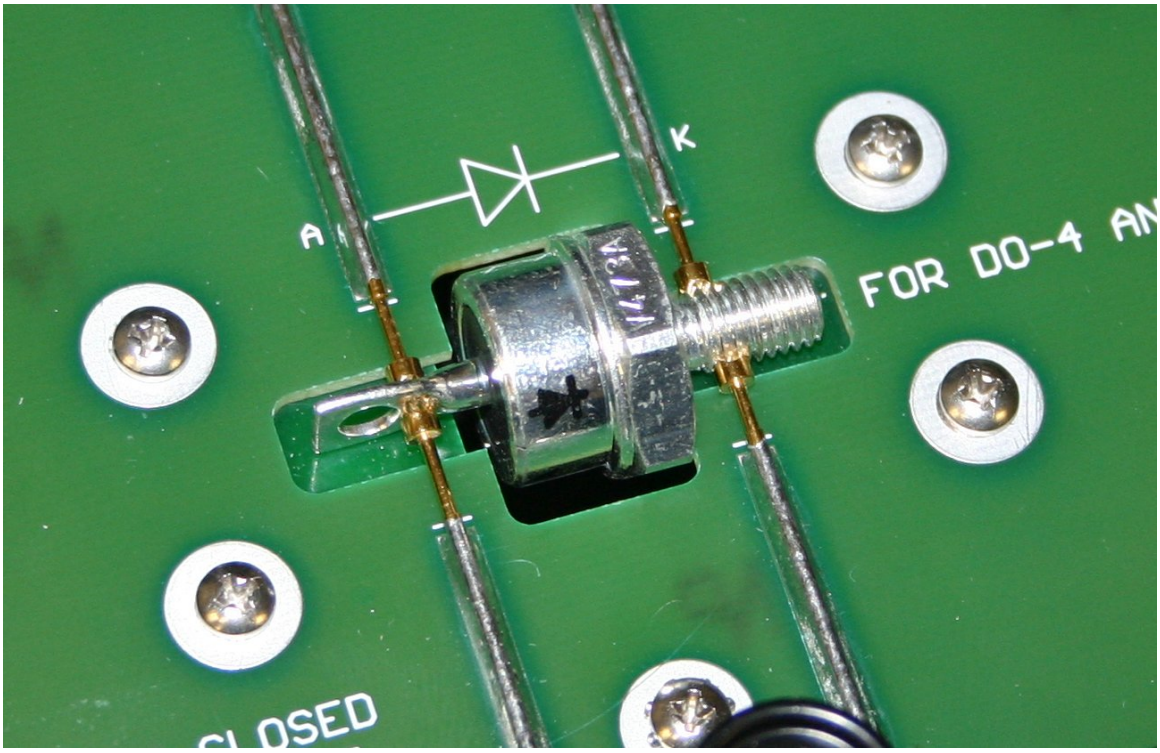
The **-AXPOST** jigs often more-convenient spring-loaded push-posts. It is easier to use, but slightly higher in inductance, than the alternative -HPOST version. The HPOST version is recommended for forward recovery tests, due to its lower inductance. The AXPOST version is recommended for reverse recovery tests, due to its ease of use. The inductance has a less detrimental effect on reverse recovery tests.



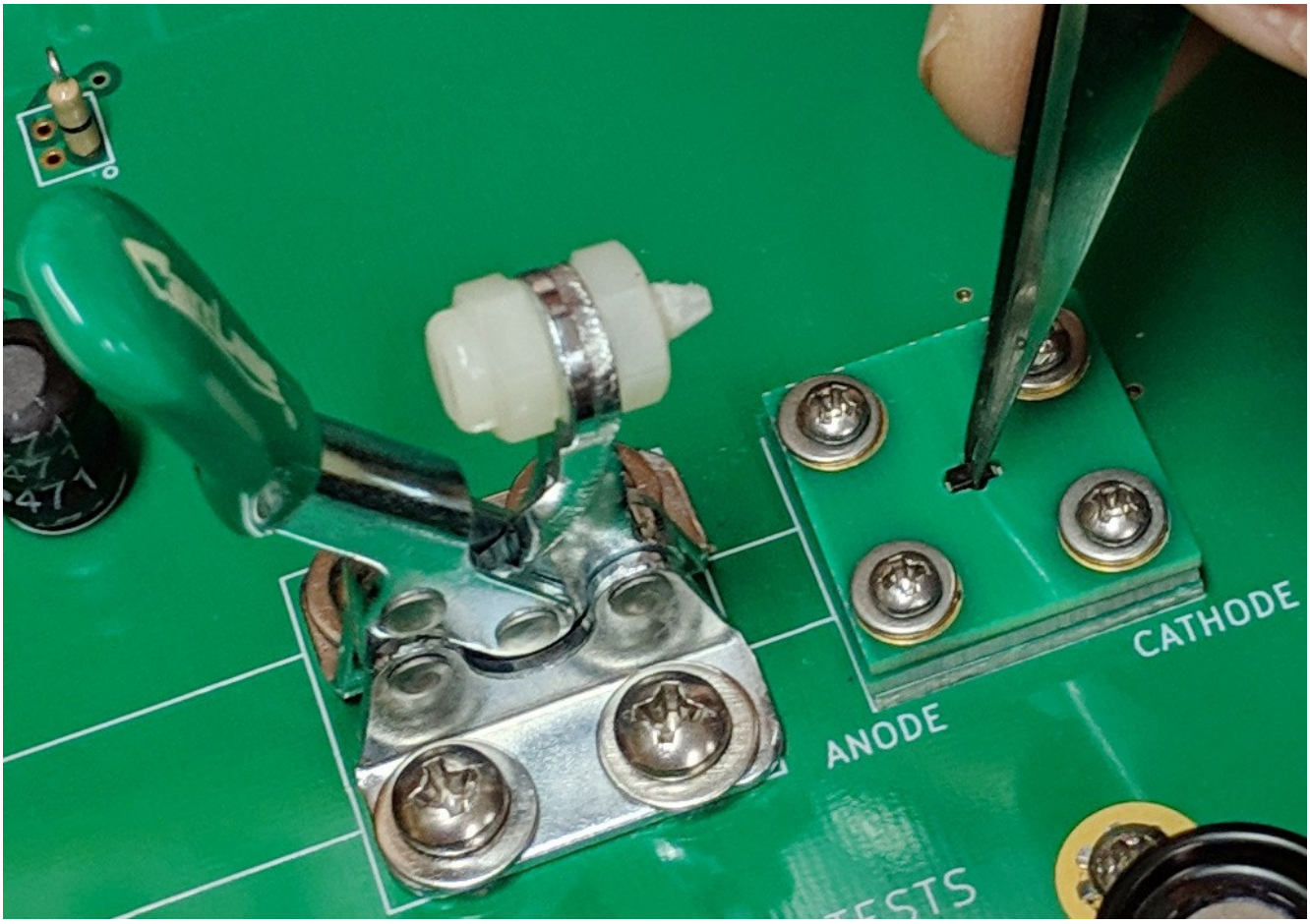
The **-LORAX** jig provides a Loranger 03186 021 6215 socket for the DUT:



The **-STUD** test jigs accept DO-4 and DO-5 stud packages:



The **-SOD123, -SOD123W,** and **SOD128** jigs clamp the SMT DUT again upwards-facing spring pins:



NOTE: *All of the above jigs are suitable for light research and development use. Consult Avtech (info@avtechpulse.com) regarding the suitability of particular jigs for heavy production use.*

The various test jigs listed above have been developed in response to particular customer requirements. Other test jigs can be provided upon request. Contact Avtech (info@avtechpulse.com) with your special test requirements!