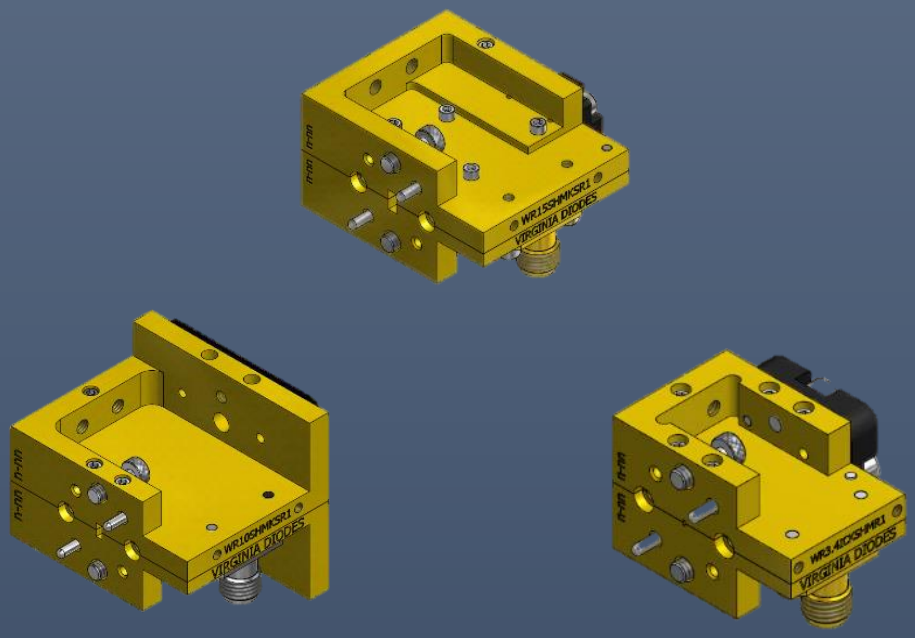
2017



Zero-Bias Detector Operational Manual (ZBD, ZBD-F, QOD)

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Zero-Bias Detectors (ZBD)

Virginia Diodes offers zero biased, Schottky diode detectors for a variety of millimeter wave and terahertz applications. These detectors provide high responsivity and extremely fast response time. VDI detectors offer full waveguide band coverage and are available from WR15 (50-75 GHz) to WR0.65 (1100-1700 GHz). Higher frequency custom detectors are available upon request.

Safety and Operational Guidelines

Read all instructions and information in this product manual before connecting the product to external equipment. Operational procedures must be followed for proper function. If you have questions, contact VDI before operating the product.

The internal components of every detector can be damaged by Electro Static Discharge (ESD). Any operator using or handling the device should wear a grounded wrist strap specifically designed to guard against ESD. The work environment including test benches should also be properly grounded.

VDI assumes the customer is familiar with microwave, millimeter wave, and VDI products in general. The user and customer are expected to understand all safety guidelines, health hazards, and general advisories that may exist and are associated with the use of this device. VDI is not responsible for any human hazards that may exist or may occur while using this device.

Virginia Diodes, Inc. (VDI) accepts no liability for damage or injury resulting from or caused by:

- Improper use, disassembly or use for purposes other than those for which the product was designed;
- Use outside common safety, health or general advisories pertaining to microwave, millimeter wave, and VDI products;
- Repairs carried out by persons other than VDI or its assigned agents.

Waveguide Inspection / Test Port Care

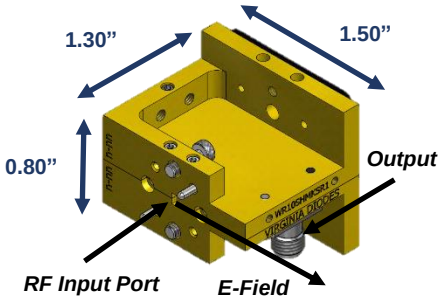
- Inspect waveguide flanges for debris prior to making connections.
- Making a connection with metal debris between the waveguide flanges can damage the waveguide interface and prevent repeatable connections.
- If debris is present, clean the flange with pre-dampened lint free wipes or swabs (e.g. TexWipe TX1065). If these are not available, lint free cloths lightly dampened with ethanol may be used (e.g. TexWipe TX604).
- When device is not in use, cover appropriate waveguide flanges with provided dust cap or protective waveguide tape.
- Waveguide screws should be torqued between 20-50 cNm, greater values can damage the interface.
- Use a torque of 90 cNm when making coaxial connections. Avoid sharp bends in cables.

General Operating Practices and Recommendations

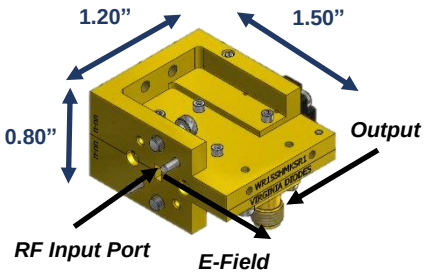
- This manual applies to products shipping after March 15, 2017.
- Check with VDI before any use is attempted beyond those described in this manual, including uses that may exceed limitations stated here or commonly accepted standards of practice.

Low Frequency Zero Bias Detectors (WR-15 to WR-10)

These detectors have a rectangular waveguide RF input port and coaxial output. The drawings and corresponding dimensions are for a typical WR-10 and WR-15 zero bias detector. The WR12ZBDs have similar form factor to the WR15ZBD.



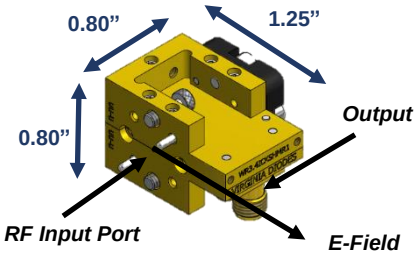
WR-10



WR-15

Middle Frequency Zero Bias Detectors (WR-8.0 to WR-1.0)

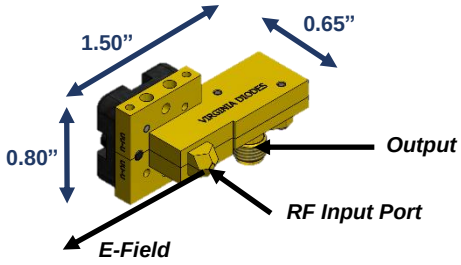
These detectors have a rectangular waveguide RF input port and coaxial output. The drawings and corresponding dimensions are for typical WR-3.4 zero bias detectors. Other ZBDs (WR-8.0 to WR-1.0) have similar configuration and dimensions.



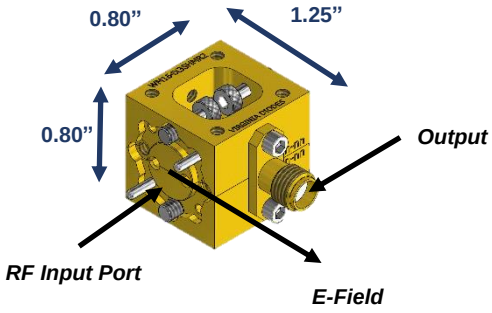
WR-3.4

High Frequency Zero Bias Detectors (WR-0.8 to WR-0.65)

The WR0.8ZBD has an integrated horn antenna (~25dBi) RF input port and a coaxial output. The WR0.65ZBD has a rectangular waveguide RF input port and a coaxial output. The drawing and corresponding dimensions are for a typical WR-0.65 and WR-0.8 zero bias detector.



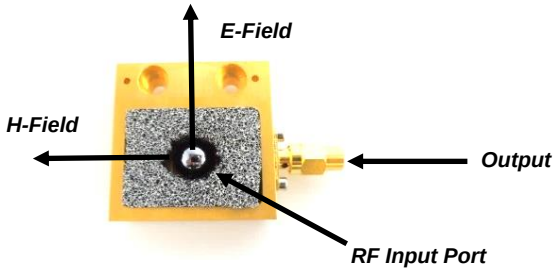
WR-0.8



WR-0.65

Quasi-Optical Detectors (QOD)

The photograph for a typical quasi-optical detector (~1.50" x 1.50" x 0.45") is shown below. These detectors will have a silicon lens RF input port and a coaxial output port. The E-Field polarization will change with frequency (±22.5°). The polarizations shown below are nominal polarizations. The QOD alignment should be adjusted for optimal performance. VDI recommends the use of RF absorber around the silicon lens to reduce reflections and potential standing waves.



General Operating Procedure

These procedures apply to all VDI zero-bias detectors.

Turn On: *Apply small signal RF input power and monitor detector output response.*
Turn Off: *Turn off small signal input power.*

RF Input Port: *DO NOT exceed damage limits listed on Page 7.*
Output Port (Extremely ESD Sensitive): *The detector output port is extremely ESD sensitive. DO NOT apply any DC biases or surges when connecting / disconnecting from output port. Discharge static from cables before connecting to the device. Replace IF port with provided 50Ω termination or appropriate cover when output port is not in use.*

ZBD (Internal ESD Protection Circuit): *Monitor detector output port using a floating voltmeter. See Page 6 for configuration details.*
ZBD-F Configuration (using Bias-Tee and Ampifier): *Appropriate voltages must be applied to the voltage pins on the provided amplifier.*
ZBD-F Configuration (using External ESD Protection Circuit): *Monitor detector output port using a floating voltmeter. See Page 6 for configuration details.*

Black Backing Plate: Unused ports are covered by a black backing plate. DO NOT tamper with the black backing plate.

Failure to follow these procedures may damage or destroy the device. The user is liable for repair costs of detectors damaged by ESD, and the use of stringent ESD precautions is recommended when making connections to VDI detectors.

Replacing Bias-Tee / Amplifier with External ESD Protection Circuit (ZBD-F only)

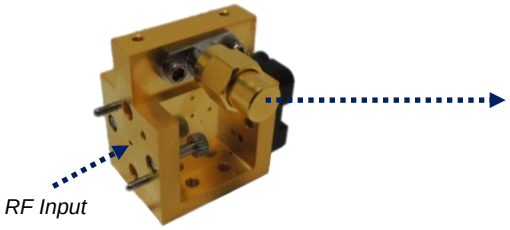
These procedures apply to ZBD-F configurations only.

An External ESD Protection Circuit is included (detached) and can be used for applications where a low frequency (DC to ~50kHz) detector output is more appropriate. To use the External ESD Protection Circuit, the bias-tee and amplifier must be removed and then connect the External ESD Protection Circuit can be connected to the detector output port. When there is nothing attached to the detector output port, the detector can be damaged by ESD events. Please use safe ESD guidelines when disconnecting and connecting components from the detector output port.

Configurations (ZBD vs. ZBD-F)

ZBD (Internal ESD Protection)

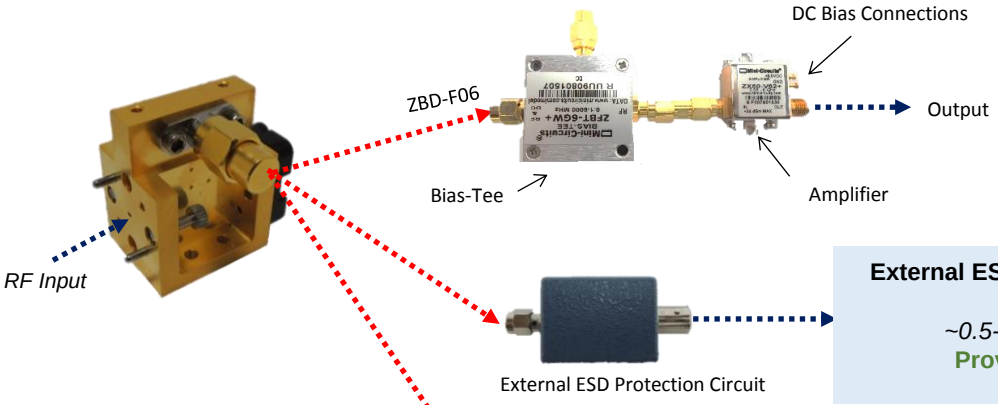
Standard ZBD configuration



Output:
DC to ~250 kHz
~2-3kΩ Output Impedance
No access to full detector response rate
Provides ESD Protection

ZBD-F (Fast Detector)†

Standard ZBD-F configuration includes 6 GHz bias-tee and amplifier.



External ESD Protection Circuit Output:
DC to ~50 kHz
~0.5-1kΩ Output Impedance
Provides ESD Protection

External components can be removed to access full detector frequency response rate.
Detector Output Port Extremely ESD Sensitive
See Maximum Detector Response Rate on Page 7

†Fast Detectors are shipped with a 6 GHz bias-tee and amplifier attached to the detector. Additional fast detector options are shown below and can be purchased at an additional cost. Contact VDI for more information.

Fast Detector Options
50 Ohm Output Impedance

ZBD-FTI (50 MHz Option)
~1kHz-50MHz*
~40 dB gain

ZBD-F20 (20 GHz Option):
~100 kHz to ~20 GHz*
~12dB gain

ZBD-F06 (6 GHz, Standard Option):
~50 MHz to ~6 GHz*
~15dB gain

ZBD-F40 (40 GHz Option):
~100 kHz to ~40 GHz*
~10dB gain

***May limit maximum detector response**
Provides ESD Protection

Product Specifications

General Specifications for Zero-Bias Detectors		
Description		**Specification**
Detector Output Flange	ZBD (with Internal ESD Protection)	2.9mm(f)
	ZBD-F (with Bias Tee and Amplifier)	2.9mm(f)
	ZBD-F (with External ESD Protection)	BNC(f)
RF Input Power	Linear	< -25 dBm
	1dB Compression	-20 dBm
Maximum RF Input Power	Recommended / Damage	0 dBm / 5 dBm
Maximum Weight (ZBD / ZBD-F)		~0.1lbs. / ~0.3 lbs.
Operating Temperature (Typical / Recommended)		25°C / 20-30°C

Product Specifications for Zero-Bias Detectors						
VDI Part Number	**RF Frequency (GHz)**	**RF Input Flange**	**Typical Responsivity (V/W)***	**Typical NEP (pW/√Hz)**		**Maximum Response Rate (GHz)****
				ZBD	**ZBD-F**	
WR15ZBD	50-75	WR-15 UG-385/U	2000	13.2	3	~10
WR12ZBD	60-90	WR-12 UG-387/U-M	2000	13.2	3	~12
WR10ZBD	75-110	WR-10.0 UG-387/U-M	2000	13.2	3	~15
WR8.0ZBD	90-140	WR-8.0 UG-387/U-M	2000	13.2	3	~19
WR6.5ZBD	110-170	WR-6.5 UG-387/U-M	2000	13.2	3	~24
WR5.1ZBD	140-220	WR-5.1 UG-387/U-M	2000	13.2	3	~31
WR4.3ZBD	170-260	WR-4.3 UG-387/U-M	1750	15.1	3.5	~36
WR3.4ZBD	220-330	WR-3.4 UG-387/U-M	1500	17.6	4.1	~40
WR2.8ZBD	260-400	WR-2.8 UG-387/U-M	1500	17.6	4.1	~40
WR2.2ZBD	325-500	WR-2.2 UG-387/U-M	1250	9.1	1.9	~40
WR1.9ZBD	400-600	WR-1.9 UG-387/U-M	1000	11.4	2.4	~40
WR1.5ZBD	500-750	WR-1.5 UG-387/U-M	750	15.2	3.2	~40
WR1.2ZBD	600-900	WR-1.2 UG-387/U-M	250	45.5	9.7	~40
WR1.0ZBD	750-1100	WR-1.0 UG-387/U-M	200	56.8	12.2	~40
WR0.8ZBD	900-1400	~25dBi Diagonal Horn†	100	113.7	24.4	~40
WR0.65ZBD	1100-1700	WM-164 UG-387/U-M	100	113.7	24.4	~40
QOD	100-1000	Silicon Lens‡	100-250	50-115	10-25	~40

† Diagonal Horn antenna has a gain of ~25dBi, specified at the middle of the waveguide band. The gain changes as a function of frequency. See VDI Application Note: VDI Waveguide Feedhorn Specification (VDI-1001) for more information.

‡ Output Lens Directivity: 25-35dB nominal.

*Typical Responsivity assumes ZBD is operated in the linear region, before saturation. Responsivity may be reduced toward band edges or for ZBD-F configurations. Responsivity data will be provided on USB drive for each ZBD.

**Maximum Response Rate applies to the bare ZBD housing; additional components such as ESD protection, bias tees, and amplifiers may further limit the response rate.

Part Number Format

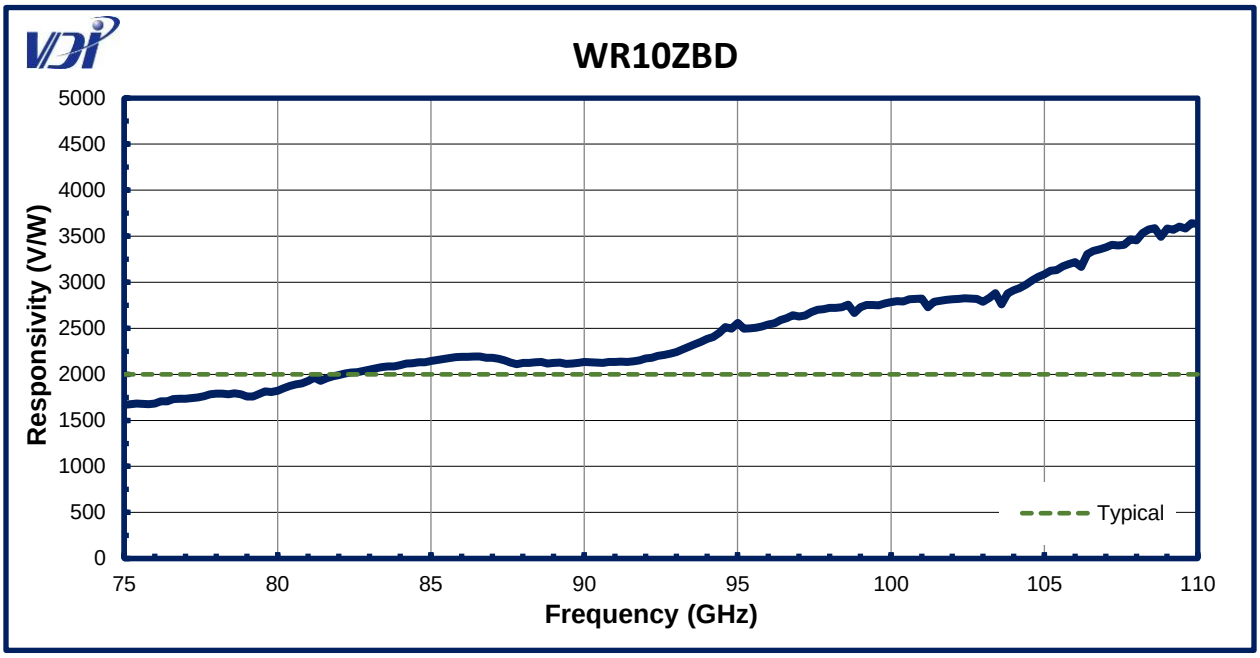
Use "VDI Part Number" in above table with appropriate suffix; -FXX = Fast Detection option with bias tee / amplifier
XX = 06, 20 or 40 (if 6, 20 or 40 GHz Bias-Tee / Amplifier Option is chosen) or TI for 50MHz transimpedance detector amplifier option.

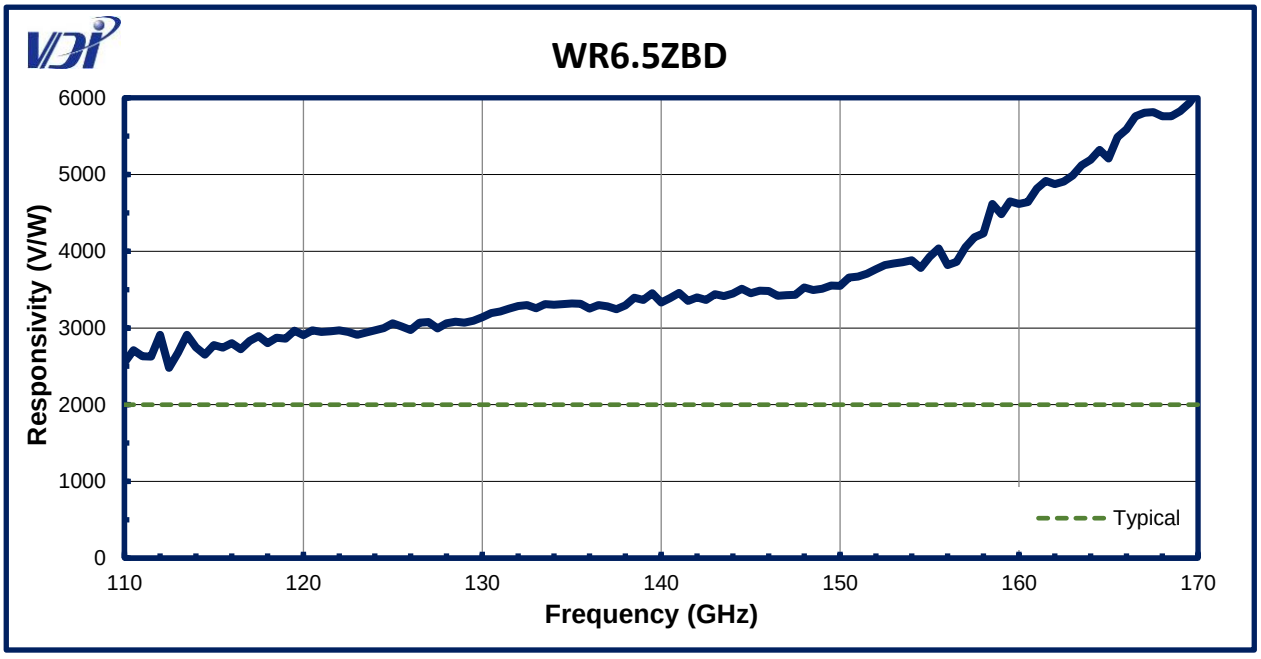
Examples:

WR8.0ZBD: 90-140 GHz Zero-Bias Detector with Internal ESD Protection Option
WR8.0ZBD-F06: 90-140 GHz Fast Detector with 6 GHz Bias-Tee / Amplifier Option (attached) and External ESD Protection Circuit (detached)
WR8.0ZBD-F20: 90-140 GHz Fast Detector with 20 GHz Bias-Tee / Amplifier Option

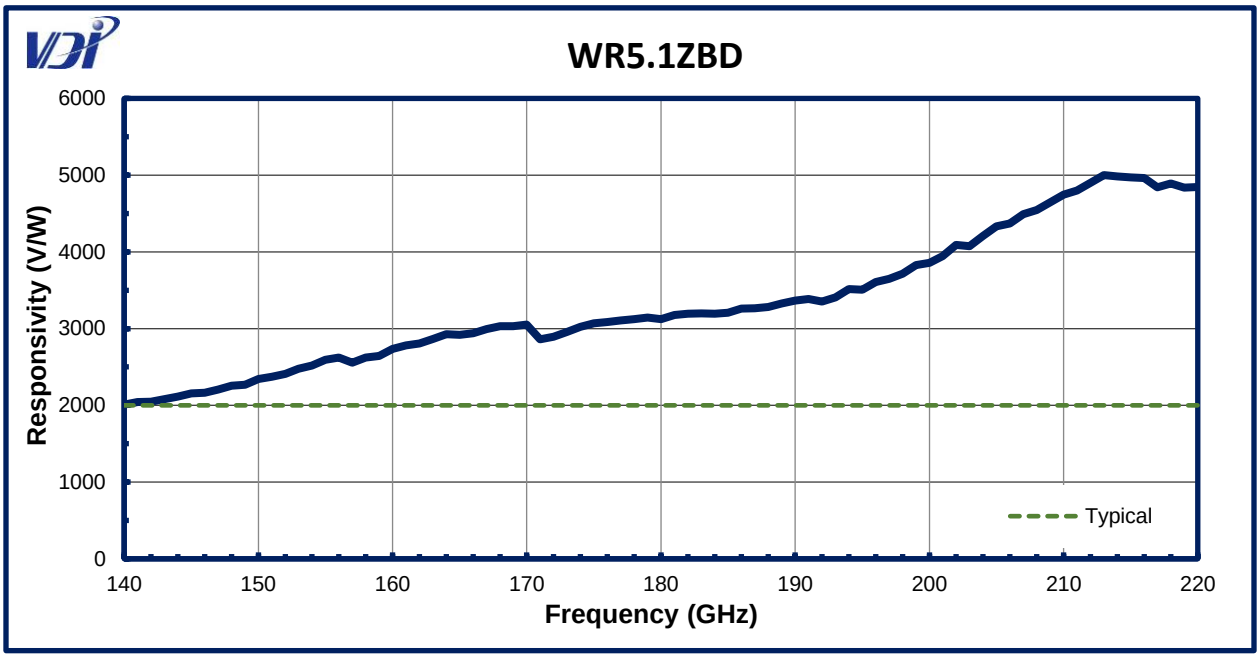
ZBD Responsivity Performance

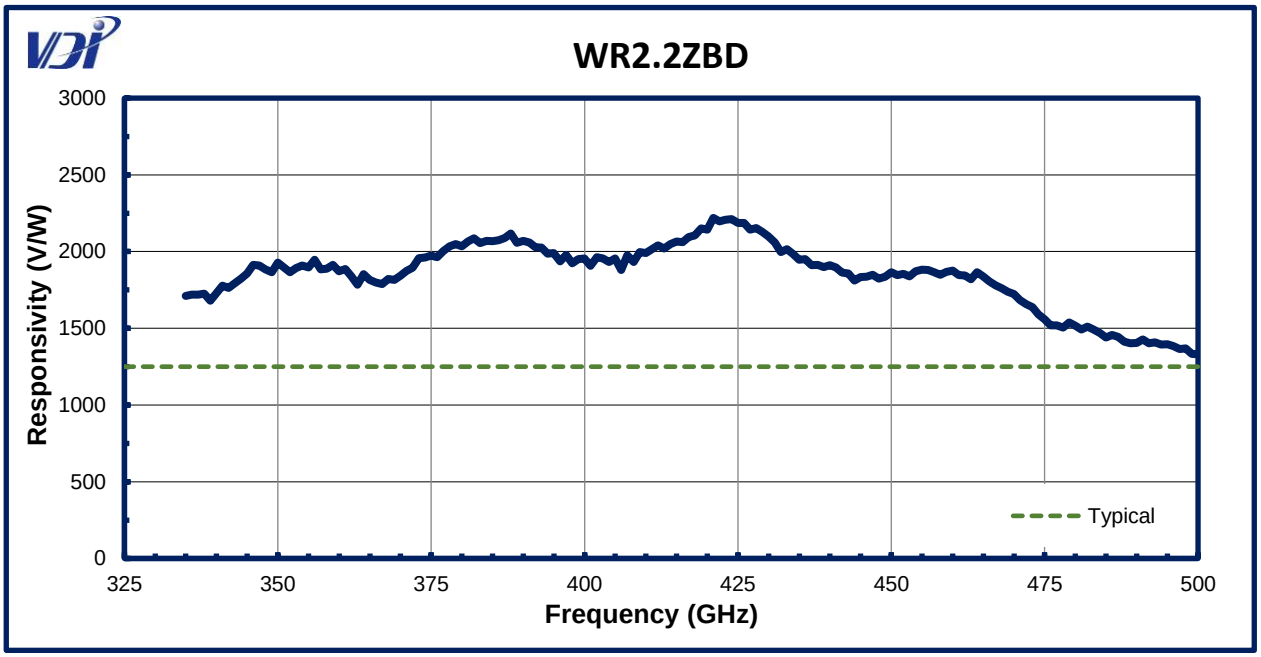
Typical responsivity plots are provided on the following page. More data is available on the VDI website. The responsivity is defined as the ratio between the output voltage and the RF input power in the linear region. Measured performance data will be shipped with each ZBD.





ZBD Performance – WR5.1 and WR2.2





Responsivity vs. RF Input Power

The plot below is an example of how the responsivity changes as a function of RF input power for a specific WR10 detector at ~93 GHz. For small signal RF input power, the detector is in the square law region, where the detector output voltage is proportional to the RF input power.

The general shape of the curve is consistent for all diode detectors. However, the scale will vary with frequency and the detector design and other operating conditions, for example temperature.

Responsivity vs. RF input power data can be supplied for all shipped ZBDs at an additional cost.

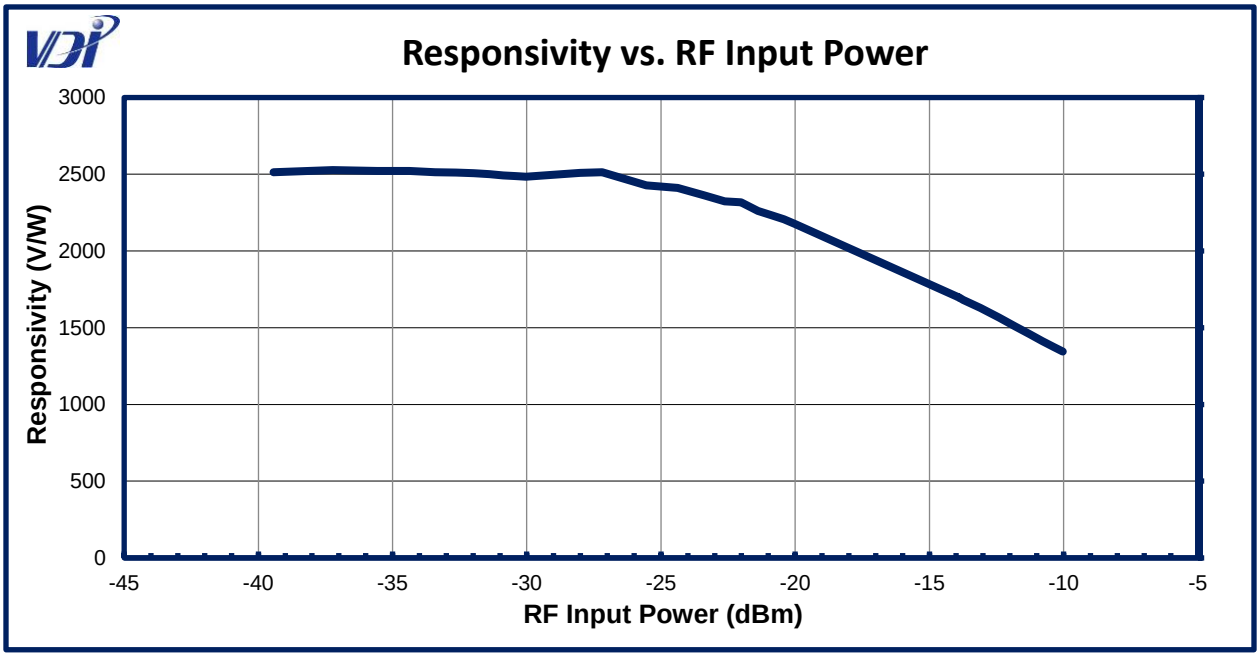
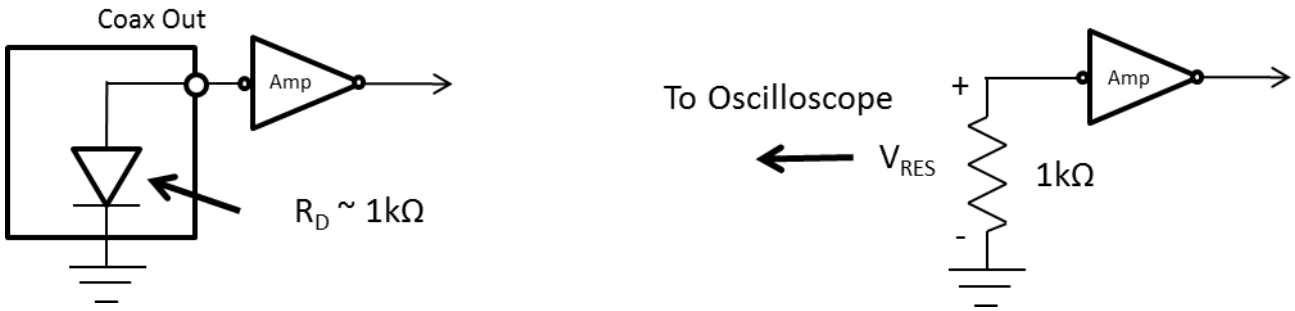


Figure 1: Responsivity vs. RF Input Power
The performance (responsivity vs. RF input power) is shown for a specific WR10ZBD at ~93 GHz.

Amplifier Pre-Testing before Use with VDI Detector

Though VDI ZBDs offer extremely wideband performance, they are extremely ESD sensitive at its coaxial detector output port. To add ESD protection, an amplifier is recommended. However, some amplifiers can exhibit bias or turn-on transients at the amplifier input, which can damage the VDI ZBD. Even with AC coupling at the amplifier input, transients can occur when the amplifier bias is applied rapidly.

Before using an amplifier with a VDI detector, it is recommended that bias or turn-on transients at the amplifier input be tested. Attach a 1kΩ resistor to the input of the amplifier. Monitor the resistor voltage on an oscilloscope as the amplifier bias is applied. The turn-on transient voltages across the resistor should be kept less than ~100mV for safe operation.



VDI Detector with External Amp **Turn-on Transient Testing**

Figure 2: Amplifier Pre-Testing
Block diagrams of amplifier pre-testing, prior to use with VDI detector is shown.

Addendum — Product Updates and Company Contacts

The Virginia Diodes staff of engineering and physical science professionals works to continually improve our products. We also depend upon feedback from colleagues and customers. Ideas to simplify component operations, improve performance or add capabilities are always welcome.

Contact VDI:
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