2022

Compact Converter Operational Manual

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Compact Converters (CC)

Virginia Diodes offers compact converters (CCs) for frequency up and down-conversion. These converters are easy to use and well suited for high performance up and down conversion of wide band modulated millimeter-wave signals. VDI CCs offer full waveguide band coverage and are available from WR28 (22.5-40 GHz) to WR2.2 (330-500 GHz) with additional CCs under development.

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 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

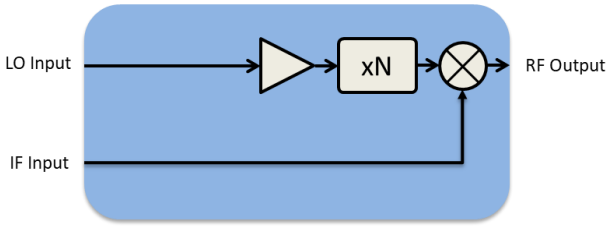
- Inspect waveguide flanges for debris prior to making connections.
- Making a connection with debris between the waveguide flanges can damage the waveguide interface and prevent repeatable connections.
- If debris is present, clean the flange with pre-dampened lint free wipes or swabs (e.g. TexWipe 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

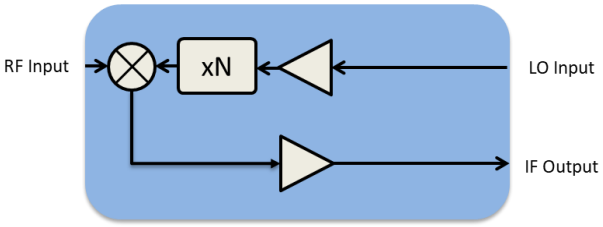
- Check with VDI before any use is attempted beyond those described in this manual, including uses that may exceed limitations stated here or commonly accepted standards of practice.

Compact Converter Configurations

Compact Up-Converter (CCU):
A CCU module is a compact converter module configured for up-conversion. Basic block diagram is shown below.

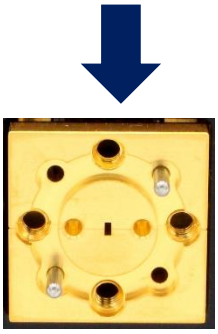


Compact Down-Converter (CCD):
A CCD module is a compact converter module configured for down-conversion. Basic block diagram is shown below.



E-field Polarization Configurations

Default E-field Polarization for each model is specified in the General Specifications table. VDI can offer alternative E-field polarization by appending -V or -H at the end of the part name. VDI plans to remove the E-field polarization option in 2022. Once option is removed, VDI plans to only ship CCU and CCD modules in the default polarization configuration.

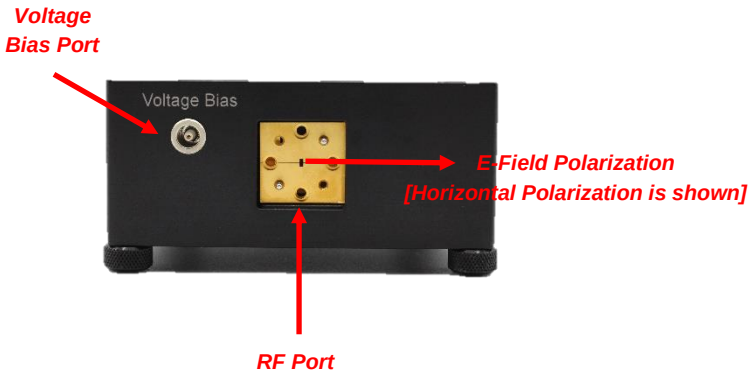


HORIZONTAL E-Field Polarization (-H)

VERTICAL E-Field Polarization (-V)

Compact Converters

CCUs and CCDs have a rectangular waveguide RF port and a coaxial LO and IF port. The drawing for a typical CCU is shown below. CCD has similar ports and labeling. Older CCU and CCD modules may have different form factors, E-field polarization or ports in different locations.



LO Input: *For optimal performance, the user must adjust LO power at each frequency for optimal performance. DO NOT exceed damage limits listed on Page 8.*

IF Port (ESD Sensitive for CCUs only): *The IF port can be used as an input or an output depending on the configuration (see Page 4). The IF port for CCUs is extremely ESD sensitive. The IF port for CCDs has ESD protection. DO NOT apply any DC biases or surges when connecting / disconnecting from IF port. Discharge static from cables before connecting to the device. DO NOT exceed damage limits listed on Page 8. Replace IF port with provided 50Ω termination when IF port is not in use.*

RF Port: *The RF port can be used as an input or an output depending on the configuration (see Page 4). DO NOT exceed damage limits listed on Page 8.*

Voltage Bias Port: *The voltage bias port provides +9V that is used to bias external VDI RF amplifiers.*

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 compact converters.

General Operating Procedure

Turn On:
With the input power turned off, make all necessary connections (i.e. LO cable, IF cable).
Connect VDI RF amplifier to Voltage Bias Port of CCU/CCD (if applicable).
Connect power supply to DC Power port on CCU/CCD.
Apply appropriate LO power to the device then apply small signal input power.

Turn Off:
Turn off small signal input power then turn off LO input power.
Disconnect power supply from DC Power port on CCD/CCD.
Disconnect and turn off all other equipment on user test bench.

CCD: Block Down-Conversion

VDI CCDs can be used to down-convert a block of millimeter-wave / THz signals to the IF band, where it can then be coupled into the RF port of an analyzer or processed by other means. Figure 1 shows how a VDI CCD down-converts a block of millimeter-wave signals. It is important to note that due to the double sideband nature of the CCDs, the mixer will convert both sidebands. The upper and lower sidebands will be down-converted to the same range IF output frequencies.

The IF Output frequency can be calculated by: $f_{IF} = | f_{RF} – N•f_{LO} |$, N is the harmonic factor for the module. N=2 is shown in the figure below.

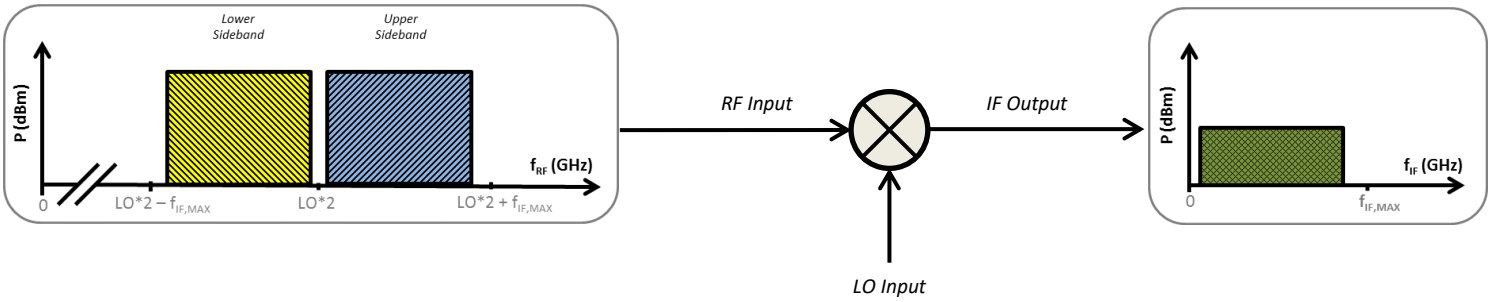


Figure 1: Diagram of double-sideband block down-conversion is shown for subharmonic mixing.

CCU: Block Up-Conversion

The CCUs can also be used to up-convert a block of IF signals to generate a block of millimeter-wave / THz signals for transmission from the RF port. Figure 2 shows how a VDI CCU up-converts a block of IF input signals. Due to the double sideband nature of the CCUs, two sidebands (upper and lower sidebands) are generated during the up-conversion process.

The lower sideband RF Output frequency can be calculated by: $f_{RF\text{-}lower} = N•f_{LO} – f_{IF}$. The upper sideband RF Output frequency can be calculated by: $f_{RF\text{-}upper} = N•f_{LO} + f_{IF}$, where N is the harmonic factor for the module. N=2 is shown in the figure below.

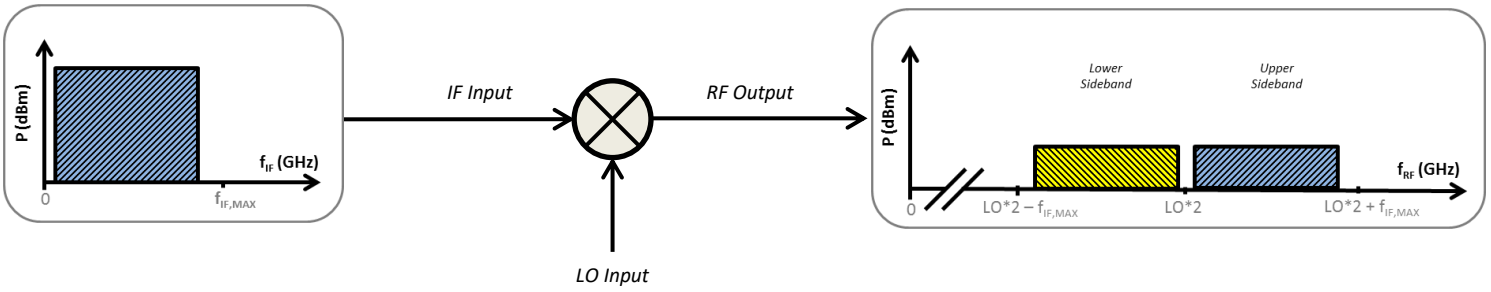


Figure 2: Diagram of double side-band block up-conversion is shown for subharmonic mixing.

CCU: Block Up-Conversion with External BPF and Amplifier

VDI recommends using an external band pass filter and amplifier with the CCU. See Figure 3 below.

BPFs may be preferred for certain applications to eliminate one sideband. VDI offers a range of filters for common wireless communication bands. Custom filters are also available upon request. VDI Amplifiers are broadband with high P1dB to provide high linear output power to overcome conversion and transmission losses. Please refer to the VDI BPF and Amplifier Product Manuals for more information.

Please see Appendix 2 for additional information about the use of broadband amplifiers with CC modules.

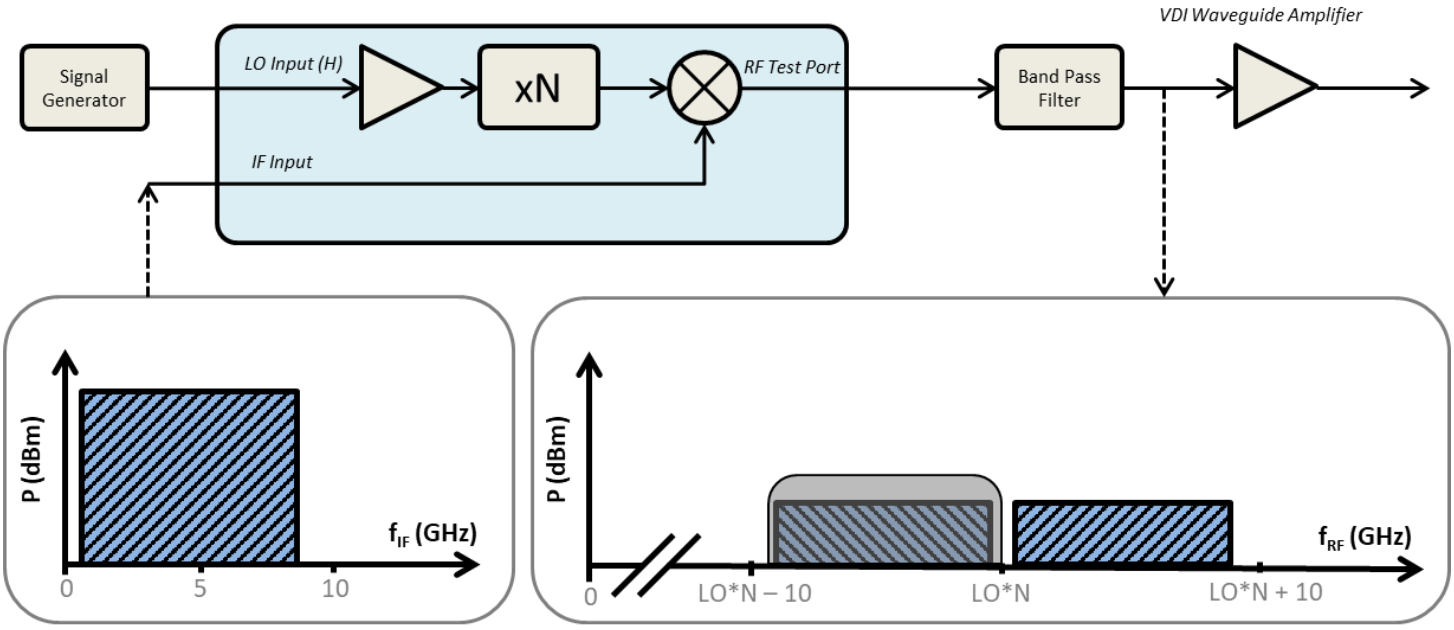


Figure 3: VDI Up-Converter Module with External BPF and Amplifier.

Table 1: General Specifications for VDI CCU and CCD Modules			
Description		**Specification**	**Connector**
LO Input Port (Typical / Damage)	WR28	0 dBm / 10 dBm	See Table 2
	WR19 (Not -B)	0-3 dBm / 6 dBm	
	WR15 (Not -B)	0-6 dBm / 9 dBm	
	WR12 (Not -B)	0-6 dBm / 9 dBm	
	WR10 (Not -B)	6-12 dBm / 15dBm	
	WR19 to WR10 (-B Only)	0-6 dBm / 9 dBm	
	WR8.0 to WR2.2	0-6 dBm / 15 dBm	
IF Input Power Damage Limit (for CCUs)† RF Input Power Damage Limit (for CCDs)†	WR28	10 dBm	2.92mm (f)
	WR19	6 dBm	2.92mm (f)
	WR15 to WR10 (Not -B)	0 dBm	2.92mm (f)
	WR15 to WR10 (-B Only)	12 dBm	2.92mm (f)
	WR8.0 to WR3.4	6 dBm	2.92mm (f)
	WR2.2	0 dBm	2.92mm (f)
IF Frequency	CCU	~10 MHz (min.), See Table 2 for Max IF	--
	CCD	~100 kHz (min.), See Table 2 for Max IF	--
RF Test Port	VDI Precision Flange	WR15 and Higher Frequency	UG-387/UM
		WR28 to WR19	UG-599/UM
Default E-Field Polarization	WR28 to WR10 (Not -B)	Horizontal	--
	All Others	Vertical	--
IF Amplifier Gain (dB)††	For CCDs Only	~12dB	--
AC Inputs	Single-Volt Power Supply (+9V / 4A)	100-240VAC, 3.5A, 50-60Hz	U.S. or E.U.
Maximum Weight	--	2.0 Lbs. (0.91 Kg.)	--
Dimensions (Enclosure, without Connectors, L x W x H)	WR28 to WR10 (Not Including CCU-B and CCD-B Modules)	3.75” x 3.00” x 1.50” (See VDI Website for Drawing)	--
	All Others	5.00” x 3.50” x 1.50” (See VDI Website for Drawing)	--
Operating Temperature	Typical / Recommended	25ºC / 20-30ºC	--

†The IF Input Damage Limit (for CCUs) and the RF Input Damage Limit (for CCDs) are the same. The IF Connector is specified here. The RF Test Port specifications are listed separately in the table above.
††CCD modules include an IF amplifier with ~12dB gain.

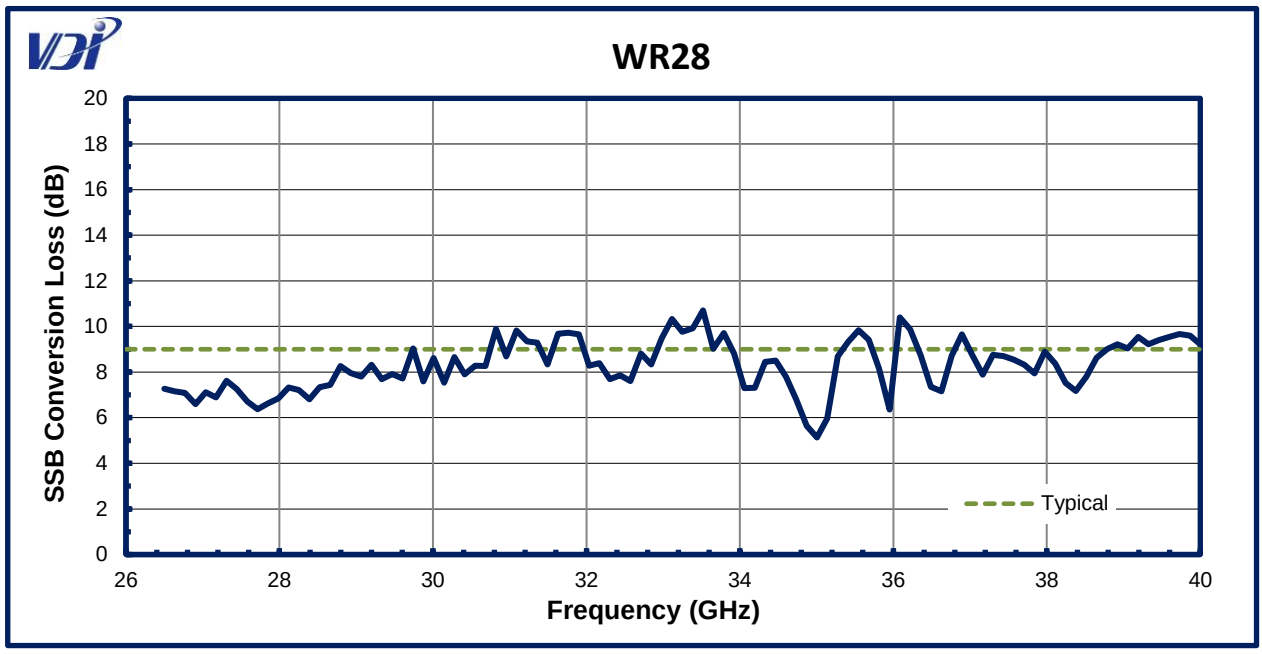
Table 2: Product Specifications for Compact Converters									
Waveguide Band	**RF Freq. (GHz)**	**Up-Converter**	**Down-Converter**	**LO Harmonic Factor**	**LO Input Freq. (GHz)**	**LO Connector**	**Intrinsic Mixer Conversion Loss (dB, typ.)†**	**Input Power (~P1dB / ~P0.1dB)**	**Max. IF Freq. (GHz)**
WR28	22.5-40	WR28CCU	WR28CCD	1	22.5-40	2.92mm(f)	9	8 / -5	8.5
WR19	40-60	WR19CCU	WR19CCD	2	20-30	2.92mm(f)	9	-4 / -14	6
		WR19CCU-B	WR19CCD-B	2	20-30	2.92mm(f)	10	+5 / -5	9
WR15	50-75	WR15CCU	WR15CCD	2	25-37.5	2.92mm(f)	10	P_{LO} – 10dB / P_{LO} – 20dB*	9
		WR15CCU-B	WR15CCD-B	2	25-37.5	2.92mm(f)	10	+5 / -5	9
		WR15CCU-B-M4	WR15CCD-B-M4	4	12.5-18.75	2.92mm(f)	10	+5 / -5	9
WR12	60-90	WR12CCU	WR12CCD	2	30-45	2.4mm(f)	10	P_{LO} – 10dB / P_{LO} – 20dB*	12
		WR12CCU-B	WR12CCD-B	2	30-45	2.4mm(f)	10	+5 / -5	12
		WR12CCU-B-M4	WR12CCD-B-M4	4	15-22.5	2.92mm(f)	10	+5 / -5	12
WR10	75-110	WR10CCU	WR10CCD	2	37.5-55	1.85mm(f)	10	P_{LO} – 10dB / P_{LO} – 20dB*	15
		WR10CCU-B	WR10CCD-B	4	18.8-27.5	2.92mm(f)	10	+5 / -5	15
WR8.0	90-140	WR8.0CCU	WR8.0CCD	4	22.5-35	2.92mm(f)	10	-1 / -11	15
WR6.5	110-170	WR6.5CCU	WR6.5CCD	6	18.3-28.3	2.92mm(f)	10	-1 / -11	17
		WR6.5CCU-M4	WR6.5CCD-M4	4	27.5-42.5	2.92mm(f)	10	-1 / -11	17
		WR6.5CCU-M12	WR6.5CCD-M12	12	9.2-14.2	2.92mm(f)	10	-1 / -11	17
WR5.1	140-220	WR5.1CCU	WR5.1CCD	6	23.3-36.7	2.92mm(f)	11	-1 / -11	22
WR4.3	170-260	WR4.3CCU	WR4.3CCD	6	28.3-43.3	2.92mm(f)	11	-1 / -11	26
WR3.4	220-330	WR3.4CCU	WR3.4CCD	6	36.7-55	1.85mm(f)	12	-1 / -11	40
		WR3.4CCU-M12	WR3.4CCD-M12	12	18.3-27.5	2.92mm(f)	12	-1 / -11	40
WR2.2	330-500	WR2.2CCU	WR2.2CCD	12	27.5-41.7	2.92mm(f)	14	-7 / -17	40

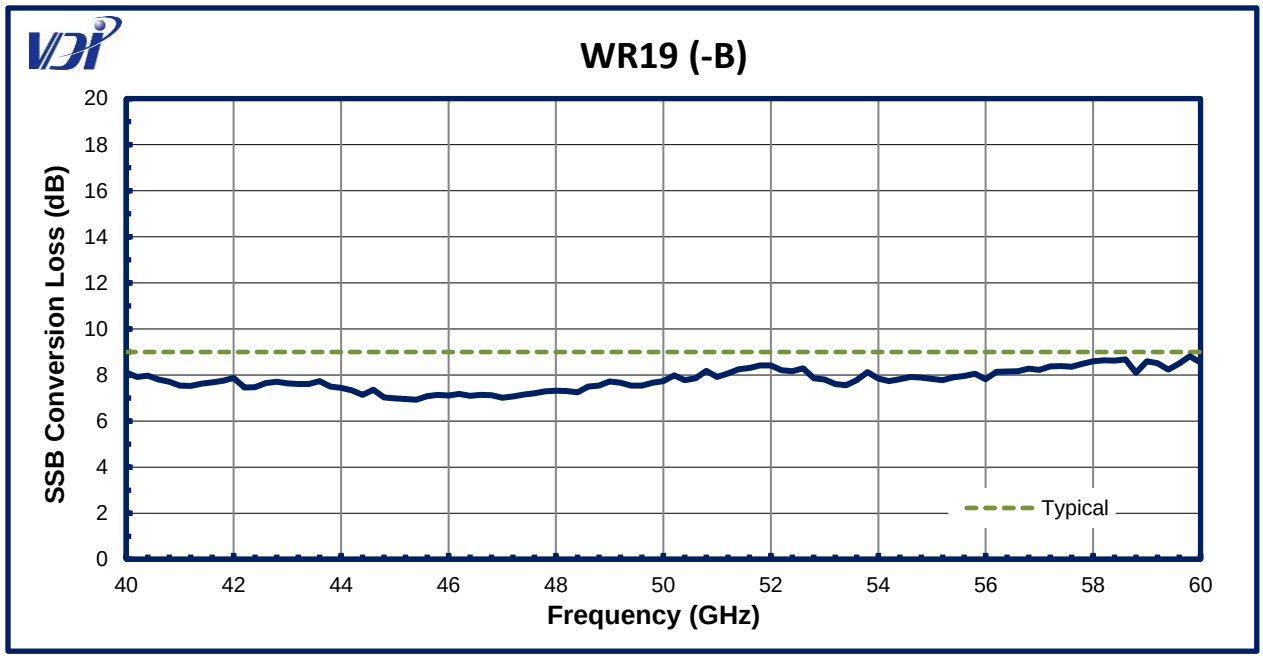
*LO Input Power for optimal conversion loss varies with LO input frequency.
†Conversion Loss is defined as the intrinsic mixer conversion loss without any external amplifiers.

General Notes:
• VDI CCs include a single-volt power supply.
• The required LO power for optimal performance varies across the frequency band. Performance specifications assume optimal RF and LO power coupled into the mixer; performance may be reduced near band edges.
• Conversion Loss performance is specified at ~1 GHz IF. Conversion loss increases as a function of IF, at a rate of ~1.5dB/10GHz, up to the specified Maximum IF Frequency. Performance is typical with reduced performance at band edges.
• RF filters can be used to eliminate one sideband of the CCU RF output. Contact VDI for more information.
• RF amplifiers can be used to increase the CCU RF output power. Contact VDI for more information.
• Where available, an input isolator will smooth the required LO input power vs. frequency.

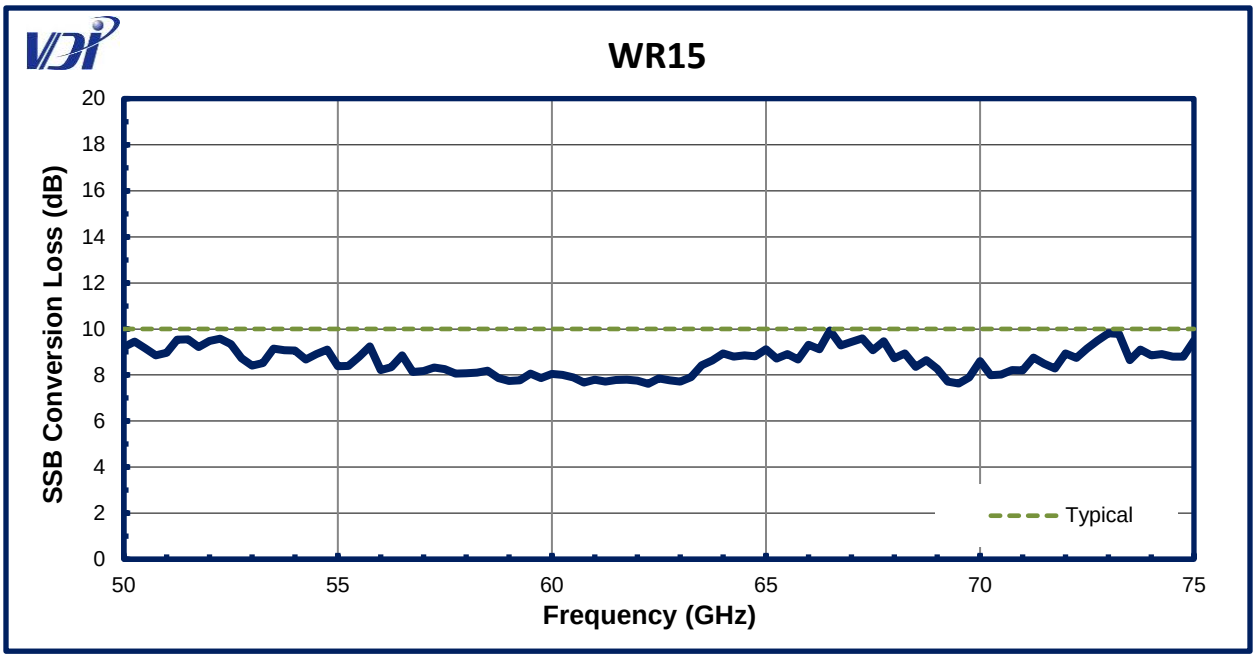
CCU/CCD Single Side Band (SSB) Conversion Loss Performance

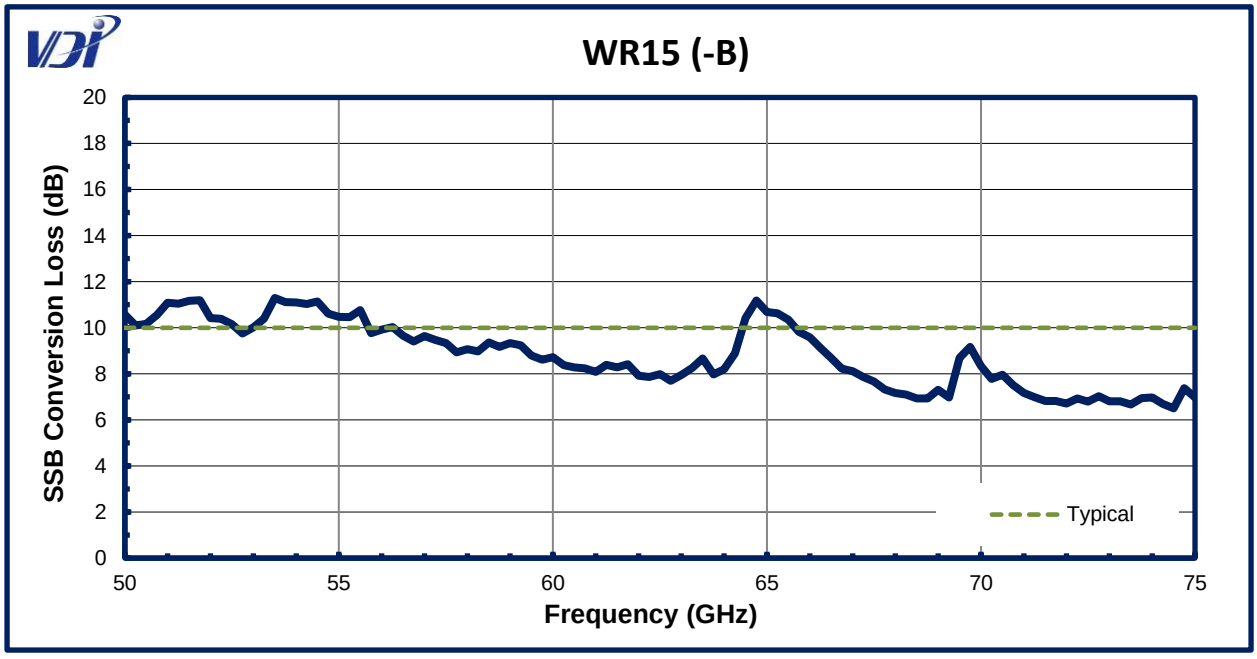
Typical CCU/CCD SSB intrinsic mixer conversion loss data is provided below. Data below does not include any internal or external amplification and is tested at ~400 MHz IF. Measured conversion loss will be shipped with each VDI CC.



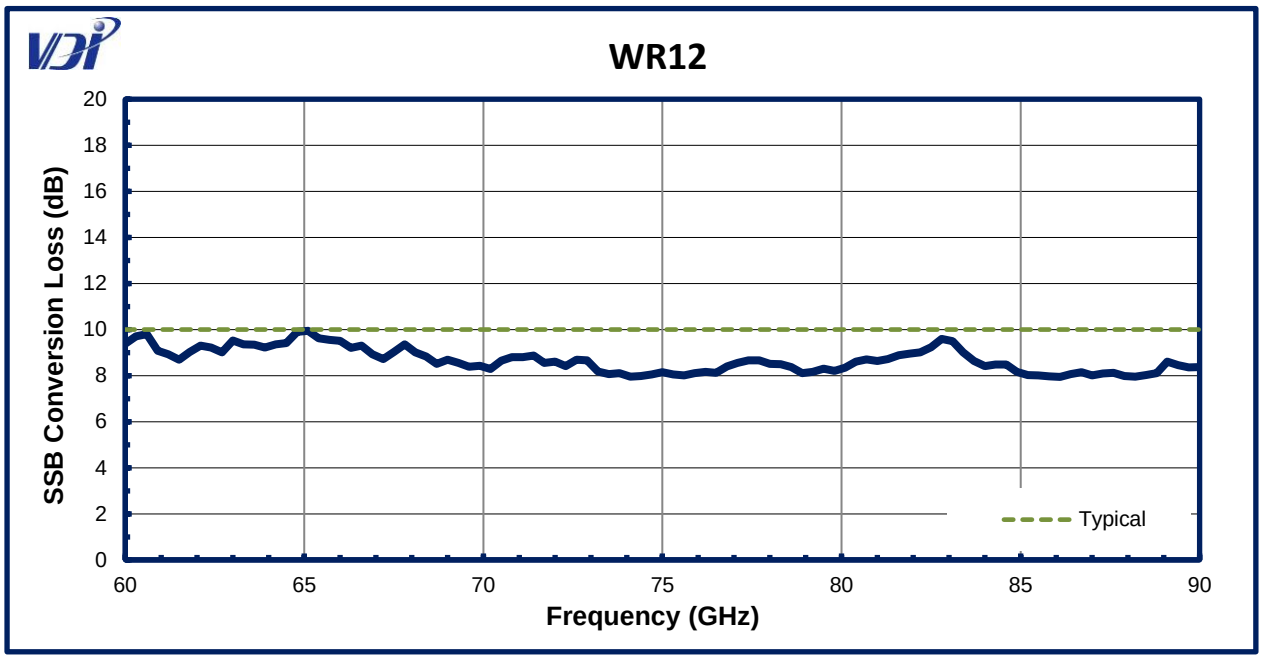


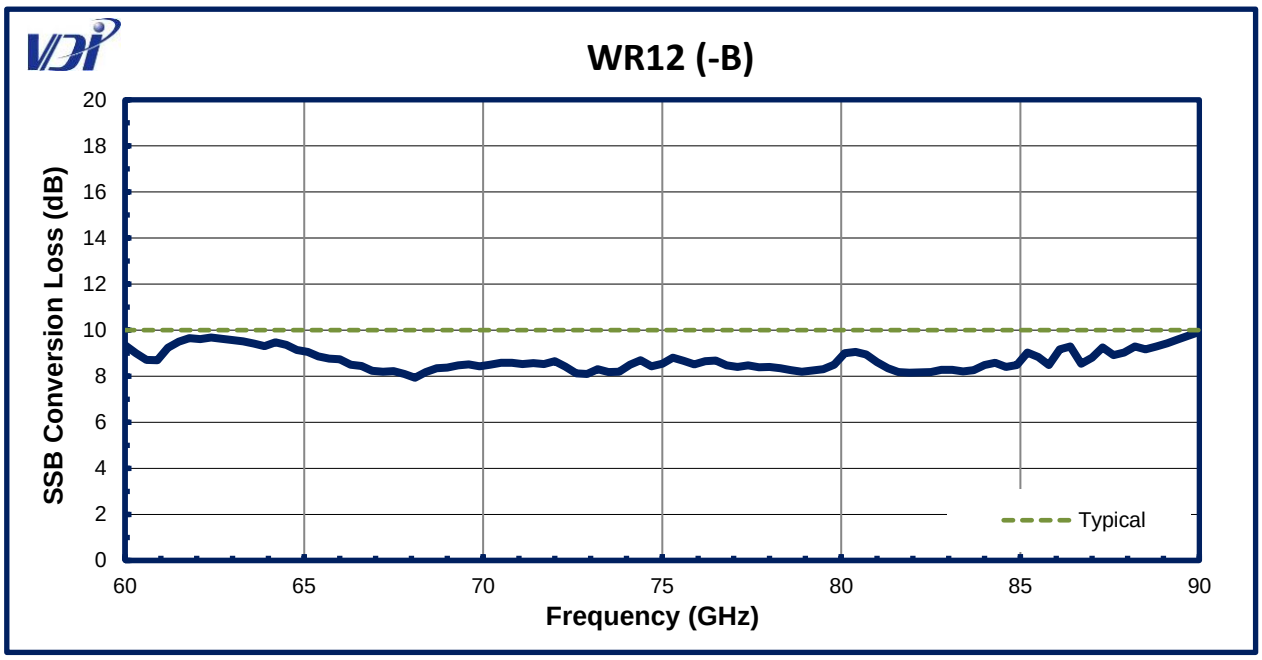
CCU/CCD Single Side Band (SSB) Conversion Loss Performance - continued



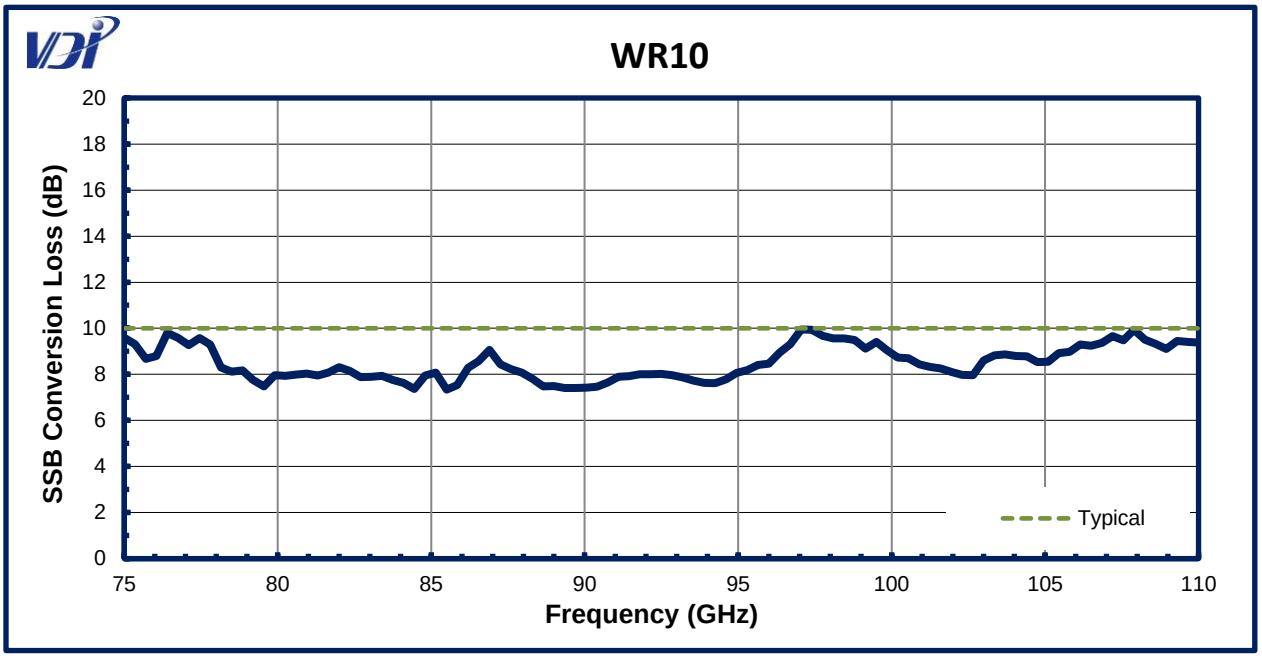


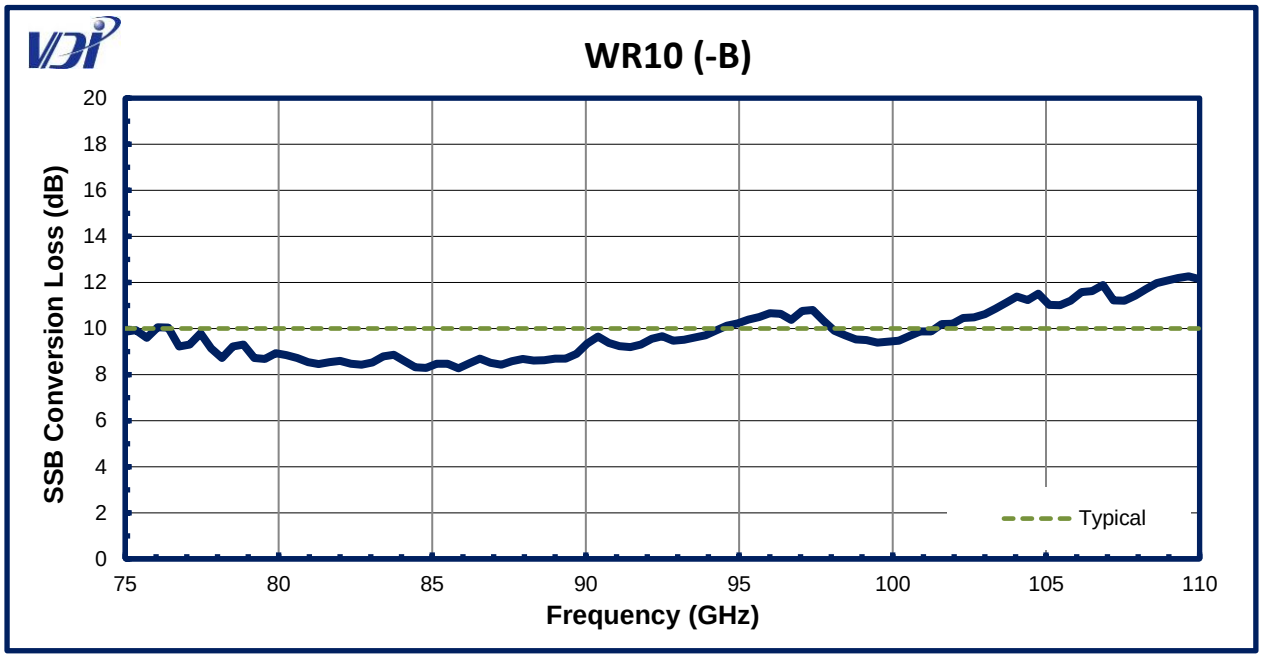
CCU/CCD Single Side Band (SSB) Conversion Loss Performance - continued



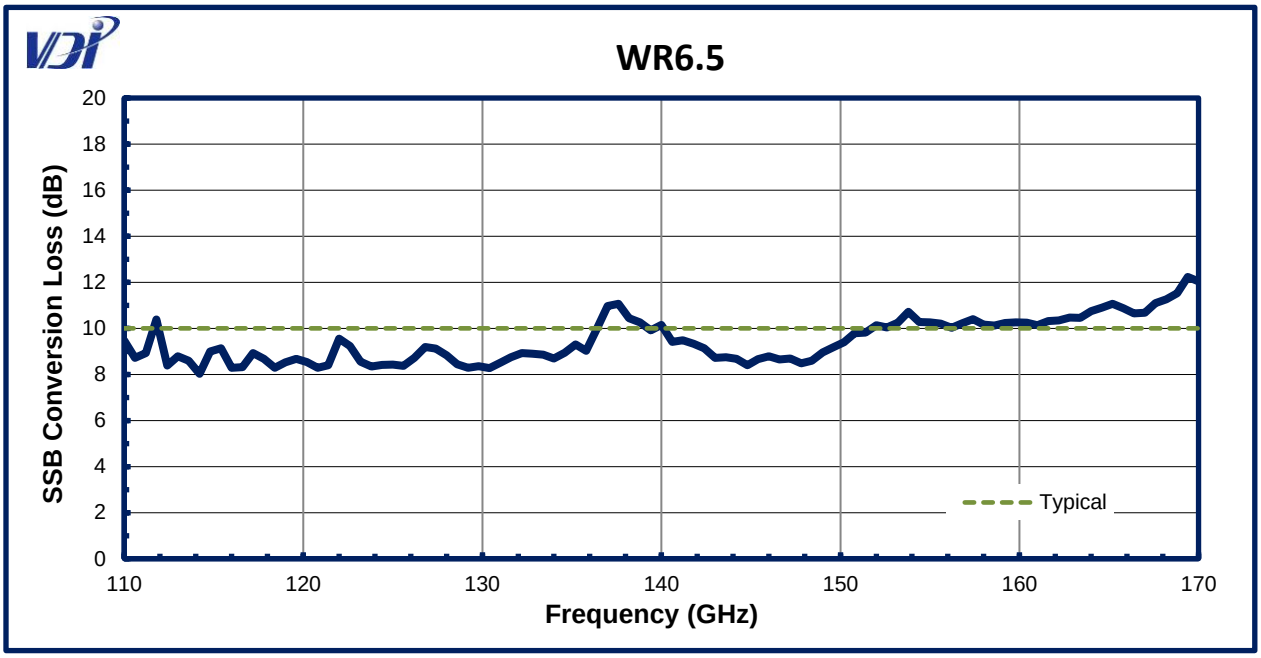


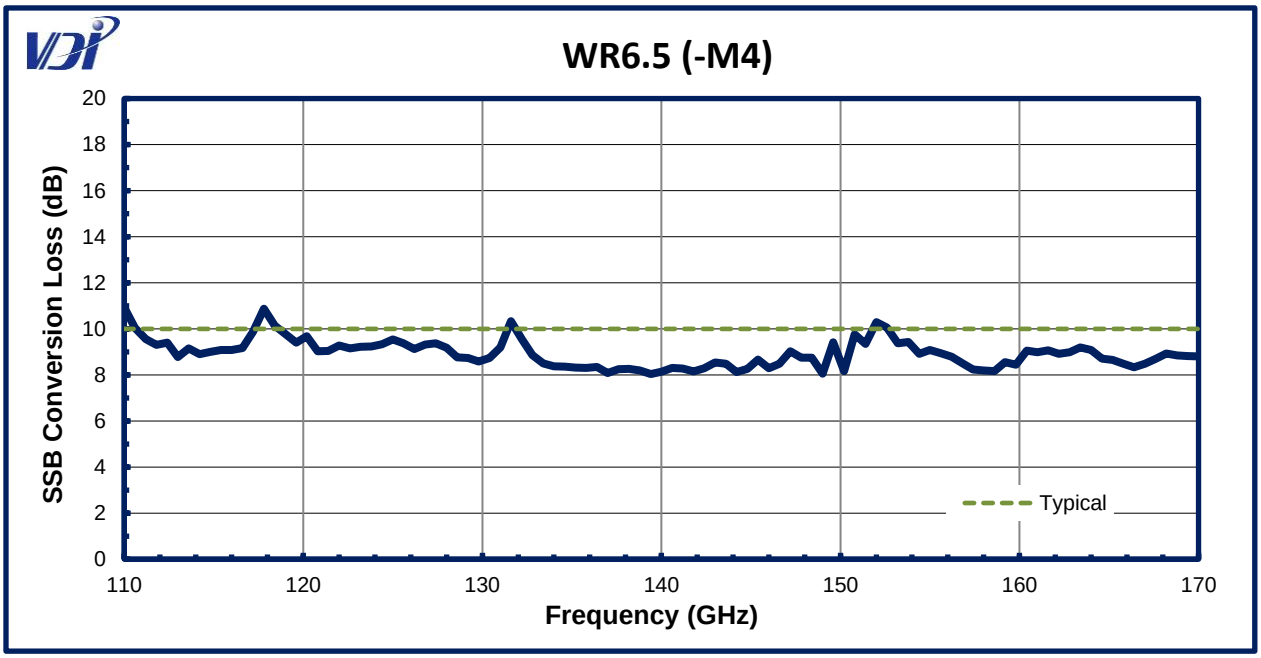
CCU/CCD Single Side Band (SSB) Conversion Loss Performance - continued



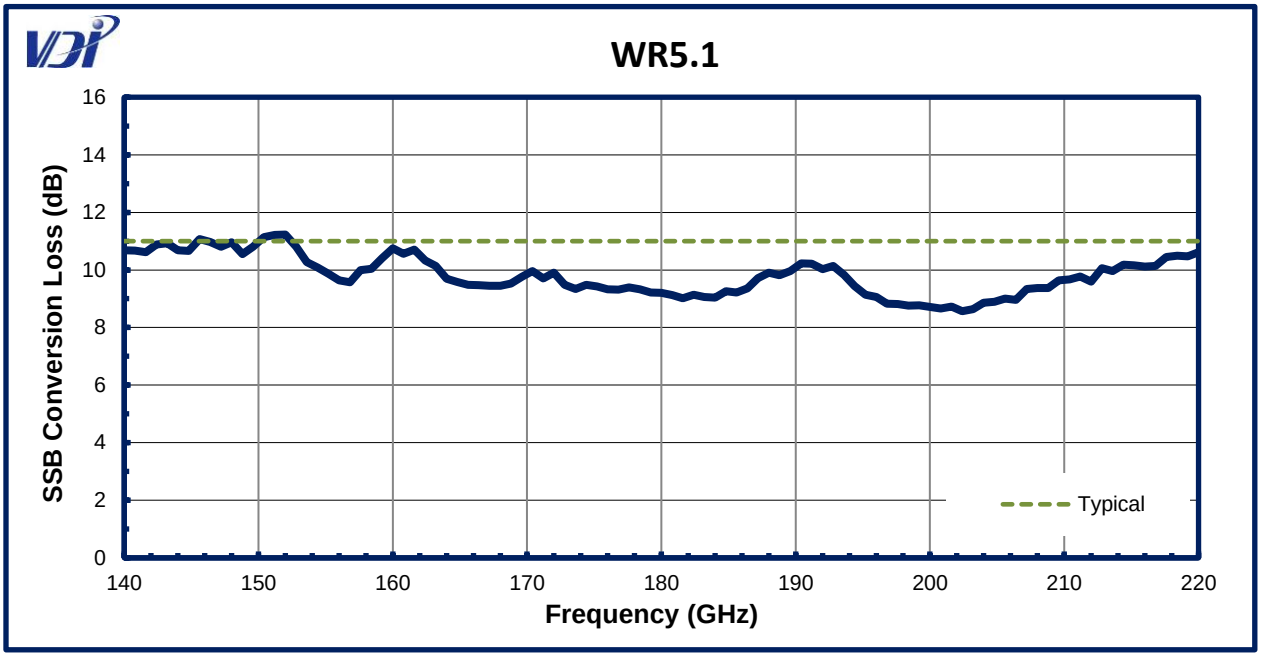


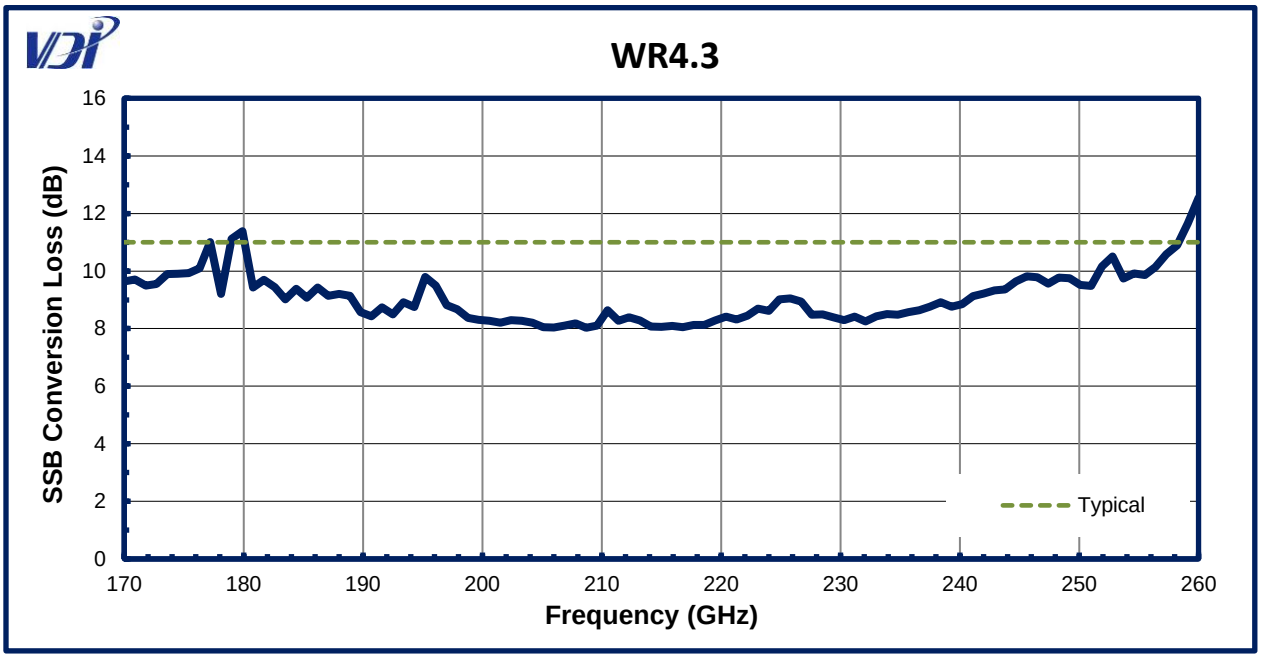
CCU/CCD Single Side Band (SSB) Conversion Loss Performance - continued



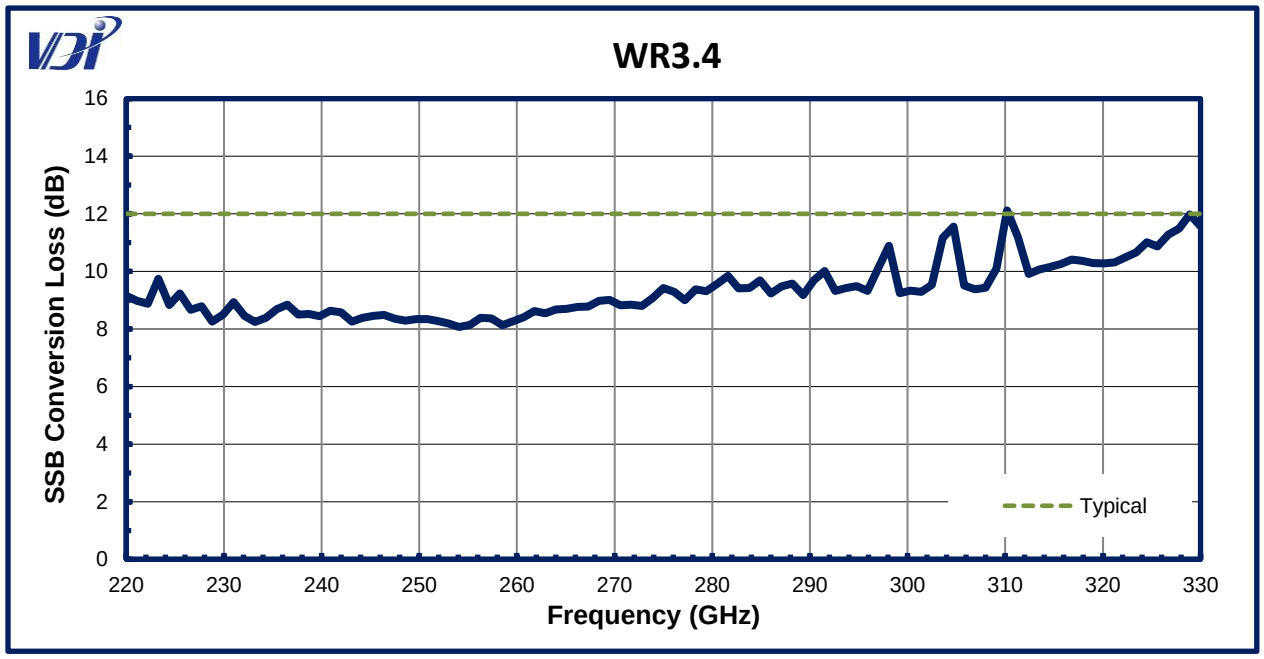


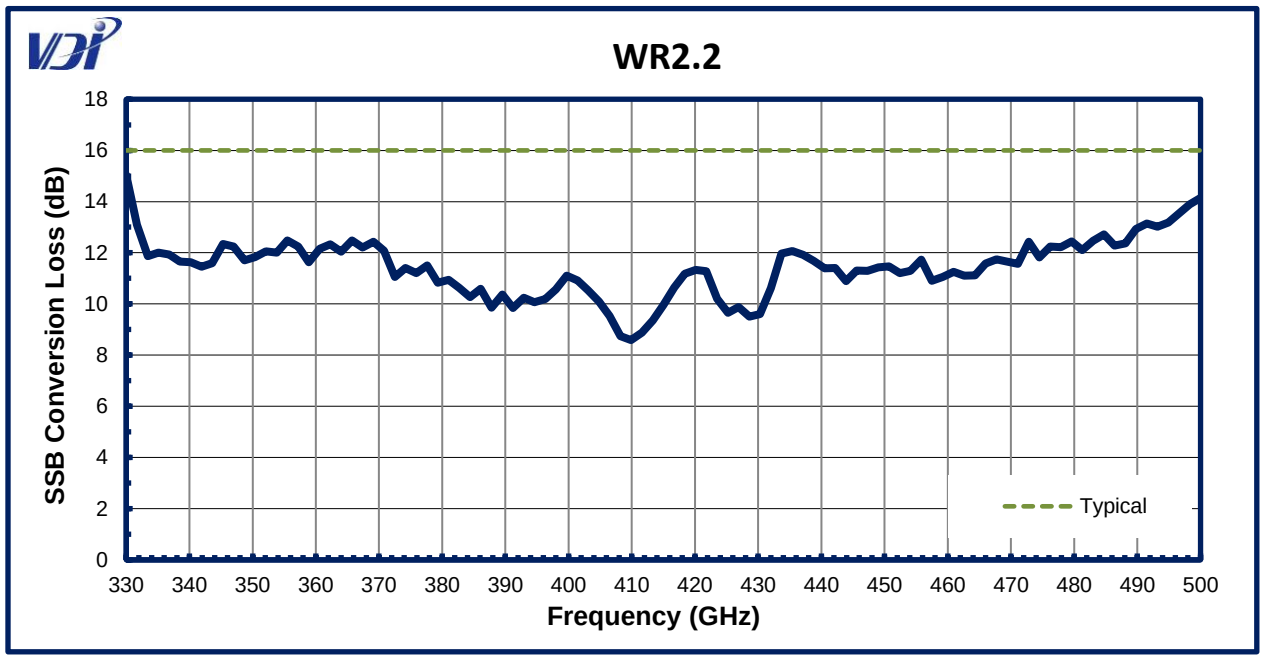
CCU/CCD Single Side Band (SSB) Conversion Loss Performance - continued





CCU/CCD Single Side Band (SSB) Conversion Loss Performance - continued



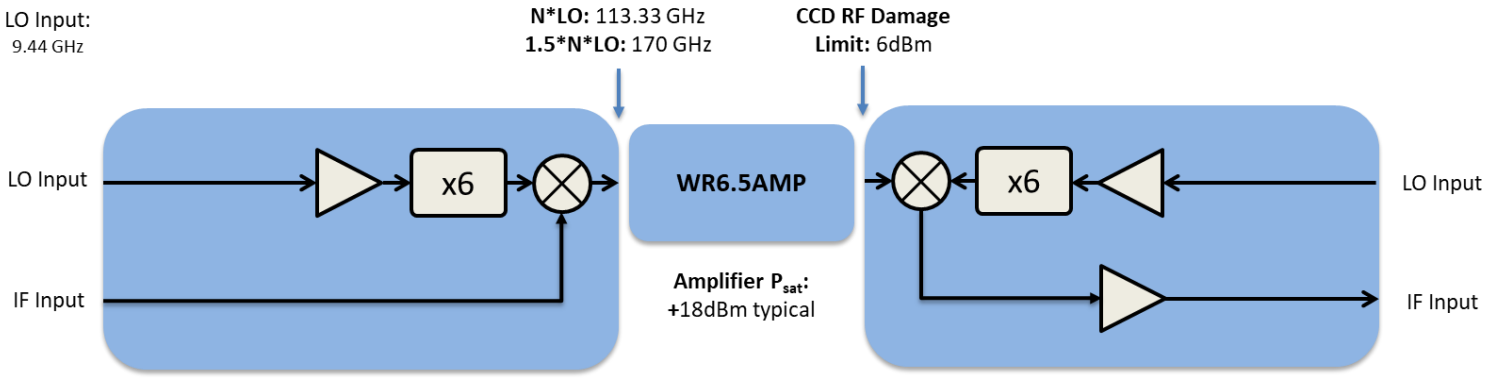


Filtering Out 1.5·N LO Harmonic Output of CC

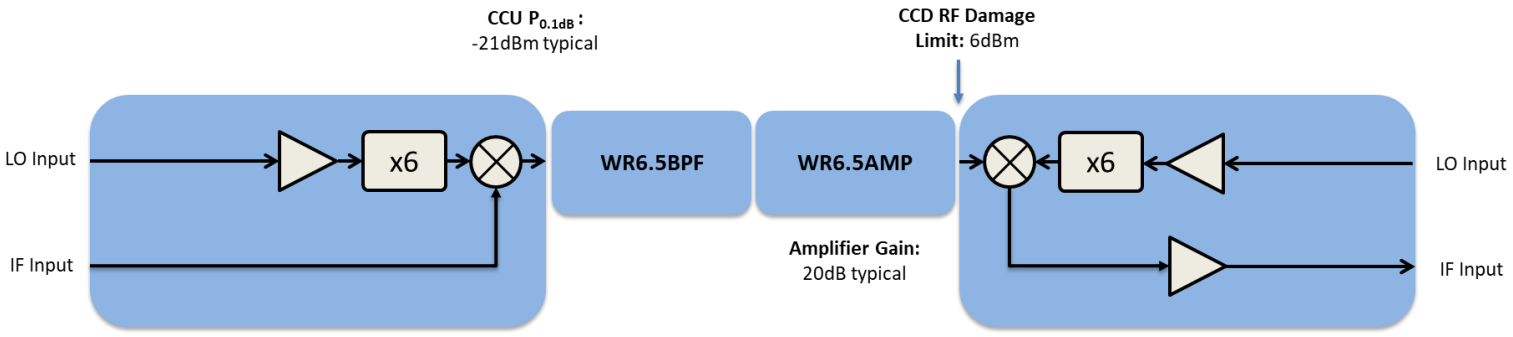
VDI recommends using a BPF in between the CCU and VDI Broadband Waveguide Amplifiers. Depending on LO input frequency of the CCU, the 1.5*N LO Harmonic may fall within the operational band of the VDI Waveguide Amplifier. Without the BPF, the amplifier can boost the unwanted LO harmonic signal. This may result in amplifier compression or damaging a matching CCD module if the CCD is directly connected to the amplifier output. The BPF will significantly reduce the level of many unwanted signals and only pass signals within the BPF pass band.

The block diagram below shows a possible scenario where you could damage a WR6.5CCD when you do not use a BPF in between the WR6.5CCU and WR6.5AMP. The 170 GHz signal (1.5*N LO Harmonic) is amplified enough to where the power at the amplifier output exceeds the damage limit of the CCD. Please contact VDI for more information.

Configuration without BPF: NOT RECOMMENDED



Configuration with BPF: RECOMMENDED



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:
Virginia Diodes, Inc. Web: http://www.vadiodes.com Email: Technical@vadiodes.com Telephone: 434.297.3257