W-Band Frequency Converter

RF: 70 – 87 GHz| IF: 20 – 27 GHz | Phase-Coherent Conversion

KEY FEATURES

- **IF: 20 - 27 GHz**
- **RF: 70 - 87 GHz**
- **1x Upconversion & 1x Downconversion channels**
- **High output power: +14dBm @ 77GHz**
- **Shared LO - Phase-Coherent Conversion**
- **Built-In-Self-Test Functionality**
- **Optional LO Generation Module**

APPLICATIONS

- RF Automated Testing
- VNA Frequency Extension
- Low-cost Production Test Stations
- Automotive Radar Research and Development
- 5G/6G Research and Development

PRODUCT DESCRIPTION

EECL's W-Band Frequency Converter provides up and down frequency conversion between K-Band (20-27 GHz) and W-Band (70-86GHz). The upconversion output features power amplification, and can produce up to +16dBm output power at W-Band. The downconversion input features a low noise figure (8dB) and very high input dynamic range.

The module integrates the LO drive chains to drive the conversion mixers, including a frequency doubler. Thus, only a low-power (-12.5 dBm typical) LO input is needed, in the K-band range (25-30 GHz). The doubled LO is shared between the upconversion and downconversion channels thus allowing for frequency-and-phase coherent conversion, as is required for radar and VNA extension applications.

The module features advanced Built-in-self-test (BIST) functionality, including a switchable self-test loopback path, real-time RF output power detection, and full monitoring of active device power supply voltages and currents.

All active RF devices use proprietary active-biasing technology to ensure unit-to-unit consistency, and minimize temperature-dependent performance variations. Furthermore, the module can be actively temperature-stabilized via a built-in heater, thus achieving near-zero performance drift even in challenging operating environments.

The module provides a low-cost gateway into E-band and W-Band frequencies for research and development into applications such as automotive radar, satcom, and telecoms research.

An optional module can be added on to internally handle LO generation, further simplifying integration to external test equipment. This optional add-on also integrates USB power and communication options.

PERFORMANCE SPECIFICATIONS

Upconversion Specifications

Parameter	Minimum	Typical	Maximum
IF Input Frequency	20 GHz	-	27 GHz
RF Input Frequency	70 GHz	-	87 GHz
Conversion Gain	-	15 dB @ 77 GHz	-
Output P_{3dB} (P_{Sat})	+ 12 dBm	+ 14 dBm @ 77 GHz	-

Downconversion Specifications

Parameter	Minimum	Typical	Maximum
RF Input Frequency	70 GHz	-	87 GHz
IF Output Frequency	20 GHz	-	27 GHz
Conversion Gain	-	-5 dB @ 77 GHz	-
Front-End Attenuator (VVA)	-4 dB	-	-40 dB
Maximum RF Input Power(1)	-	+0 dBm @ VVA = -4 dB +30 dBm @ VVA = -40 dB	-
Noise Figure(2)	-	8 dB @ VVA = - 4 dB	-

(1) Maximum RF Input Power depends on Front-end attenuator (VVA) setting. Consult EECL if exact data is needed for other VVA values.
(2) Noise figure depends on Front-end attenuator (VVA) setting. Consult EECL if exact data is needed for other VVA values.

LO Specifications

Parameter	Minimum	Typical	Maximum
LO Input Frequency	25 GHz	27.5 GHz	30 GHz
LO Multiplication	-	2x	-
LO Input Power	-15 dBm	-12.5 dBm	- 5 dBm

Power Supply

Parameter	Minimum	Typical	Maximum
DC Supply Voltage	6V	-	16V
Current Draw	-	1A @ 6V(1)	-
Power Consumption	-	6W	-

(1) Current consumption varies with input DC supply voltage. Consult EECL if exact data is needed for other supply voltages.

DC Blocking - Maximum Voltage Ratings

Parameter	Minimum	Typical	Maximum
DC Voltage on LO input	-	-	16 VDC
DC Voltage on IF input/outputs	-	-	16 VDC
DC Voltage on RF input/outputs	-	-	16 VDC

Self-Test Loopback Mode

Parameter	Minimum	Typical	Maximum
Loopback Path Attenuation	-	20 dB @ 77 GHz	-

Connectors and Mechanical

Parameter	Specification
IF & LO Connectors	SMPM - Male (2.92mm (Female) option available on request)
RF Connectors	1mm - Female (waveguide option available on request)
Power & Control Connector	TE-Connectivity 234464-E
Communication Protocol	UART or SPI (other options available on request)
Size	75 x 75 x 16 mm (2.95 x 2.95 x 0.63 inch)
Weight	180g (0.4 lbs)
Housing Material	Gold-plated Aluminium

TYPICAL PERFORMANCE DATA

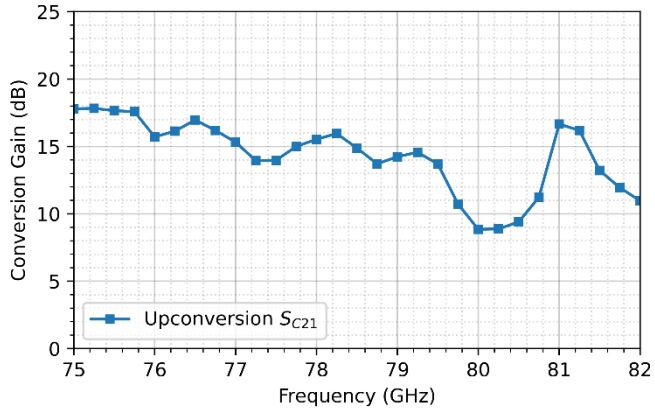


Figure 1. Up-Conversion Gain (RF = 75 – 82GHz, IF = 20 – 27GHz, LO = 55 GHz, Pin = -30dBm)

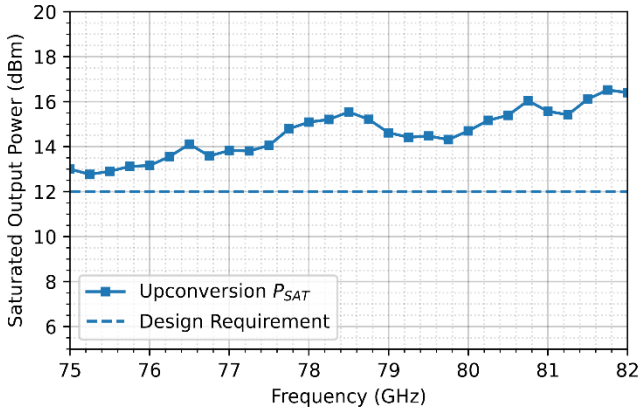


Figure 2. Up-Conversion P_{3dB} (P_{Sat}) (RF = 75 – 82GHz, IF = 20 – 27GHz, LO = 55 GHz, Pin = Pout - Gain)

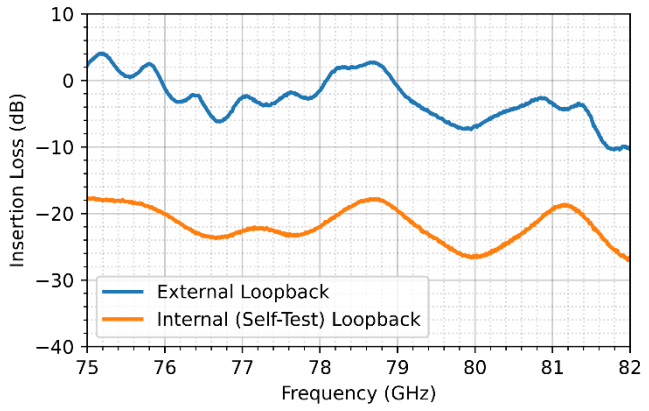


Figure 3. Loopback Gain - External (short thru between RF OUT and RF IN) vs Internal (Self-Test). Data plotted over RF frequency.

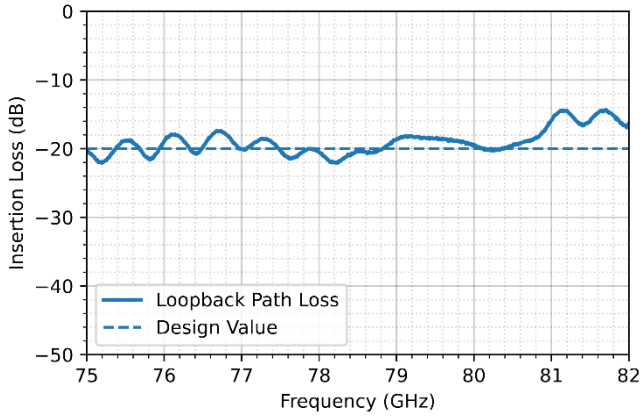
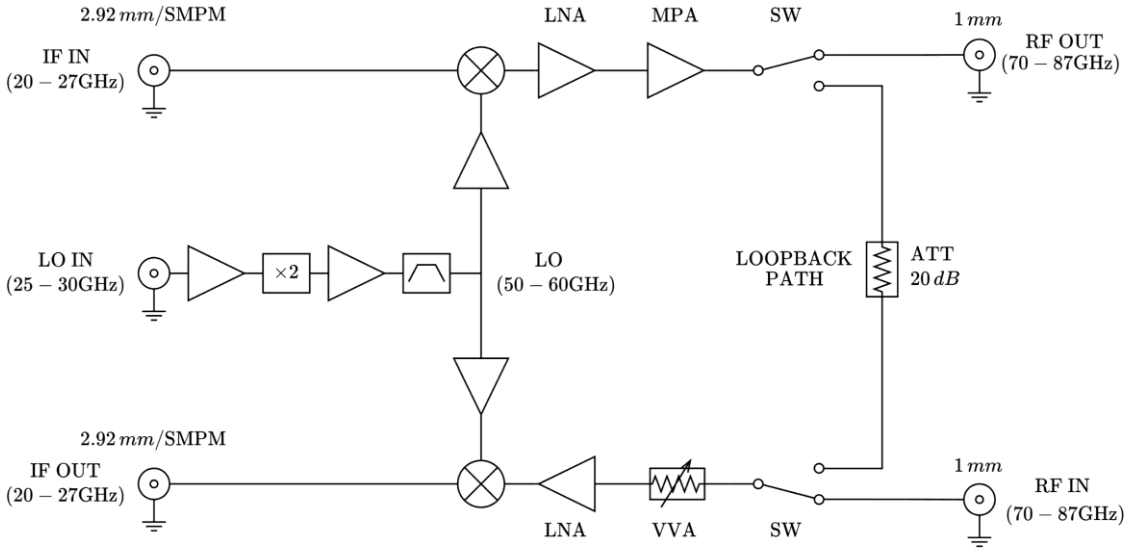


Figure 4. Internal Self-Test Loopback Path Insertion Loss

FUNCTIONAL BLOCK DIAGRAM



DETAILED DESCRIPTION

The converter can be broadly divided into three main subsections - a shared Local Oscillator (LO) section, a W-band upconversion section, and a W-band downconversion section.

LO Input and Generation

The shared LO chain comprises amplification, a frequency doubler, and a bandpass filter. The input LO frequency (nominally 25 – 30 GHz) is doubled internally, allowing the input LO to be K-band, same as the IF input and outputs. The doubled LO is amplified, split to the upconversion and downconversion mixers through a printed power divider, and then further amplified to the correct mixer drive level. The integrated amplification inside the LO chain allows the module input LO drive level to be only -12 dBm - much lower than many commercially available frequency converters at these frequencies, many of which require upwards of 10-15 dBm of input LO power.

A printed bandpass filter is used to supress any non-doubled input LO signals (25 – 30 GHz) from reaching the mixer, creating unwanted conversion products.

The shared-LO nature of the up-downconversion guarantees a stable phase relationship between the IF input and outputs, thus allowing the converter to be used in phase-sensitive applications, such as VNA extenders, and radar front-ends.

An optional module can be added on to internally handle the input LO generation, further simplifying integration to external test equipment.

Upconversion

The upconversion RF chain consists of the upconverting mixer and two amplification stages - a W-Band Low-Noise Amplifier (LNA) and a W-Band Medium Power Amplifier (MPA). This allows for a high typical upconversion gain of 15 dB and maximum output power of +14 dBm at 77 GHz.

Downconversion

The downconverter RF chain consists of an input Voltage-Variable Attenuator (VVA) followed a W-Band LNA identical to the one used in the upconversion chain.

The variable attenuator allows flexible configuration of the downconversion, supporting either a high maximum input power (up to +30 dBm) or a low

noise figure (as low as 8 dB). Intermediate configurations are also possible, allowing the end user to tailor input power handling and noise performance to their application requirements.

Built-In-Self-Test

This converter is designed to be compatible with long-term integration inside an industrial or otherwise complex testing environment. To facilitate this Built-in Self-Test functionality is integrated, to allow for the device performance and health to be verified remotely and automatically.

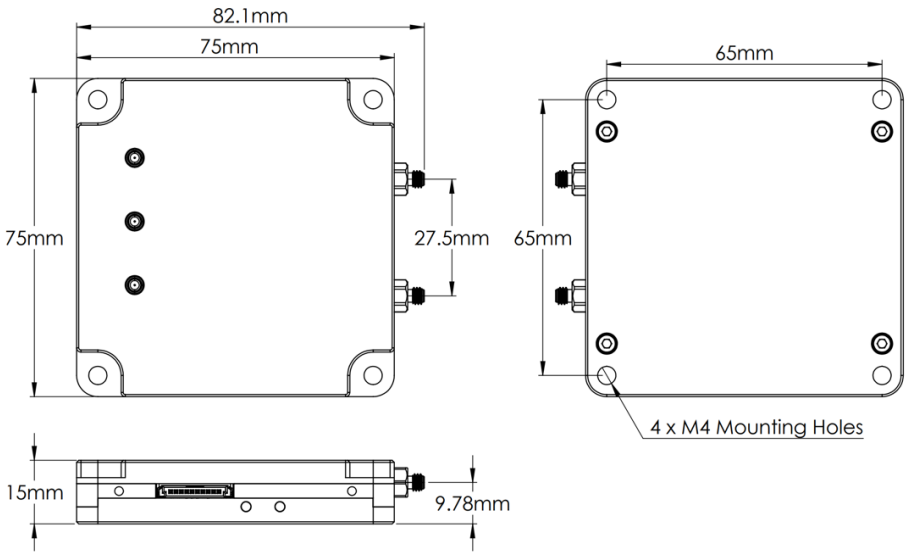
The main such self-test feature is a switchable internal loopback connection (see Functional Block Diagram) which allows for full performance validation, without requiring the converter to be disconnected from a DUT or associated test fixture. A fixed 20 dB attenuator is present in the loopback path to allow self-test even at the maximum upconversion output power without adjusting the downconversion VVA settings.

Additional built-in self-test functionality includes an output RF power detector integrated in the upconversion chain, and a suite of monitoring features on all associated DC circuitry, including precision RF supply voltage monitoring and bias current measurement.

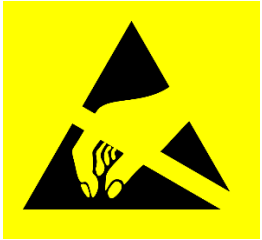
These features allow a comprehensive automatic performance verification, with minimal system downtime, and no manual intervention.

MECHANICAL INFORMATION

All dimensions are in mm.



ELECTROSTATIC DISCHARGE (ESD) CAUTION



This device is ESD sensitive. Proper ESD precautions must be observed when storing, handling, and operating the device.

Failure to observe such precautions can result in degraded performance, permanent damage, or failure of the device.