SC2430

NR Signal Conditioning Module

Product Specification

Typical Applications

- 5G NR FR1 Development
- Software Defined Radio Applications
- Advanced Wireless Communications Research
- High Volume Production Test and Measurement

Summary

The SC2430 NR Signal Conditioning Module (SCM) is a front end solution that provides signal conditioning and amplification for Software Define Radio (SDR) systems. It was designed specifically for use in conjunction with the NI Ettus-USRP X410. In this configuration, its input and output radio characteristics are compliant with select 3GPP 5G/NR standards for 5G NR User Equipment (UE) and gNodeB (gNB) implementations.

Description

The SC2430 SCM houses two front-end (FE) modules. Each module incorporates two independent pairs of transmit (Tx) and receive (Rx) channels in a Time Division Duplex (TDD) configuration. For applications requiring Frequency Division Duplex (FDD) operation, one radio channel can be configured as a continuous Transmit path and the second as a continuous Receive path.

In summary, the SC2430 can simultaneously support 4 TDD or 2 FDD channels.

The channels incorporate signal conditioning and amplification blocks in both the Tx and Rx path that align with several 5G NR frequency bands (n34, n38, n39, n40, n41, n46, n47, n48, n77, n78, n79, n90, and n96). In addition, bypass paths are available for applications operating outside of these bands.

RF Connectivity to the SDR is established via 8 SMA connectors. The Tx and Rx ports are AC coupled and support signals in the 350 MHz to 7.125 GHz range. The channels provide instantaneous bandwidths (IBW) of 100 MHz (350 MHz to 600 MHz), 200 MHz (600 MHz to 800 MHz), and 400 MHz (800 MHz to 7.125 GHz).

The transmit path can generate 34 dB of gain at 1.9 GHz and 30 dB at 3.5 GHz. Peak output power (P1dB) is approximately 27 dBm and the third order intercept point (OIP3) is 41 dBm. The noise figure is typically 8 dB or better across all frequencies at maximum gain. Band filtering can provide over 50 dB of out of band rejection.

In the receive path, 27 dB of gain is available at 1.9 GHz and 23 dB at 3.5 GHz. Noise figure ranges from 4 dB (1.9 GHz) to 7 dB (3.5 GHz). The input third order compression point is -5 dBm (1.9 GHz) to -1 dBm (3.5 GHz). The unit can survive a maximum no-damage input power +10 dBm. Two banks of 5G NR specific band filters are incorporated into the design, providing over 50 dB of out of band rejection.

The control interfaces are digital ports that the user accesses to configure and program the SCM. Two control options are possible.

The first is an SPI-based interface combined with other GPIO that are presented on the front panel HDMI connectors. SPI signaling is present on pins 1, 4, 6, 7, and 9. The remaining pins are used for GND, Automatic Transmit/Receive or ATR (pins 10, 12), and attenuator latching (13, 15). The ATR and latching pins are provided to facilitate high speed TDD operation as defined in the 5G specification. The SPI port can

operate at 40 MHz for write and 16 MHz clocks on read functions.

Users of the NI Ettus-USRP X410 SDR will likely prefer this control option. Like other USRP compatible hardware, the SC2430 can be setup as a UHD device and controlled through the X410. The SC2430 driver is compatible with the UHD Extension Framework. When the SC2430 Extension is enabled, X410 configuration will include SCM performance. For example, setting X410 gain will result in X410 and SCM gain settings that are optimum for the current operating conditions.

Standard HDMI cables can be used for the interconnection. Alternatively, short, mechanical locking cables are available from SCT. These cables incorporate chokes to minimize emissions. A separate interface is provided for each module.

A second control option provides users access to the SC2430 via a UART console interface on the USB-C connector at the rear of the chassis. The USB port is required during firmware updates in the field.

A full API specification is available on the support page of SCT's website, https://www.signalcraft.com/support.

The external power input requires a 12 VDC, 16 Amp, supply. A universal AC/DC power brick is included with the SC2430. Other compatible supplies can be used if high density or rack mounted operation is desired. The SC2430 can be powered on via the front panel push button or set to auto-start on application of the 12-volt input. The front panel pushbutton also serves as indicator for the SC2430 power status.

On the front panel, the SC2430 is equipped with one LED per channel to indicate its status (Transmitting or Receiving).

SC2430 – Typical 5G NR Radio Emulator Configuration (NI Ettus USRP X410 SDR Pictured Here)

Definitions

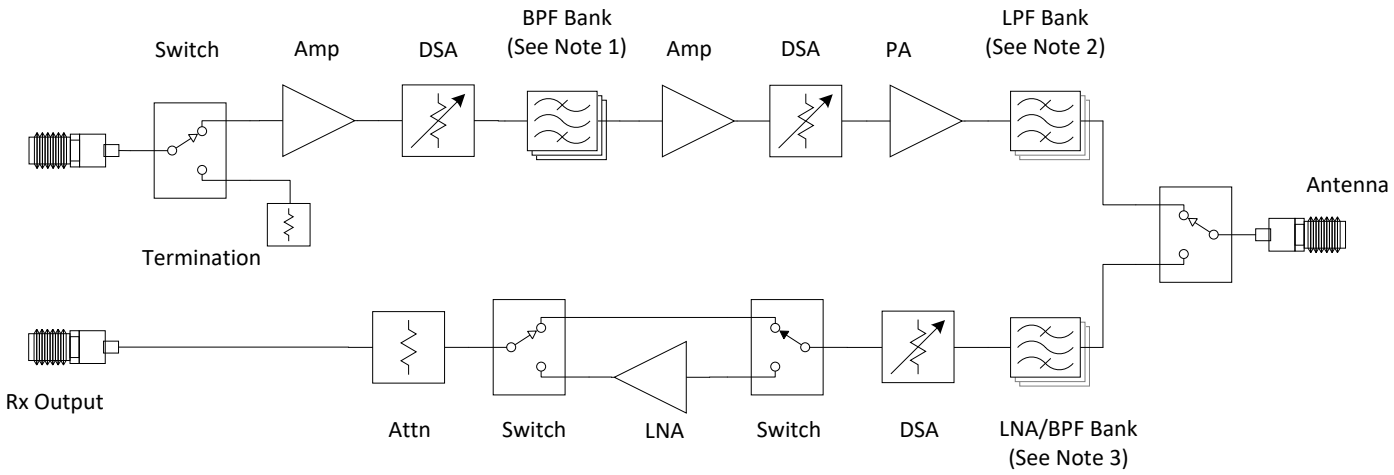
The following definitions apply to these specifications:

- *Typical* values describe the expected performance for the majority of units. Typical values may not be verified on all units shipped from the factory.
- *Minimum* (*Min*) and *Maximum* (*Max*) values describe warranted product performance.

Specifications are subject to change without notice. For the most recent SC2430 specification, visit www.signalcraft.com.

Block Diagram

Single RF Channel



Comments

Note 1

On the transmit site, wider BPF that lump several adjacent NR Bands are implemented.

BPF Bypass	300 MHz to 7125 MHz
BPF Band A	1880 MHz to 2690 MHz (n39, n34, n40, n41, n53, n38)
BPF Band B	3300 MHz to 4200 MHz (n78, n77, n48)
BPF Band C	4400 MHz to 5000 MHz (n79)
BPF Band D	5150 MHz to 5925 MHz (n46, n47)
BPF Band E	5925 MHz to 7125 MHz (n96)

Note 2

See comment in Note 1.

LPF Bypass	300 MHz to 7125 MHz
LPF Band 1	1880 MHz to 2690 MHz (n39, n34, n40, n41, n53, n38)
LPF Band 2	3300 MHz to 5000 MHz (n78, n77, n48, n79)
LPF Band 3	5150 MHz to 7125 MHz (n46, n47, n96)

Note 3

Each path of this bank contains an LNA combined with the following NR Band channel filters:

NR Band	Frequency
n34	2010 MHz – 2025 MHz
n38	2570 MHz – 2620 MHz
n39	1880 MHz – 1920 MHz
n40	2300 MHz – 2400 MHz
n41	2496 MHz – 2690 MHz
n46	5150 MHz – 5925 MHz
n47	5855 MHz – 5925 MHz
n48	3550 MHz – 3700 MHz
n77	3300 MHz – 4200 MHz
n78	3300 MHz – 3800 MHz
n79	4400 MHz – 5000 MHz
n90	2496 MHz – 2690 MHz
n96	5925 MHz – 7125 MHz

Transmit (Tx) Path Specifications

General

Parameter	Min	Typical	Max	Comments
Frequency Range (MHz)	350	-	7125	
Gain (dB) 1.9 GHz 2.4 GHz 3.5 GHz 5.8 GHz	-	 34.0 32.5 30.0 24.0	-	Includes 0C to +55C performance. See typical performance plots in next section.
Gain Control Range (dB)	63	-	-	
Gain Control Resolution (dB)	-	1	-	
Output Power (dBm) 1.9 GHz 2.4 GHz 3.5 GHz 5.8 GHz	-	 17 17 17 13	-	Linear Power assuming 10 dB PAR. See typical performance plots in next section.
Output Compression Point (dBm) 1.9 GHz 2.4 GHz 3.5 GHz 5.8 GHz	-	 27 27 27 23	-	See typical performance plots in next section.
OIP3 (dBm) 1.9 GHz 2.4 GHz 3.5 GHz 5.8 GHz	-	 41 41 41 37	-	Output third order compression point. See typical performance plots in next section.
Noise Figure (dB) 1.9 GHz 2.4 GHz 3.5 GHz 5.8 GHz	-	 7 7 8 8	-	See typical performance plots in next section.
Off Attenuation (dB)	-	27	-	
Out of band rejection	-	-	-	See table and performance plots below.
Tx to Rx Channel Isolation (dB)	-	70	-	Between adjacent channels.
Tx to Rx Path Isolation (dB)	-	50	-	Between paths in the same channel.
Switch Settling Time (uS)	-	18	-	On activation of ATR control line.
Attenuator Settling Time (uS)	-	18	-	On assertion of attenuation latch control.
Band Selection Time (uS)	-	500	-	Filter bank switching time.

Receive (Rx) Path Specifications

General

Parameter	Min	Typical	Max	Comments
Frequency Range (MHz)	350	-	7125	
Gain (dB) 1.9 GHz 2.4 GHz 3.5 GHz 5.8 GHz	-	 27 27 23 17	-	Includes 0C to +55C performance. See typical performance plots in next section.
Gain Control Range (dB)	31.5	-	-	
Gain Control Resolution (dB)	-	1	-	
No Damage Input Power (dBm)	-	-	10	
Input Power (dBm)	-	-	-5	Operating (linear) power.
IIP3 (dBm) 1.9 GHz 2.4 GHz 3.5 GHz 5.8 GHz	-	 -5 -3 -1 7	-	Input Third Order Intercept Point. See typical performance plots in next section.
Noise Figure (dB) 1.9 GHz 2.4 GHz 3.5 GHz 5.8 GHz	-	 4 5 5 7	-	See typical performance plots in next section.
Off Attenuation (dB)	27	-		
Out of band rejection	-	-	-	See table and performance plots below.
Switch Settling Time (uS)	-	18	-	On activation of ATR control line.
Attenuator Settling Time (uS)	-	18	-	On assertion of attenuation latch control.
Band Selection Time (uS)	-	500	-	Filter bank switching time.

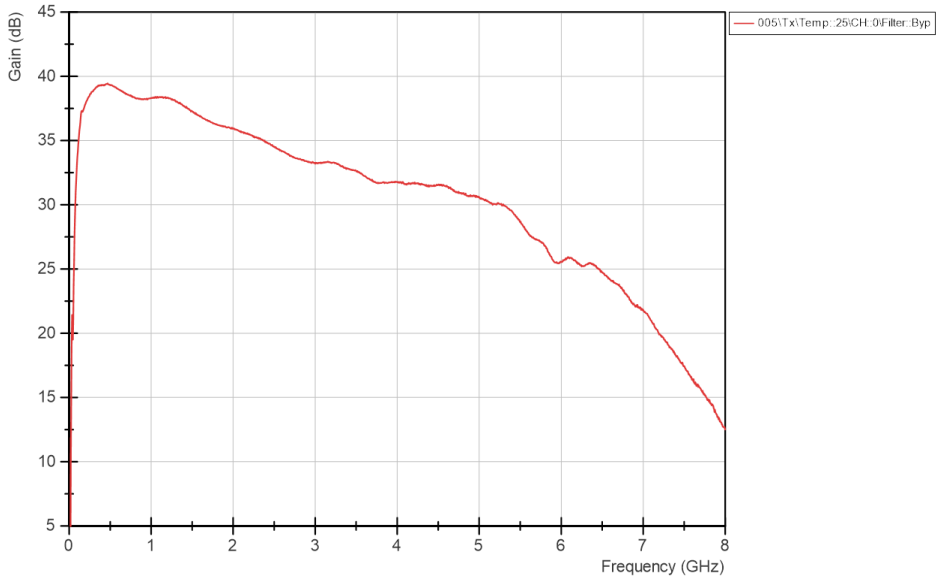
NR Operating Bands

NR Band	Uplink (UL) Frequency BS receive / UE transmit F_{UL_low} – F_{UL_high}	Downlink (DL) Frequency BS transmit / UE receive F_{DL_low} – F_{DL_high}	Duplex Mode
n34	2010 MHz – 2025 MHz	2010 MHz – 2025 MHz	TDD
n38	2570 MHz – 2620 MHz	2570 MHz – 2620 MHz	TDD
n39	1880 MHz – 1920 MHz	1880 MHz – 1920 MHz	TDD
n40	2300 MHz – 2400 MHz	2300 MHz – 2400 MHz	TDD
n41	2496 MHz – 2690 MHz	2496 MHz – 2690 MHz	TDD
n46	5150 MHz – 5925 MHz	5150 MHz – 5925 MHz	TDD
n47	5855 MHz – 5925 MHz	5855 MHz – 5925 MHz	TDD
n48	3550 MHz – 3700 MHz	3550 MHz – 3700 MHz	TDD
n77	3300 MHz – 4200 MHz	3300 MHz – 4200 MHz	TDD
n78	3300 MHz – 3800 MHz	3300 MHz – 3800 MHz	TDD
n79	4400 MHz – 5000 MHz	4400 MHz – 5000 MHz	TDD
n90	2496 MHz – 2690 MHz	2496 MHz – 2690 MHz	TDD
n96	5925 MHz – 7125 MHz	5925 MHz – 7125 MHz	TDD

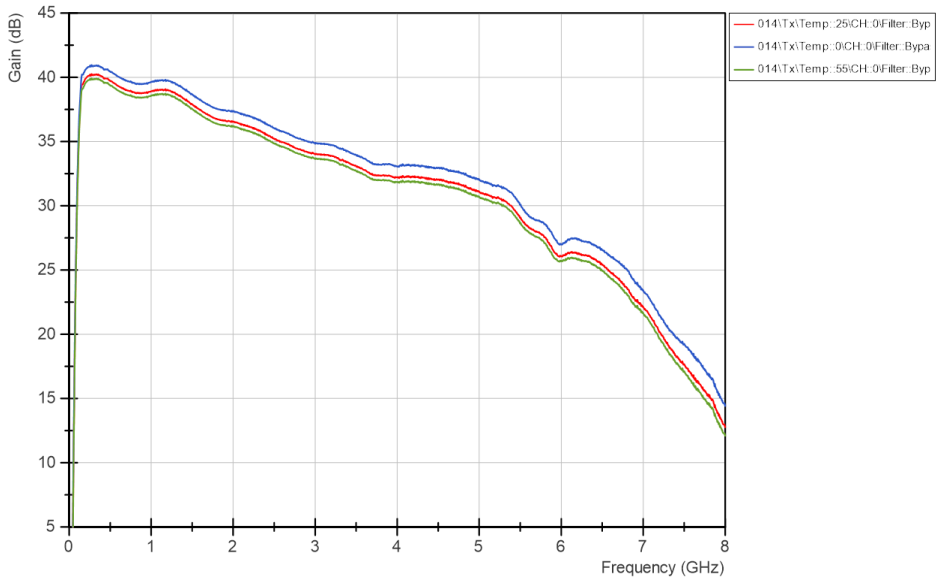
Typical Performance

The following plots were taken from a production unit and represent typical SC2430 performance.

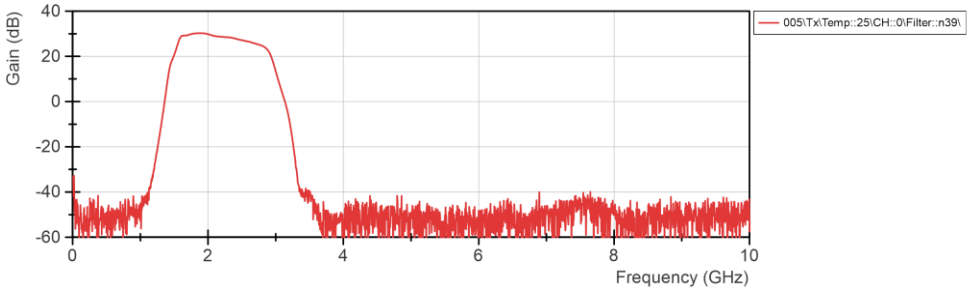
Transmit Response – Maximum Gain, Bypass Path



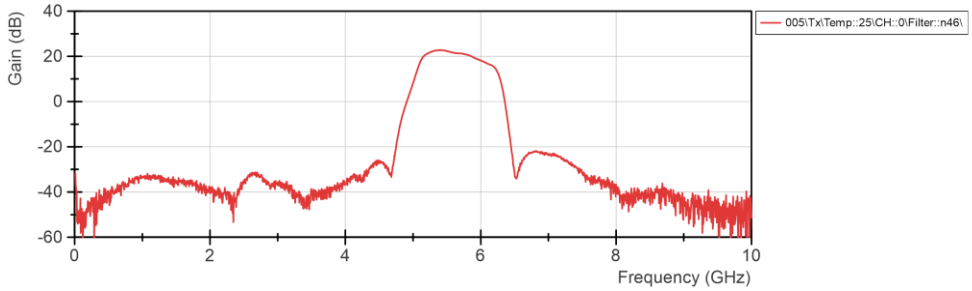
Transmit Response vs Temperature – Maximum Gain, Bypass Path



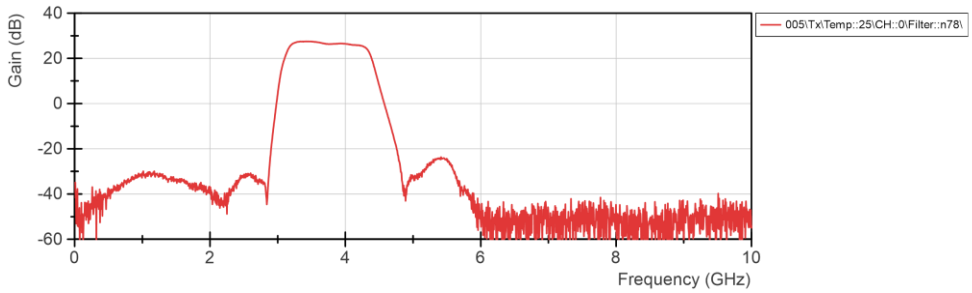
Transmit Response – Maximum Gain, n34/n38/n39/n40/n41 Filter Bank



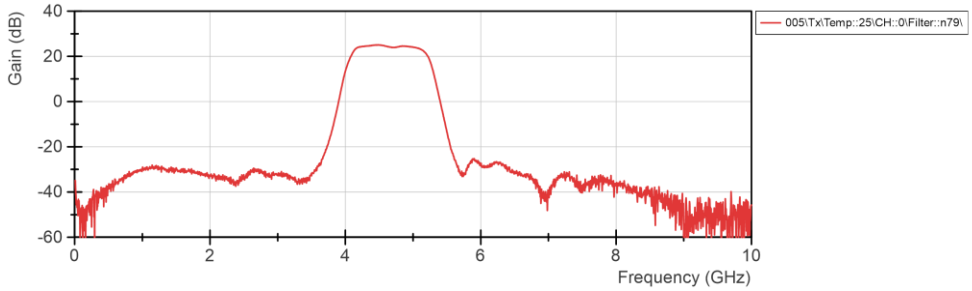
Transmit Response – Maximum Gain, n46 Filter Bank



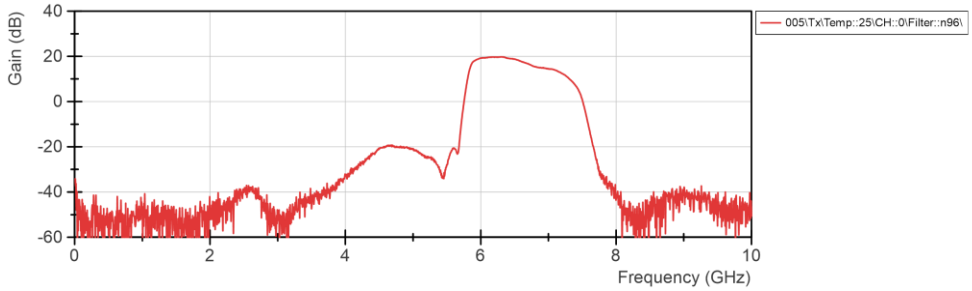
Transmit Response – Maximum Gain, n48/n77/n78 Filter Bank



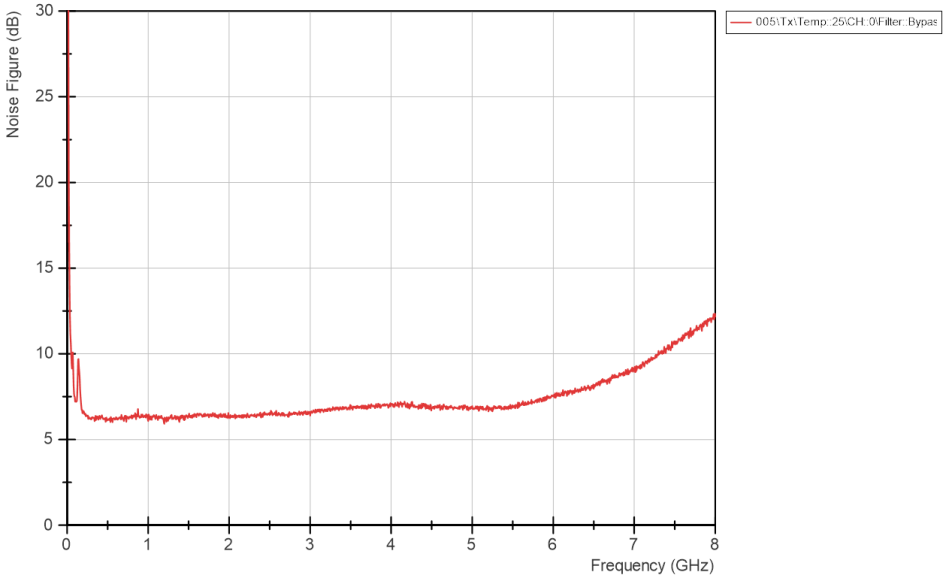
Transmit Response – Maximum Gain, n79 Filter Bank



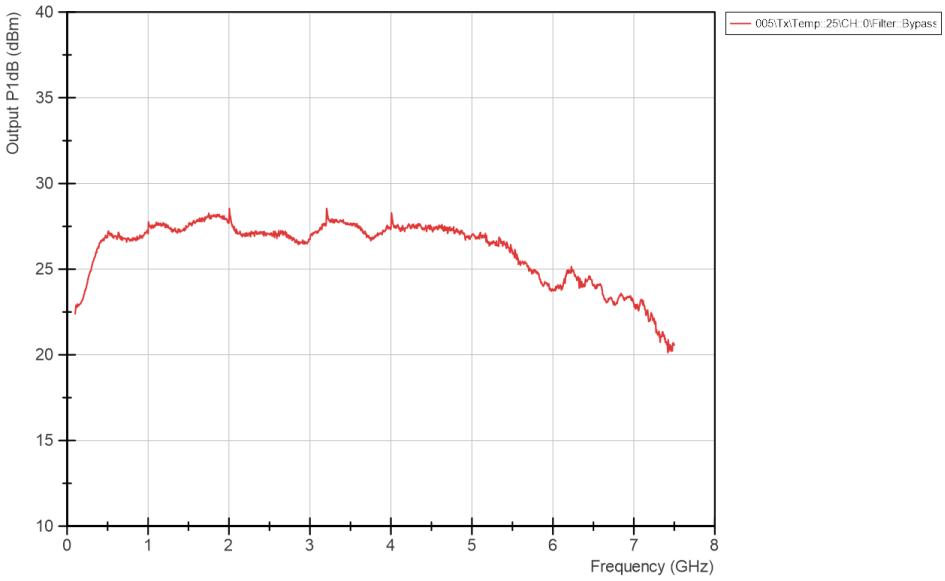
Transmit Response – Maximum Gain, n96 Filter Bank



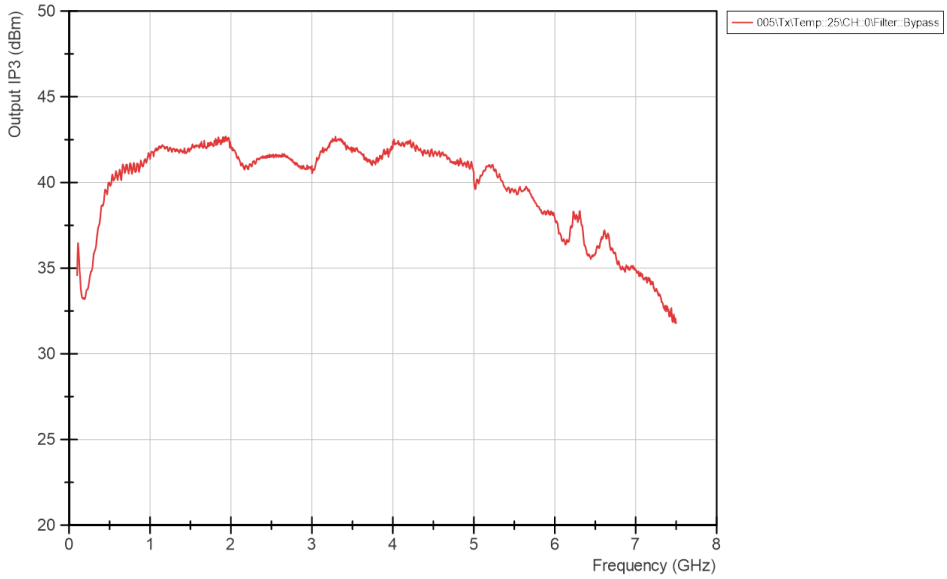
Transmit Noise Figure – Maximum Gain, Bypass Path



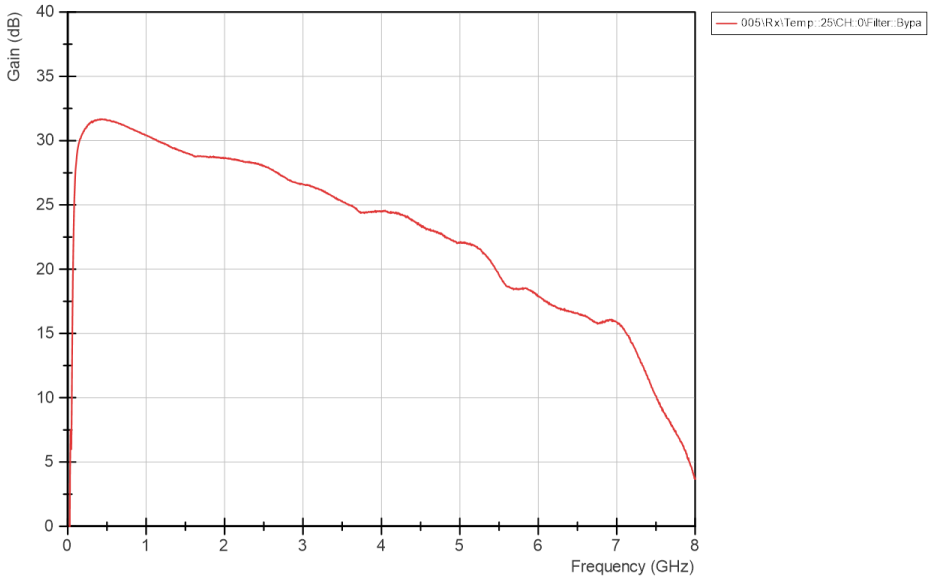
Transmit Output P1dB – Maximum Gain, Bypass Path



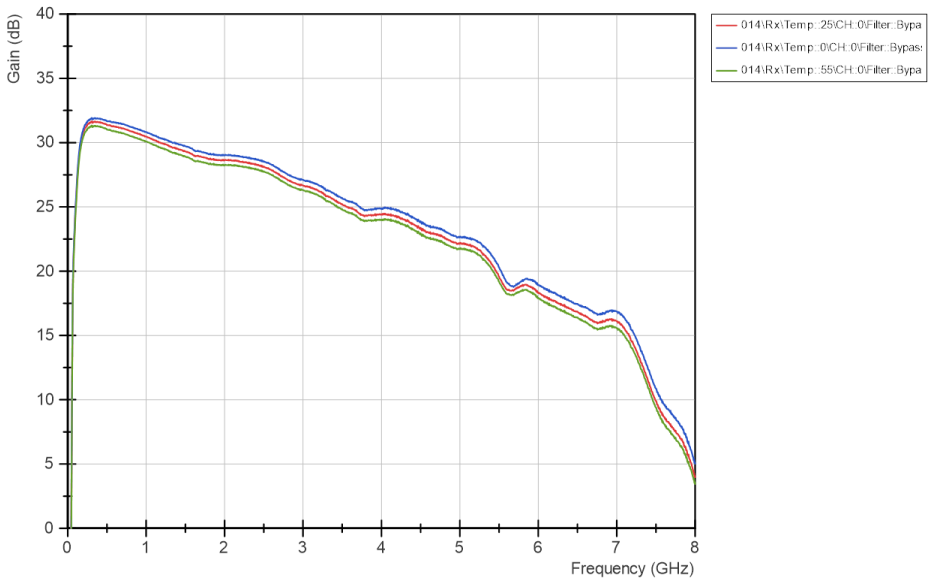
Transmit Output IP3 – Maximum Gain, Bypass Path



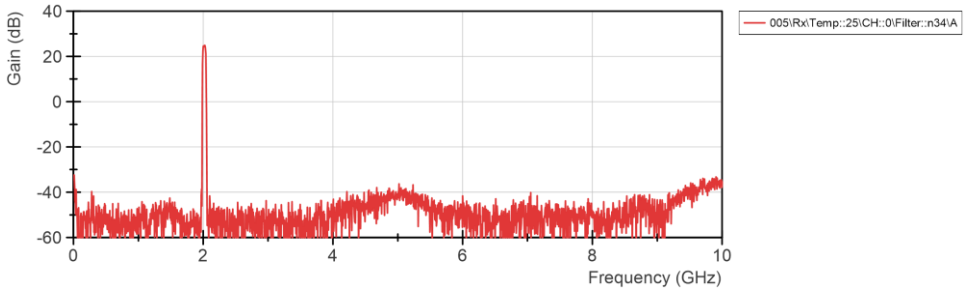
Receive Response – Maximum Gain, Bypass Path



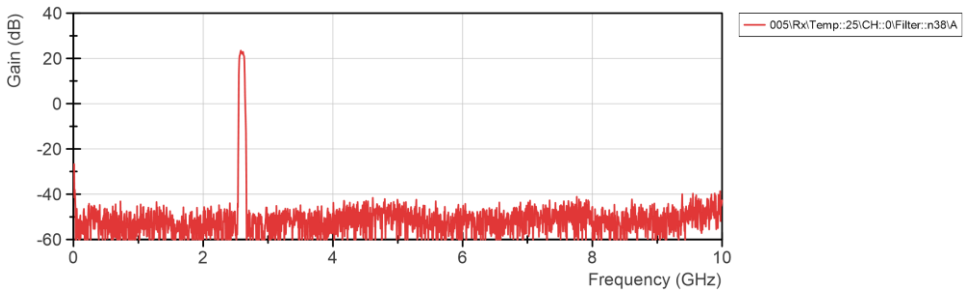
Receive Response vs Temperature – Maximum Gain, Bypass Path



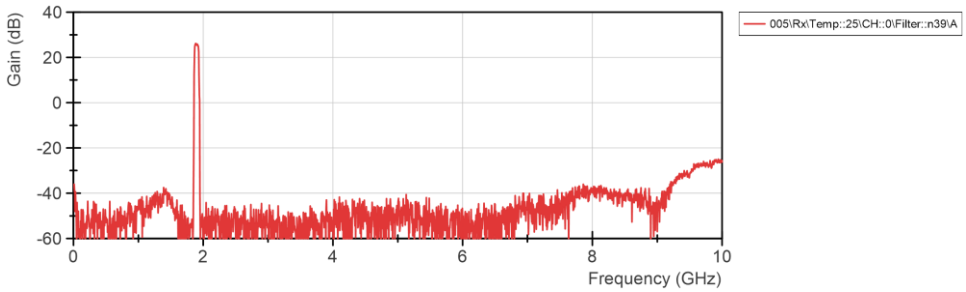
Receive Response – Maximum Gain, n34 Channel Filter



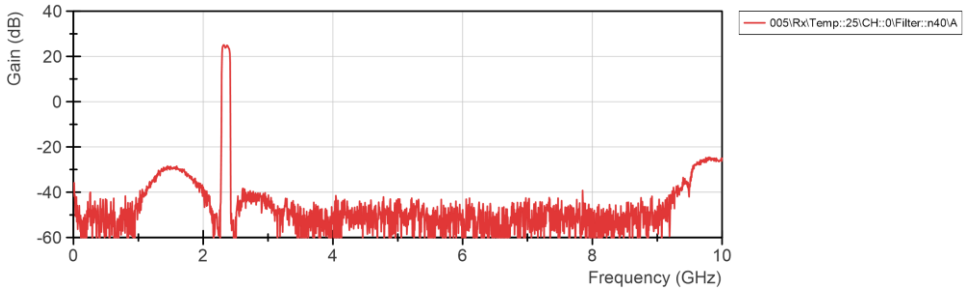
Receive Response – Maximum Gain, n38 Filter Bank



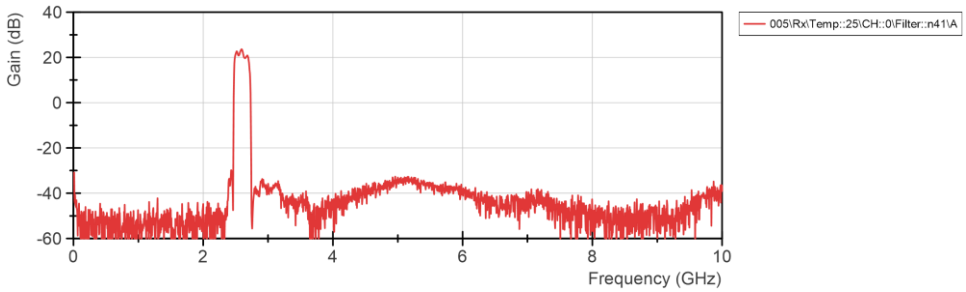
Receive Response – Maximum Gain, n39 Channel Filter



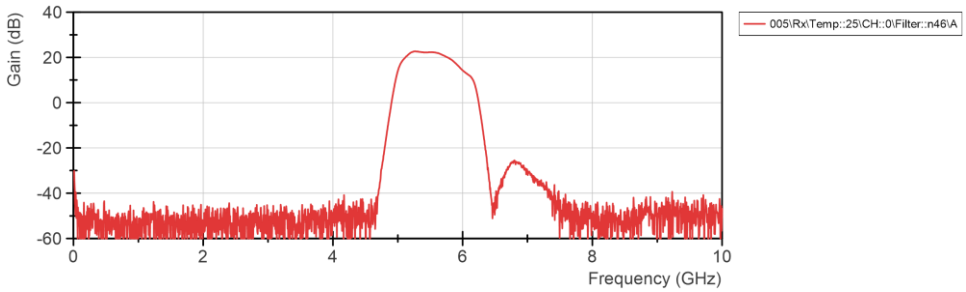
Receive Response – Maximum Gain, n40 Filter Bank



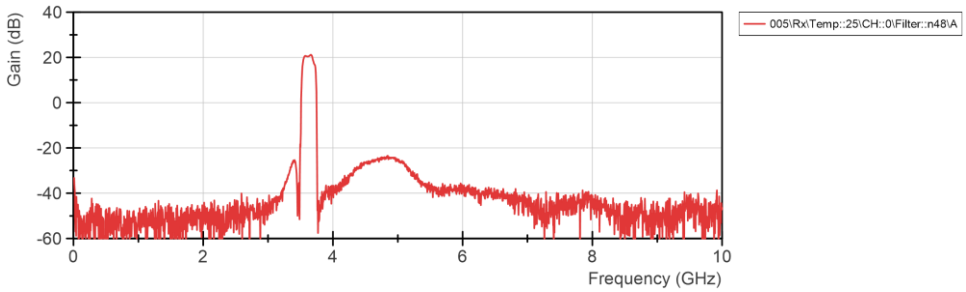
Receive Response – Maximum Gain, n41 Filter Bank



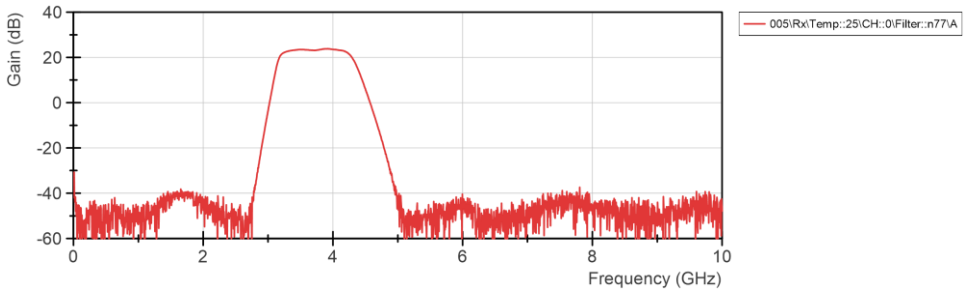
Receive Response – Maximum Gain, n46 Filter Bank



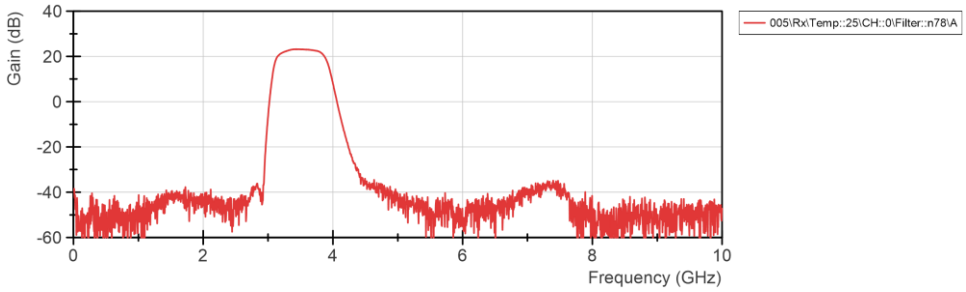
Receive Response – Maximum Gain, n48 Filter Bank



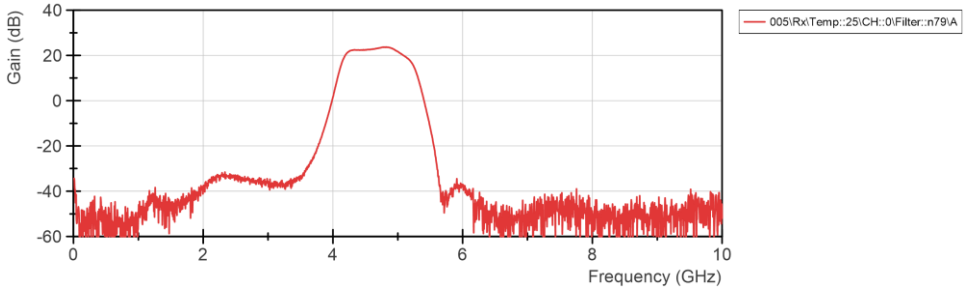
Receive Response – Maximum Gain, n77 Filter Bank



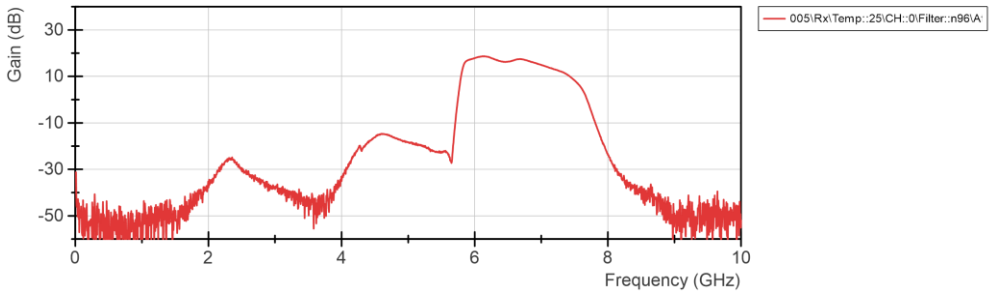
Receive Response – Maximum Gain, n78 Filter Bank



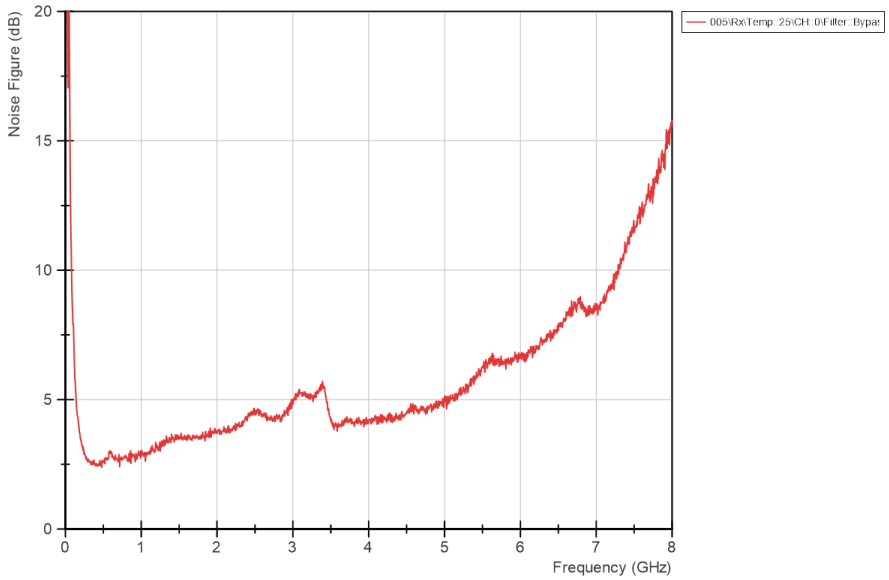
Receive Response – Maximum Gain, n79 Filter Bank



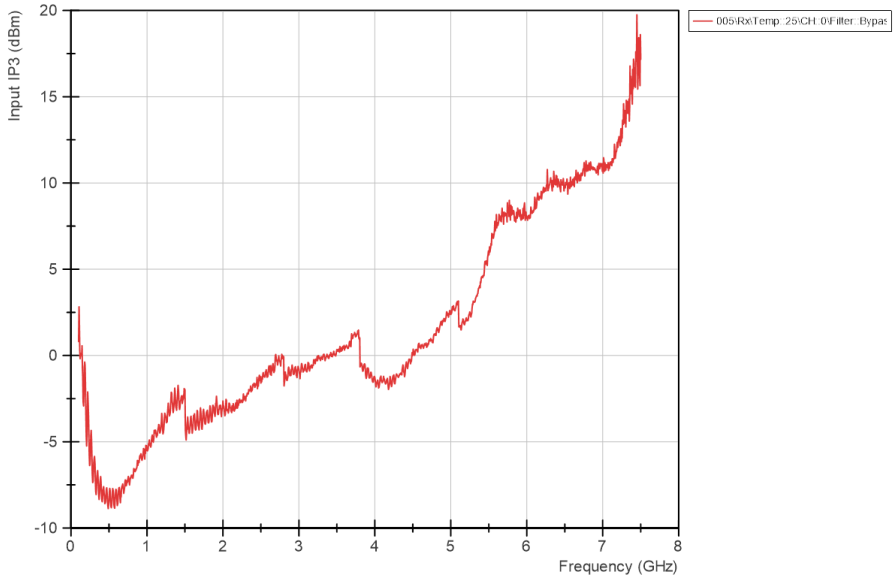
Receive Response – Maximum Gain, n96 Filter Bank



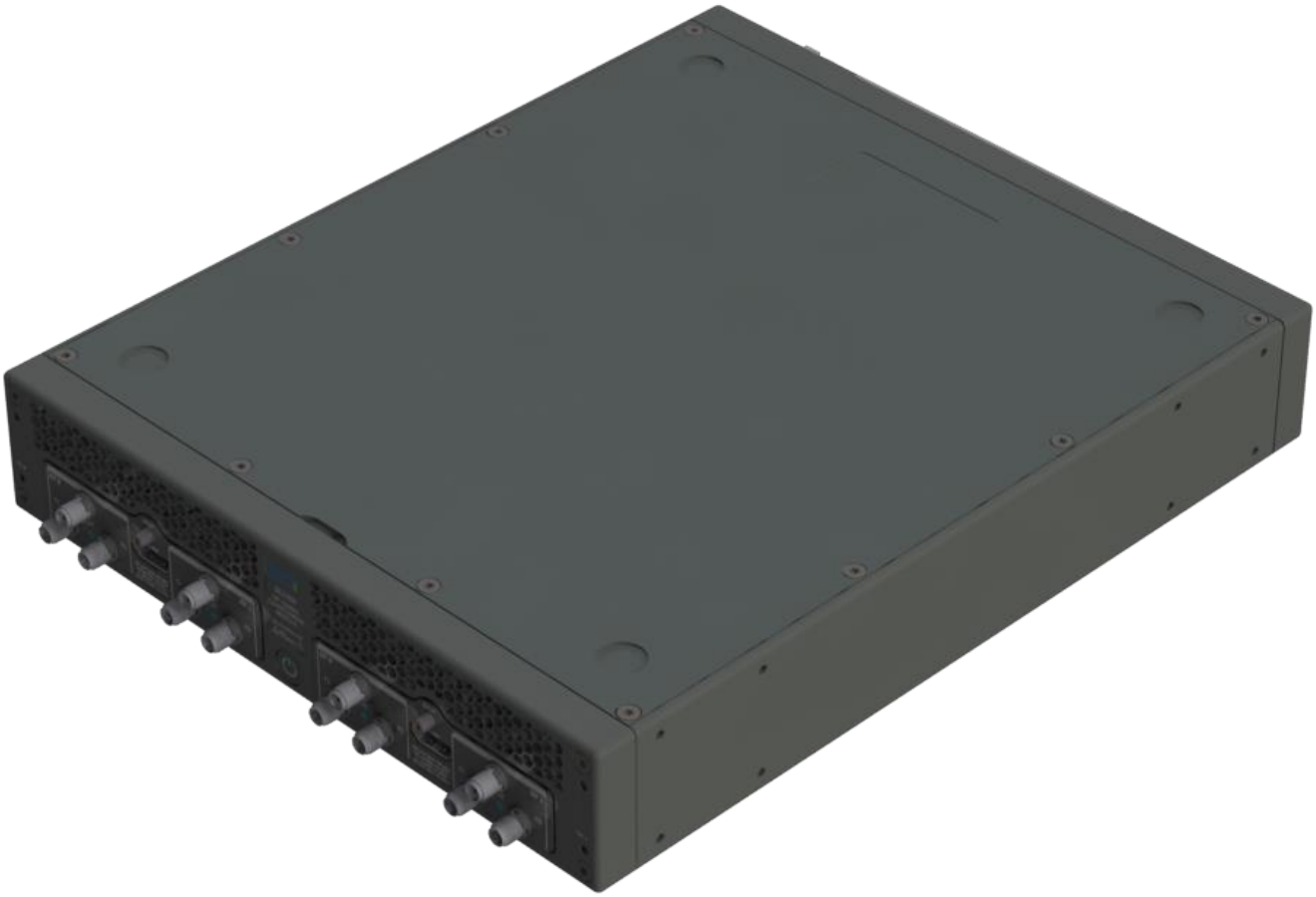
Receive Noise Figure



Receive Input IP3 – Maximum Gain, Bypass Path



Mechanical Overview



Interfaces

Indicators

Front Panel Power Button	Red/Green	Power Indicator: OFF = Unit is not powered GREEN Slow Blink = Powered in standby (RF card(s)not powered) GREEN Solid = Powered in active mode (RF card(s) powered) GREEN Fast Blink = Powered awaiting RF card(s) shutdown RED Solid = Fault of some sort (RF card(s) powered) RED Fast Blink = Fault (powered RF card(s) awaiting shutdown) RED Slow Blink = Fault (RF card(s) not powered)
Rear Panel DB0	Red/Green	Controlled by RF Daughter Card Slot 0: OFF = Daughterboard is OFF AMBER = Daughterboard is ON, but not configured GREEN = Daughterboard is configured and normal operation RED = Daughterboard is ON and in Fault (Blink functions are supported, additional definitions possible)
Rear Panel DB1	Red/Green	Controlled by RF Daughter Card Slot 1: OFF = Daughterboard is OFF AMBER = Daughterboard is ON, but not configured GREEN = Daughterboard is configured and normal operation RED = Daughterboard is ON and in Fault (Blink functions are supported, additional definitions possible)
Rear Panel Mode	Red/Green	Boot Mode Indicator: OFF = Daughterboards are not powered GREEN = Daughterboards in Normal Run Mode AMBER = Daughterboards in BOOTMODE for F/W update
Rear Panel Power	Red/Green	Power indicator: Will mimic front panel power button LED functions OFF = Unit is not powered or powered in standby GREEN Solid = Powered in active mode (RF card(s) powered) GREEN Fast Blink = Powered awaiting RF card(s) shutdown RED Solid = Fault of some sort (RF card(s) powered) RED Fast Blink = Fault (powered RF card(s) awaiting shutdown) RED Slow Blink = Fault (RF card(s) not powered)

Control Inputs (See API Specification for Pin Out Diagram)

- Rear Panel USB-C - Console API
- Front Panel HDMI Connector – SPI (1.8 to 3.3 volts), see pinout below
    - Custom HDMI Cable Assembly with Mechanical Locking Screws:
        - SCT P/N SC2430-54 for up/down configuration or
        - SCT P/N SC2430-55 for side/side configuration
- Rear Panel Reset Pushbutton
- Maintenance Mode Pushbutton

Power Supply

- 110-220 V_{AC} to 12 V_{DC} Adaptor Included (AC Cable Not Included)
- Optional power supply configurations require 12 V_{DC} 16 Amp capability
    - Existing Rear Panel Connector
        - Molex P/N 0026013116
    - Compatible Mating Connectors:
        - Molex P/N Molex 1727080006 (mating part)
        - Molex P/N 2029881141 (contacts for 16AWG wire, contact rated to 13.5A)

Calibration

Due to the large number of operating conditions and user configurations, calibration will not be provided on this product.

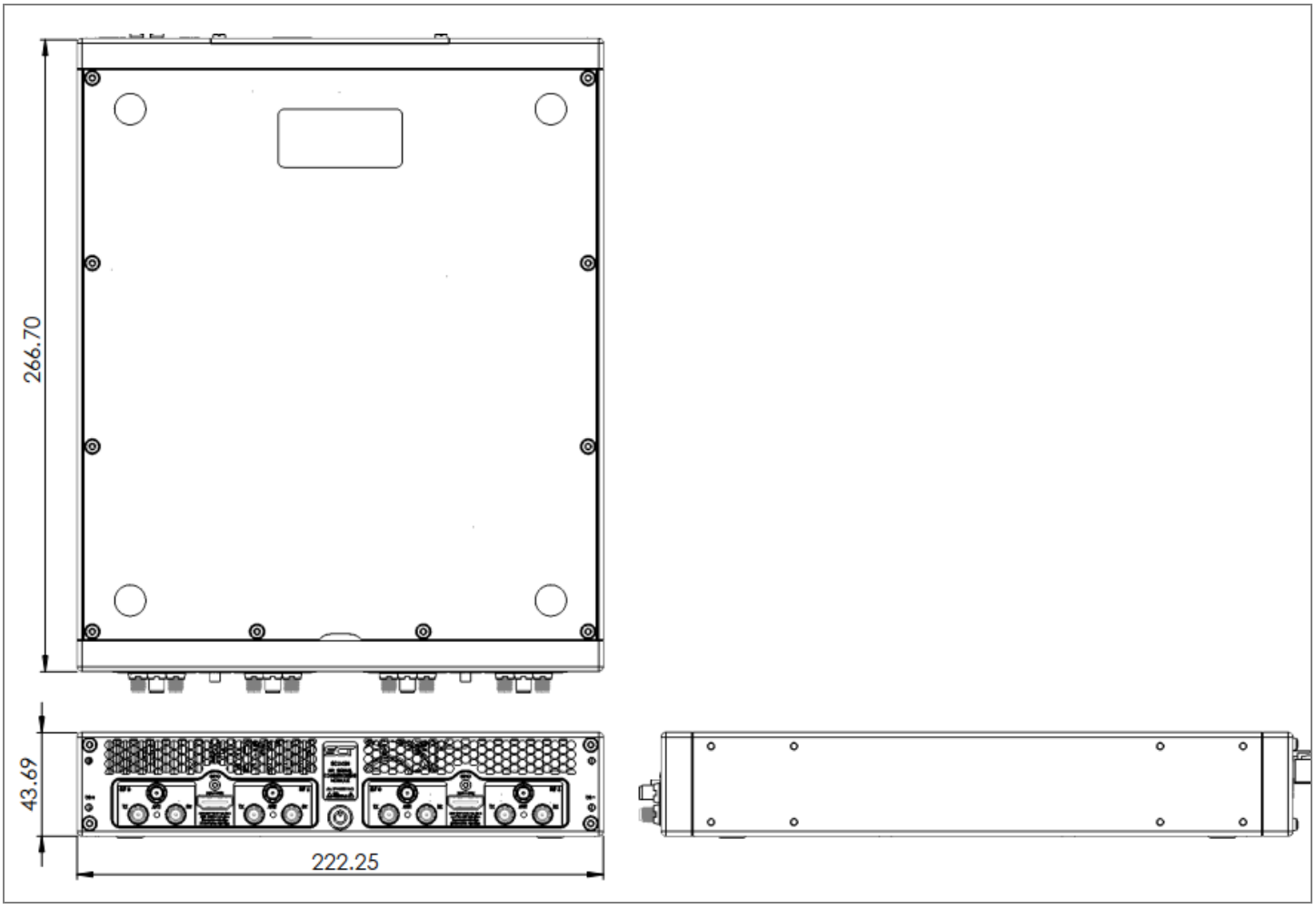
Physical Characteristics

Weight

3.8 kilograms

Mechanical Dimensions

All dimensions in millimeters.



Compliance and Certifications

The EU Declaration of Conformance (DoC) for this product can be obtained from the support section of our website, located at www.signalcraft.com/support/support-microwave/.

Electromagnetic Compatibility

This product meets the requirements of the following EMC standards for electrical equipment for measurement, control, and laboratory use:

Electromagnetic Compatibility (EMC) Directive 2014/30/EU
FCC Part 15 Radio Frequency Devices, Subpart B - Unintentional Radiators - Class A
ICES-Gen Iss.1 2021 General Requirements for Compliance of Interference-Causing Equipment
ICES-003 Iss.7 2020 Information Technology Equipment (including Digital Apparatus) – Class A
KS C 9610-6-4:2017 (Emissions)
KS C 9811:2019 Class A (Emissions)
KS C 9610-6-2:2019 (Immunity)

Environmental Management

SCT is committed to designing and manufacturing products in an environmentally responsible manner. We believe that eliminating hazardous substances from our products is beneficial to the environment and our customers.

At the end of the product's life cycle, customers are responsible for ensuring that all materials are disposed of according to local laws and regulations.

	RoHS Directive (EU) 2015/863 amending Annex II to Directive 2011/65/EU

Environmental

Parameter	Value	Comments
Ambient Operating Temperature	0 to 55 °C	Tested in accordance with IEC 60068-2-1 and IEC 60068-2-2, 16 hours
Ambient Storage Temperature	-40 to 71 °C	Tested in accordance with IEC 60068-2-1 and IEC 60068-2-2, 16 hours
Relative Humidity Operating Range	10 – 90%	Non-condensing, Tested in accordance with IEC 60068-2-78, 2 days, 40°C
Relative Humidity Storage Range	5 to 95%	Non-condensing, Tested in accordance with IEC 60068-2-78, 2 days, 40°C
Mechanical Shock	30 G	Operating, 11 ms, half-sine pulse, Tested in accordance with IEC 60068-2-27, 3 hits per face for a total of 18 hits
Mechanical Shock	50 G	Non-operating, 11 ms, half-sine pulse; Tested in accordance with IEC 60068-2-27, 3 hits per face for a total of 18 hits
Maximum Altitude	2000 m	Operating at 25 °C ambient temperature

Support

For technical support and to access product documentation, visit www.signalcraft.com/support or reach us at support@signalcraft.com.

Warranty

Full one-year parts and labour when used under normal installation and operation conditions. Repair services are available for products no longer covered under warranty.

Ordering Information

Send inquiries to support@signalcraft.com.