0.2 – 8.8 GHz Receiver Front End with Optional Continuous Wave Output

Data Sheet DGRF-8800Rx+/DGRF-8800Rx

Features

Receiver RF frequency range: 0.2 – 8.8 GHz
Receiver IF frequency range: 10 – 110 MHz
Max instantaneous bandwidth: 100 MHz
Average receiver conversion gain: 40 dB
Average receiver noise figure: 3.9 dB
Integrated LNA with 20 dB gain and 1.5 dB NF
Integrated IF amplifier with 30 dB gain
1 ppm TXO reference for s maximum stability
Power Supply: 5.0 V
Average Current draw: 500 mA
CW output frequency range[1]: 0.035 – 8.8 GHz
Average CW output power[1]: 10 dBm

Applications

Frequency extension module
Reconfigurable communications
Software Defined Radios
Satellite Communications
Test Measurement Equipment
Electronic Warfare

General Description

The DGRF-8800Rx+/DGRF-8800Rx is a receiver front end designed to extend the frequency range of any receiver system up to 8.8 GHz. The optimum downconverted Intermediate Frequency (IF) is 60 MHz and has an Instantaneous Bandwidth (IBW) of 100 MHz. The IF frequency can be tuned between 10 – 110 MHz, however, the IBW is dependent on the chosen IF.

The DGRF-8800Rx+ also provides a Continuous Wave (CW) output port capable synthesizing output frequencies between 35 MHz to 8.8 GHz. The CW output shares the same Voltage Control Oscillator (VCO) as the receiver front end and cannot be operated simultaneously with the receiver. The DGRF-8800Rx model does not have the optional CW output, however, still shares the same receiver performance as the DGRF-8800Rx+

The receiver front end input is DC coupled, matched to 50Ω, and maintain a DC bias of 0 VDC. The IF output of the receiver front end is AC coupled and matched to 50Ω. The CW output is also AC coupled and matched to 50Ω.

Functional Block Diagram

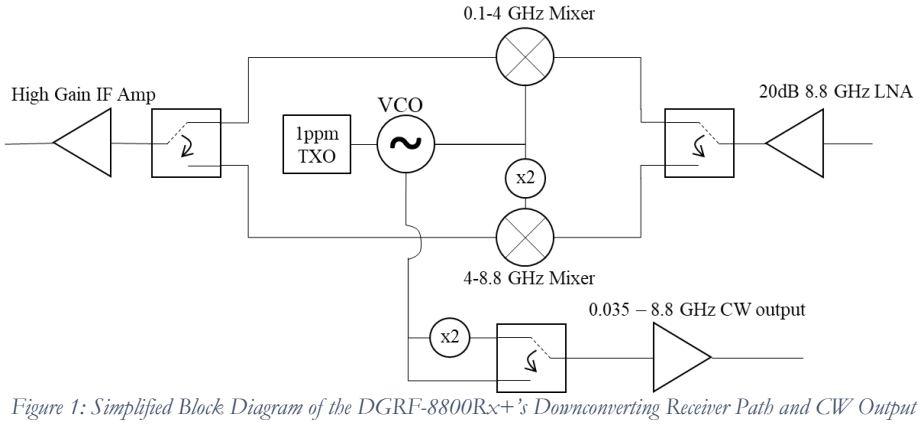


Figure 1: Simplified Block Diagram of the DGRF-8800Rx+'s Downconverting Receiver Path and CW Output

[1] Only applies to DGRF-8800Rx+ model

Table of Contents

Specifications

V_{dd} = 5 V ± 4%; GND = 0. Operating temperature range is -25°C to 80°C.

Table 1.

Parameter	Min	Typ	Max	Unit	Test Conditions / Comments
Receiver Characteristics					
RF Input Frequency	0.2		8.8	GHz	
RF Input Sensitivity	-110		-20	dBm	
IF Output Frequency	10		110	MHz	
Instantaneous Bandwidth	10		100	MHz	IBW dependent on IF frequency
Conversion Gain	35	40	45	dB	Conversion gain at IF = 75 MHz
Noise Figure[1]	1.5	4	7	dB	NF measured at IF = 75 MHz
Input LNA Characteristics					
Gain	18	20	21.5	dB	Within 0.2 – 8.8 GHz bandwidth
Noise Figure	1.2	1.5	2.5	dB	Within 0.2 – 8.8 GHz bandwidth
Output IF Amp Characteristics					
Gain	25	29	30	dB	Within 10 – 110 MHz bandwidth
CW Output Characteristics					
RF Output Frequency	0.035		8.8	GHz	
RF Output Power	0	11	14	dBm	
CW Noise Characteristics[2]					
2 GHz Center Frequency		-79		dBc/Hz	10 KHz offset from 2 GHz Carrier
		-109		dBc/Hz	100 KHz offset from 2 GHz Carrier
		-127		dBc/Hz	1 MHz offset from 2 GHz Carrier
		-152		dBc/Hz	10 MHz offset from 2 GHz Carrier
4 GHz Center Frequency		-73		dBc/Hz	10 KHz offset from 4 GHz Carrier
		-103		dBc/Hz	100 KHz offset from 4 GHz Carrier
		-120		dBc/Hz	1 MHz offset from 4 GHz Carrier
		-149		dBc/Hz	10 MHz offset from 4 GHz Carrier
6 GHz Center Frequency		-73		dBc/Hz	10 KHz offset from 6 GHz Carrier
		-91		dBc/Hz	100 KHz offset from 6 GHz Carrier
		-112		dBc/Hz	1 MHz offset from 6 GHz Carrier
		-144		dBc/Hz	10 MHz offset from 6 GHz Carrier
Typical RMS Jitter		1.08		ps	
PLL Loop BW		70		KHz	
PLL Phase Margin		40		deg	
Power Supply					
V_{dd}	4.8	5	5.2	V	
I_{dd}	490		520	mA	

[1] Noise figure measurements were made using an HP8970B and HP8971C noise figure test set and calibrated using a known noise source and previously characterized device

[2] Phase noise measurements were made using a Holzworth Instrumentation HA7062C phase noise analyzer.

Absolute Maximum Ratings

Table 2.

Parameter	Rating
V_{dd} to GND	-0.3 V to + 5.5 V
RF power to receiver input	0 dBm
DC voltage to receiver input	+0.1 VDC
Operating temperature	85°C

Operation at or above any of the listed values in table 2 may cause permanent damage to the product or affect the product performance and reliability.

ESD Caution

Many of the internal components are rated to the human body model: Class 1A in accordance with ANSI/ESD STM 5.1-2001, however, great care should be taken when handling the product. Accidental ESD discharge can affect much of the internal circuity and degrade the performance of the product. Proper ESD precautions should be taken to avoid damaging or degrading the performance of the device.

Port Configuration and Functional Description

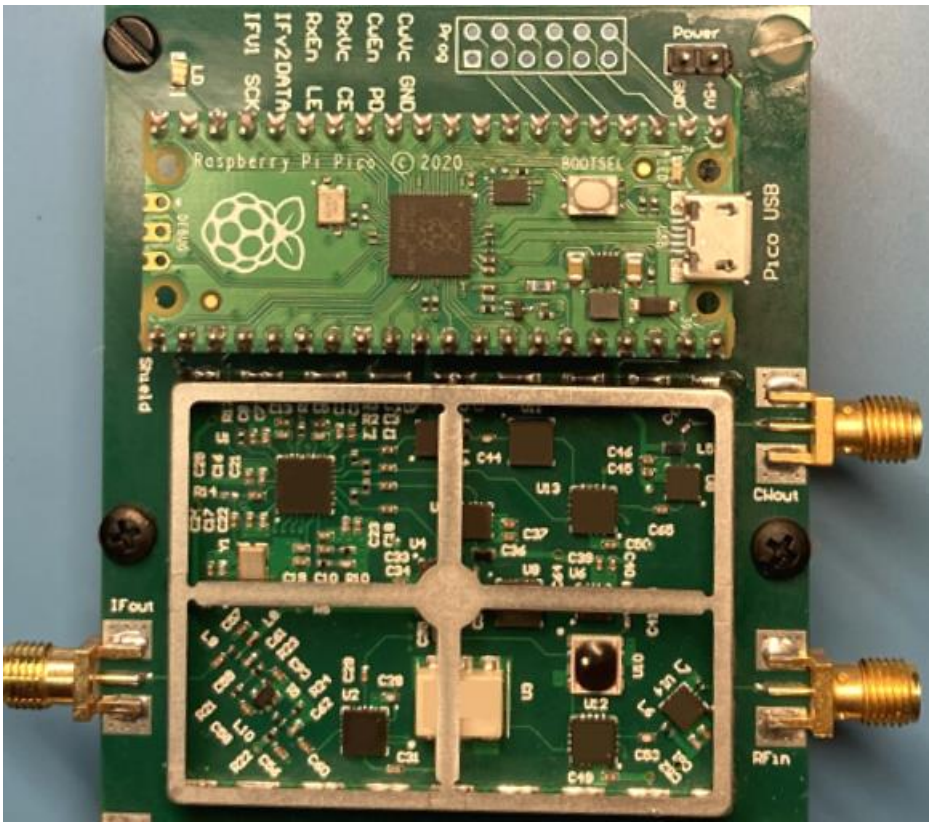


Figure 2: Photograph of Rev. A Circuit Boad for DGRF-8800Rx

Table 3.

Port	Label	Description
CW output	CWout	This port is where the continuous wave output is generated. This port only exists on the DGRF-8800Rx+ model and is omitted on the DGRF-8800Rx. The port is AC coupled and matched to 50Ω. When not in use it's best practice to terminate the port in 50Ω, however, it does not affect the receiver performance if left open.
RF Input	RFin	This port is the input to the receiver and is matched to 50Ω. The port is DC coupled and the input should not exceed ±0.1 VDC.
IF output	IFout	This port is the downconverted IF output of the receiver and is matched to 50Ω. The port is AC coupled.
Pico USB	PicoUSB	The micro-USB port can be used to reprogram the Raspberry Pi Pico and also provides power to the receiver. The USB +5.0 VDC also provides power to the receiver's +3.3 VDC LDO. The Raspberry Pi Pico comes pre-loaded with DGRF software to run the receiver and only needs power to operate as described in the datasheet and user guide.
Power +5V	+5	This pin provides the +5.0 VDC to the receiver and powers the +3.3 VDC LDO. This pin can be ignored when operating the receiver through the Raspberry Pi Pico USB port as the receiver is powered through the Raspberry Pi Pico's +5.0 VDC Vbus pin.
Power GND	GND	This pin provides the ground connection to the receiver. This pin can be ignored when operating the receiver with the Raspberry Pi Pico's USB port as the ground connection is provided through the USB ground.

Receiver Performance Characteristics

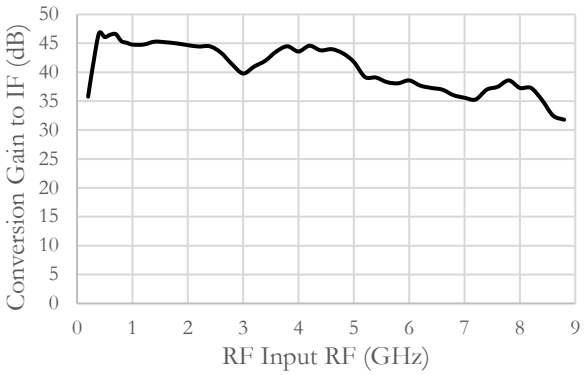


Figure 3: Receiver conversion gain vs. input RF frequency. IF = 75 MHz, RF input power = -60 dBm

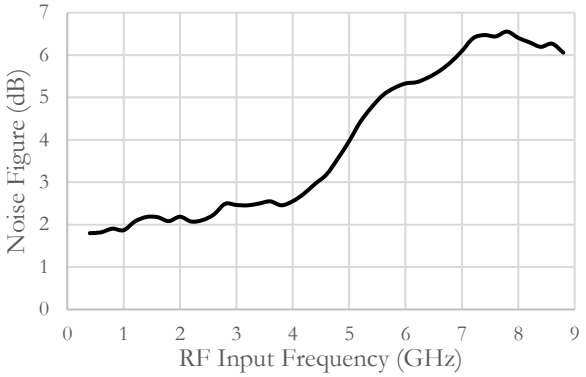


Figure 4: Receiver Noise Figure (NF) vs. input RF frequency. IF = 75 MHz. Measurement performed on HP8970B/HP8971C test set

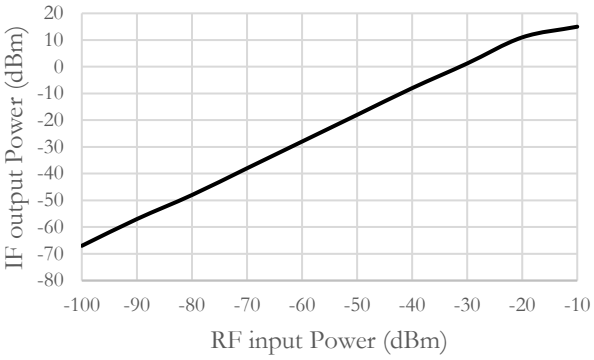


Figure 5: 75 MHz IF output power vs. RF input power at 8 GHz

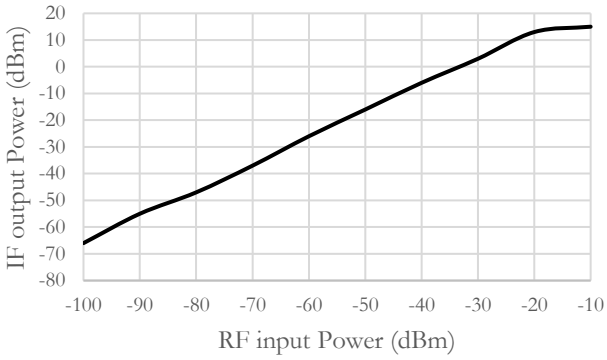


Figure 6: 75 MHz IF output power vs. RF input power at 6 GHz

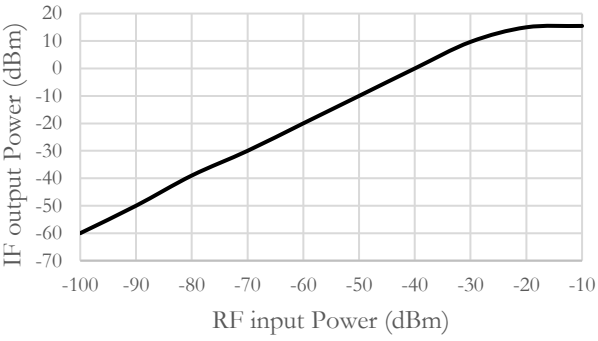


Figure 7: 75 MHz IF output power vs. RF input power at 4 GHz

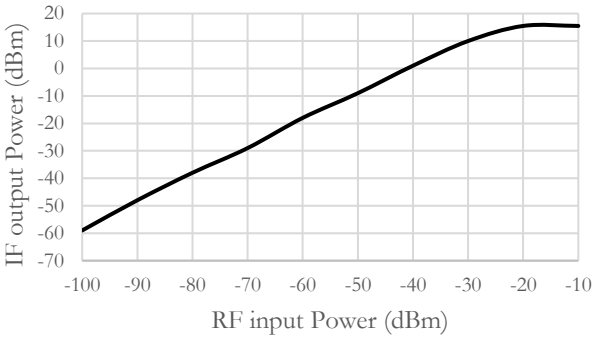


Figure 8: 75 MHz IF output power vs. RF input power at 2 GHz

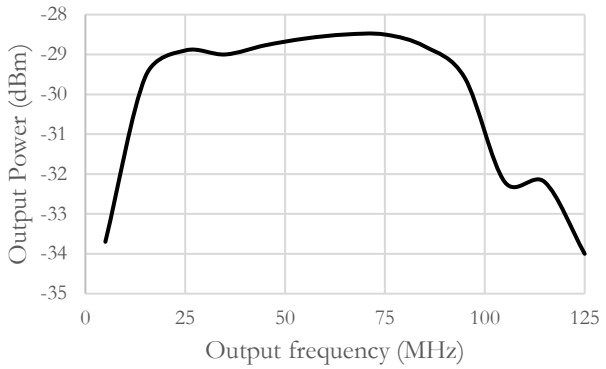


Figure 9: Downconverted Instantaneous Bandwidth of an input centered at 8 GHz with -60 dBm input power

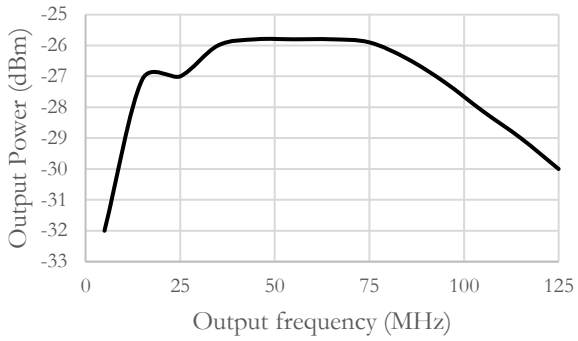


Figure 10: Downconverted Instantaneous Bandwidth of an input centered at 6 GHz with -60 dBm input power

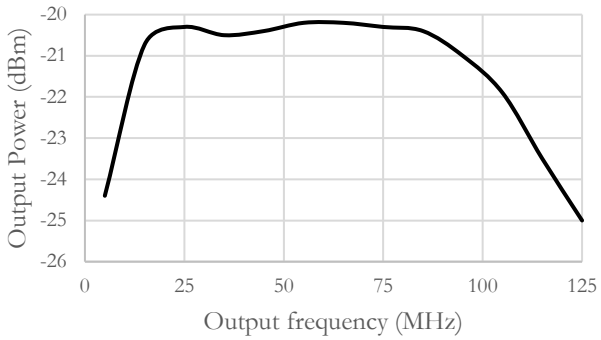


Figure 11: Downconverted Instantaneous Bandwidth of an input centered at 4 GHz with -60 dBm input power

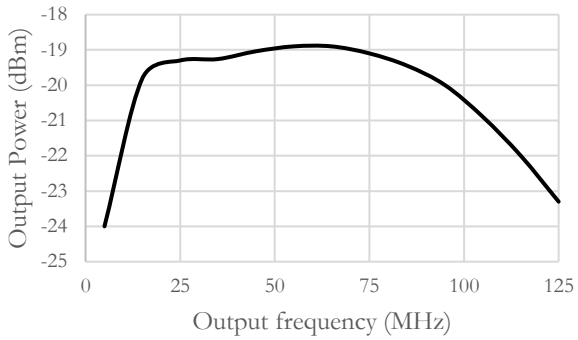


Figure 12: Downconverted Instantaneous Bandwidth of an input centered at 2 GHz with -60 dBm input power

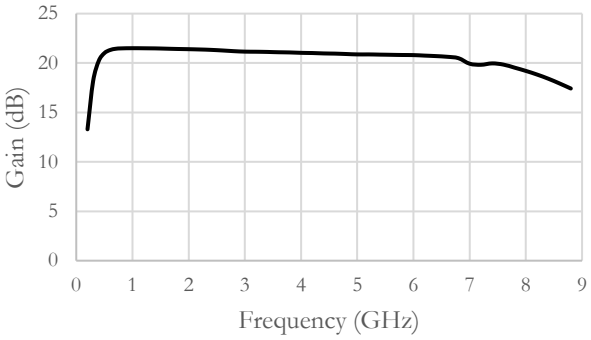


Figure 13: RF input LNA Gain vs. Frequency

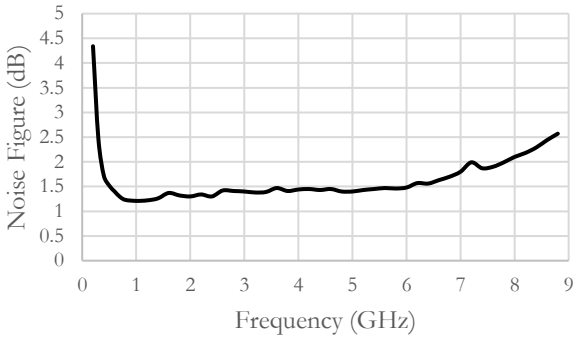


Figure 14: RF input LNA Noise Figure vs. Frequency

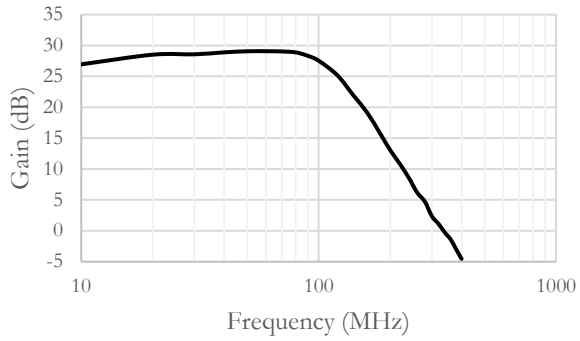


Figure 15: IF output IF Amplifier Gain vs. Frequency

Continuous Wave Output Performance Characteristics

The continuous wave output is only available on the DGRF-8800Rx+ model.

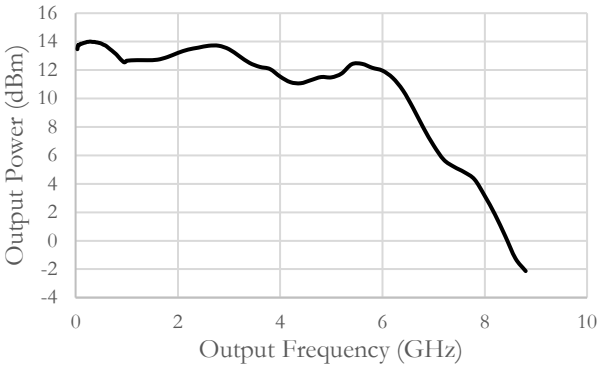


Figure 16: CW output power vs. frequency

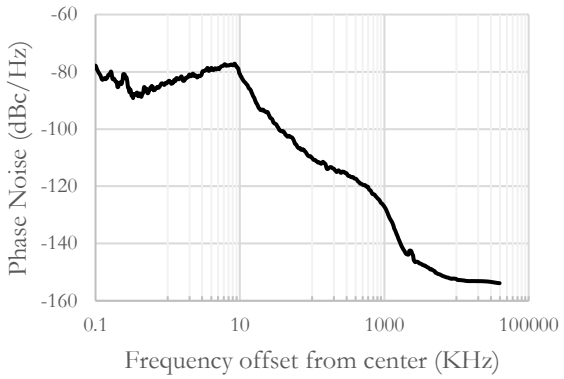


Figure 17: Phase noise of CW output at 2 GHz.

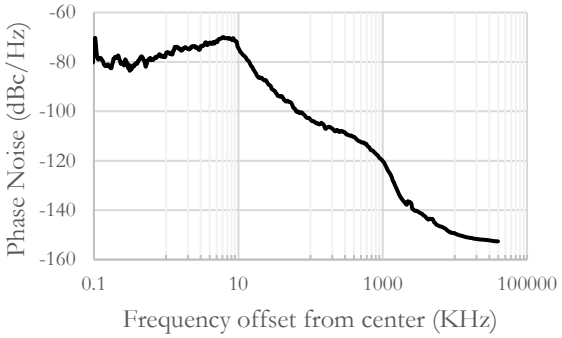


Figure 18: Phase noise of CW output at 4 GHz

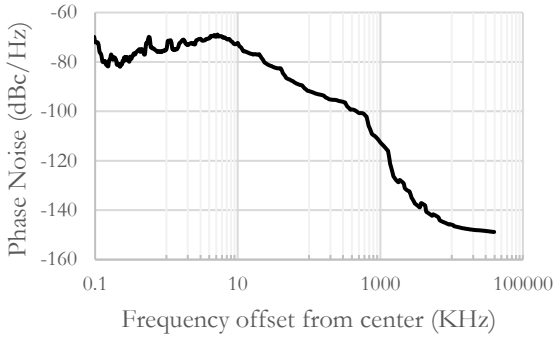


Figure 19: Phase noise of CW output at 6 GHz

User Guide

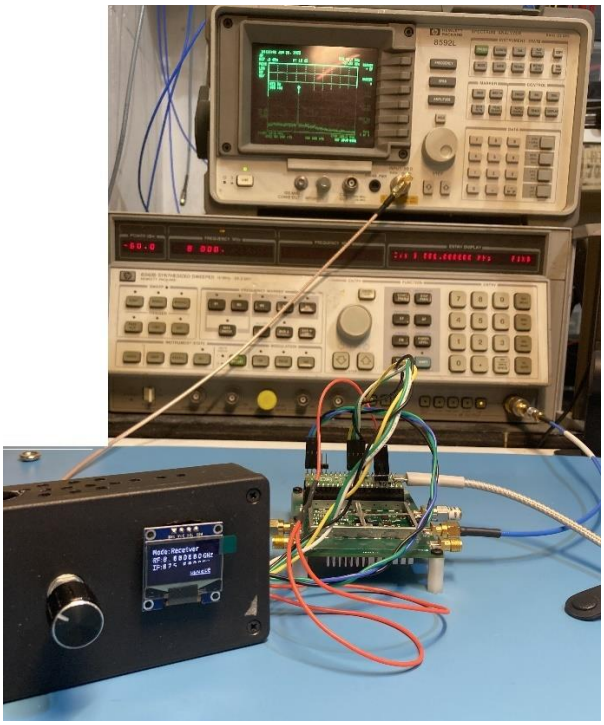


Figure 20: Photograph of DGRF-8800Rx+ under test along with its rotary encoder user interface and OLED screen

Above is a photograph of an unpackaged DGRF-8800Rx+ circuit board along with its rotary encoder user interface and OLED display screen under test. The DGRF-8800Rx+ is powered though the USB port connected to a Raspberry Pi Pico which is used to control the components within the DGRF-8800Rx+ and interacts with the rotary encoder, push button on the encoder, and OLED screen.

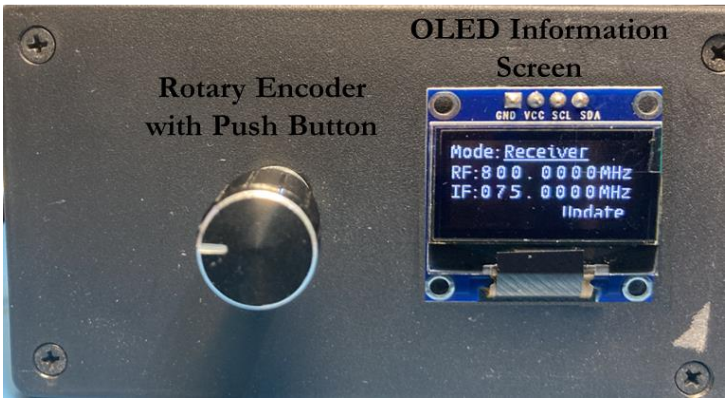
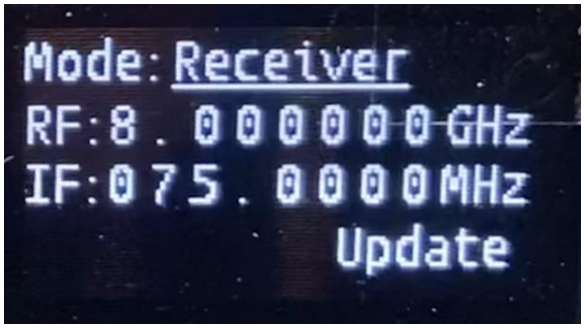
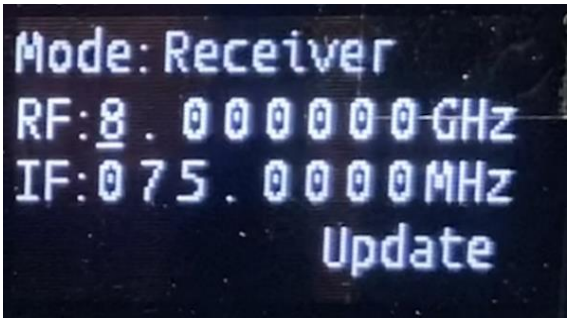


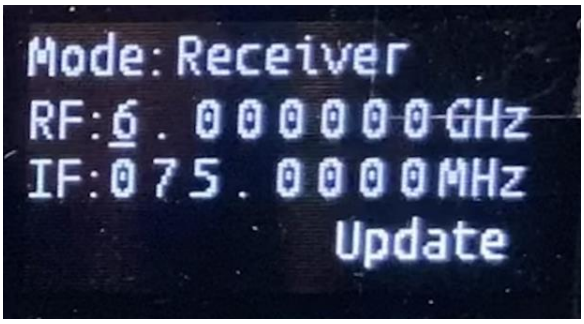
Figure 21: Photograph of the Rotary Encoder with Push Button Input and OLED display screen

Above is a close-up picture of the rotary encoder with a push button used to program and adjust the settings of the DGRF-8800Rx+ along with the OLED display screen which shows the state of the DGRF-8800Rx+ receiver. There are three inputs the rotary encoder can provide: a push button input, rotating the encoder right, or rotating the encoder left. The push button on the encoder allows the user to cycle through the various settings to be changed within the DGRF-8800Rx+. Rotating the encoder will change the setting currently selected by the push button.



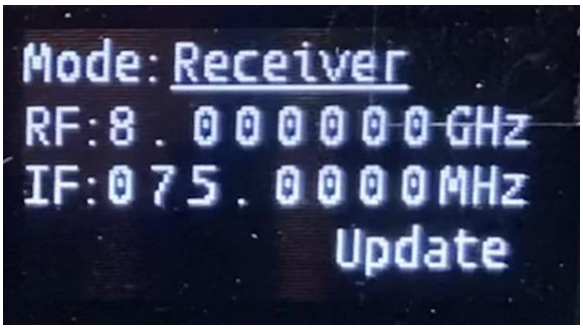


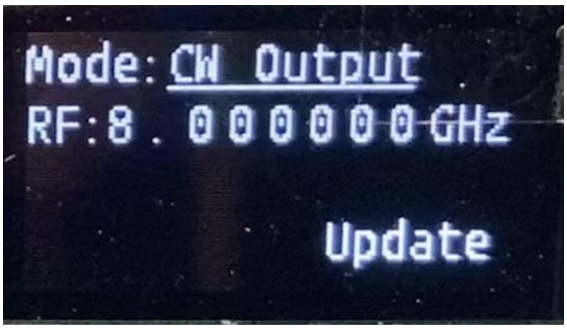
The two screen captures above show the functionality of the push button of the rotary encoder. The underlined setting ("Receiver" on the left and "8" on the right) is the setting currently selected. Pushing the rotary encoder switch will change which setting is selected. In the case shown above, the initial selected setting is the DGRF-8800Rx+'s mode, "Receiver". After pushing the switch on the encoder 1 time, the selected setting moves from "Receiver" to the most significant figure in the RF frequency, "8".



The two screen captures above show the functionality of rotating the rotary encoder. In the example above, the most significant figure of the RF frequency is the selected setting. Rotating the encoder counterclockwise will reduce the value of the number and rotating the encoder clockwise will increase the value of the number. In the case shown above, the initial RF frequency is set to 8.0 GHz. With the most significant figure selected, rotating the encoder counterclockwise by two increments will change the RF frequency from 8.0 to 6.0 GHz.

Mode Selection:



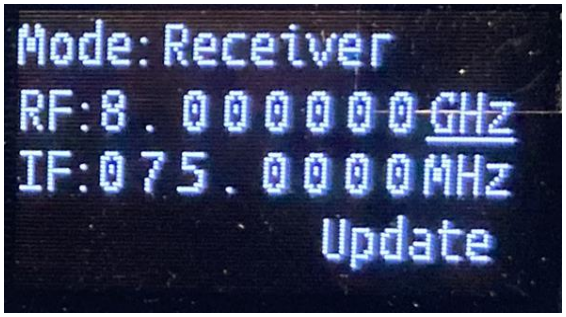


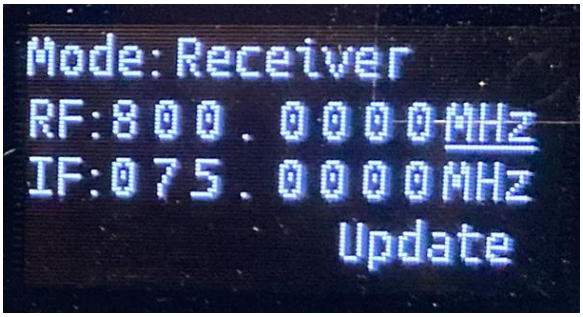
There are two modes the DGRF-8800Rx+ can operate in, "Receiver" and "CW Output". To switch between the two modes, ensure the mode is selected by pushing the switch on the encoder until the mode is underlined. Once the mode is selected, rotate the encode in either direction to switch between modes.

In the "Receiver" mode the DGRF-8800Rx+ is set to downconvert a signal centered at a defined RF frequency to a defined IF frequency. In "Receiver" mode the DGRF-8800Rx+ takes the RF input through the RF_{in} port and provides the IF output from the IF_{out} port. In "Receiver" mode the CW_{out} port is muted to save power. The limits on the RF frequency are 200 MHz – 8.8 GHz. The limits on the IF frequency are 10 MHz – 110 MHz. The IF IBW will be a function of which IF frequency is chosen. To achieve the maximum 100 MHz IBW, the IF frequency must be set to 60 MHz.

In the "CW Output" mode the DGRF-8800Rx+ is set to provide a continuous wave output out of the CW_{out} port. This mode is omitted in the DGRF-8800Rx model. The DGRF-8800Rx+ will produce an output at the RF frequency specified. The limits to the RF frequency in the "CW Output" mode is 35 MHz to 8.8 GHz. The output power at specific frequencies can be found in Fig. 16.

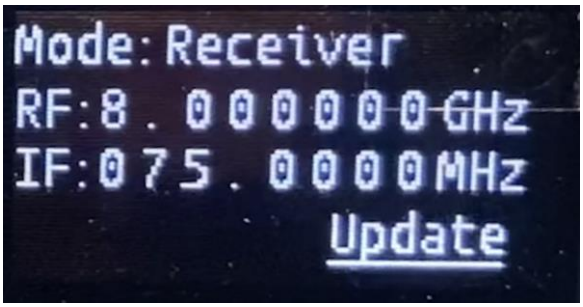
Frequency Scale Selection:

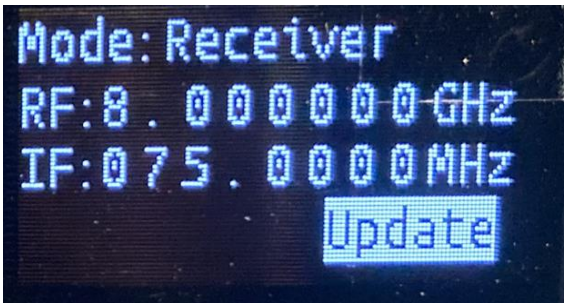




There are two frequency scales which can be used within the DGRF-8800Rx+. To switch between the two frequency scales, ensure the frequency scale is selected by pushing the switch on the encoder until the frequency scale is underlined. Once the frequency scale is selected, rotate the encoder either direction to switch between "GHz" or "MHz".

Updating the DGRF-8800Rx:





To update any changes made to the DGRF-8800Rx+ settings, it is necessary to update the device to enact any changes. To update the DGRF-8800Rx+, ensure "Update" is selected by pushing the switch on the encoder until "Update" is underlined. Once "Update" is selected, rotate the encoder in either direction to initiate the update process. "Update" will flash for one second to indicate the command was issued and the DGRF-8800Rx+ is updated properly.

DGRF-8800Rx Error Messages:

If the user selects an inappropriate setting, an error code will appear on the OLED display. Below are the error codes and their meaning.

ERR1: RF frequency is out of range within Receiver mode. Ensure the RF frequency falls between 200 MHz and 8.8 GHz.

ERR2: IF frequency is out of range within Receiver mode. Ensure the IF frequency falls between 10 MHz and 110 MHz.

ERR3: RF frequency is out of range within CW output mode. Ensure the RF frequency falls between 35 MHz and 8.8 GHz.

Part Dimensions

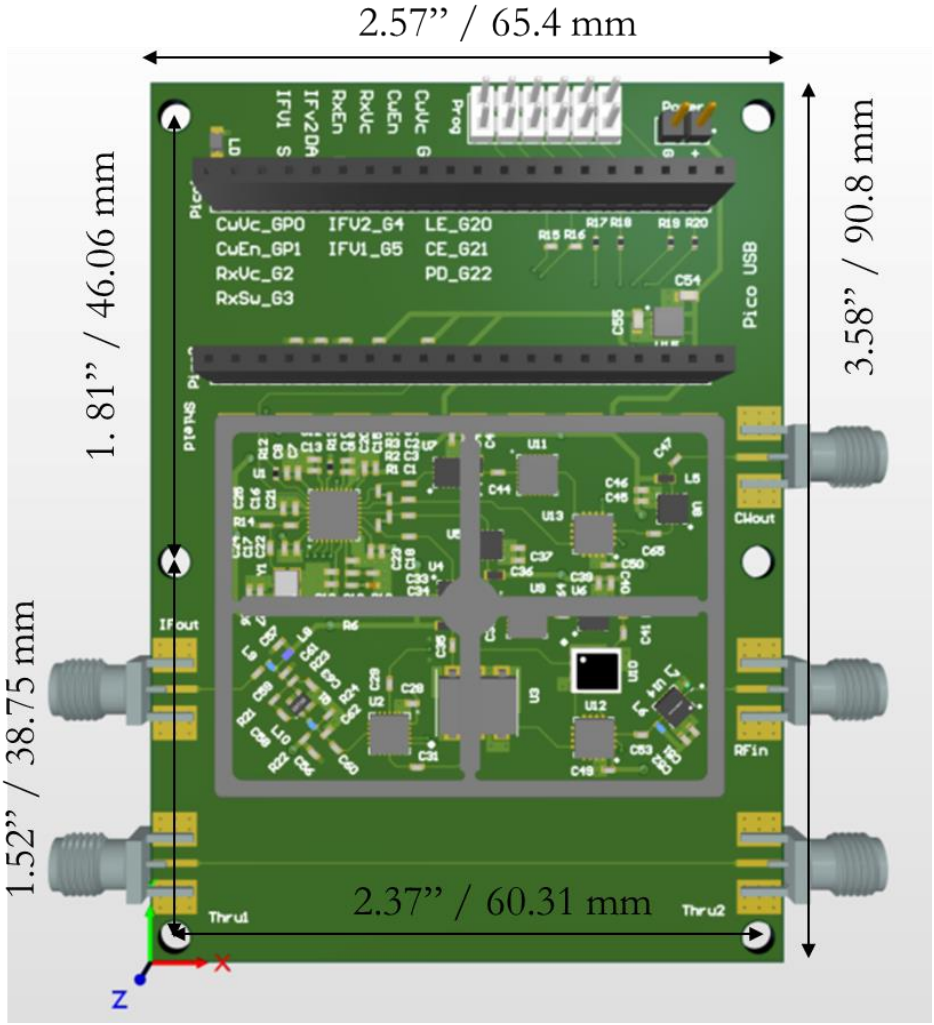


Figure 22: Dimensions for the initial prototype design for the DGRF-8800Rx+ PCB. When the product is transitioned to mass production the PCB will be altered slightly to eliminate the through line test ports and line. The mounting holes will be adjusted to fit the custom designed PCB housing.