MM-Wave Stepped-CW "G-Band" Transceiving System – 144 to 216 GHz

The high mm-wave components up for sale in this eBay offer comprise a G-Band "kit" allowing the construction of a 144-220 GHz pitch-catch transceiving system. The system these parts were once part of is a high-resolution short-range radar for observation of salt build-up in an environment where other region-of-interest interrogation methods were not applicable.

This parts kit can be easily configured as a free-field reflection-transmission test station for measuring sub-terahertz material properties, or properties of a region of interest. Systems of this type are often called Vector Network Analyzer Extensions because they enable standard VNA's to operate as host controllers and displays for high-band front ends operating at much higher frequencies.

The G-Band components offered here have been disassembled from a working prototype system and will work in conformance with their performance specifications.

A part price tally sheet shows that the component parts in the offered kit originally cost almost $29,000. At this time, breaking the kit up and selling the components individually is not offered as an option. Also, the on-offer kit does not include the baseband IF processor components shown in some of the photographs and block diagrams. This should not be an issue because a technically able customer would reasonably want to design their own Master Oscillator and IF processing using components and methods, they are already familiar with. Using a high-end vector network analyzer would jump-start a working brass-board system. In any case, the baseband Master Oscillators and signal processing components are available.

I am the designer of this system and for the general interest of a potential buyer, a certain amount of system design information is presented here. Also, I am happy to answer whatever questions a buyer might wish to ask. Until then …

Best Regards, - Craig

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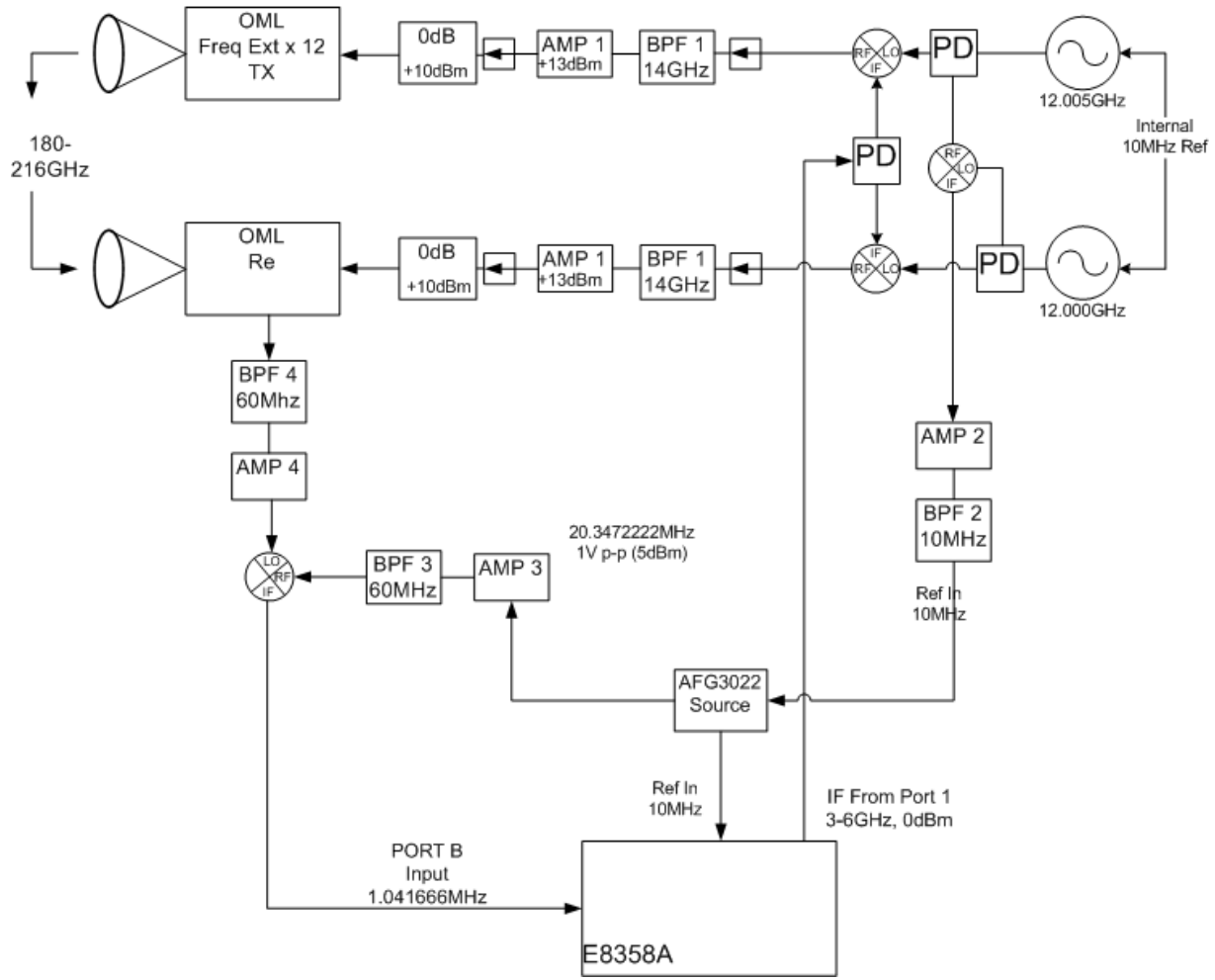
Stepped-CW G-Band Radar System Block Diagram – Early Version



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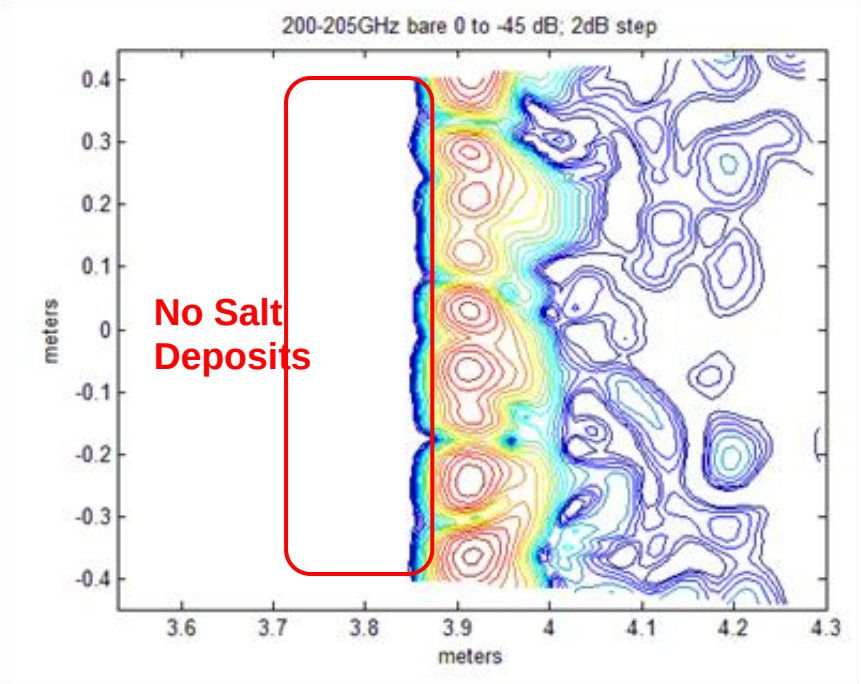
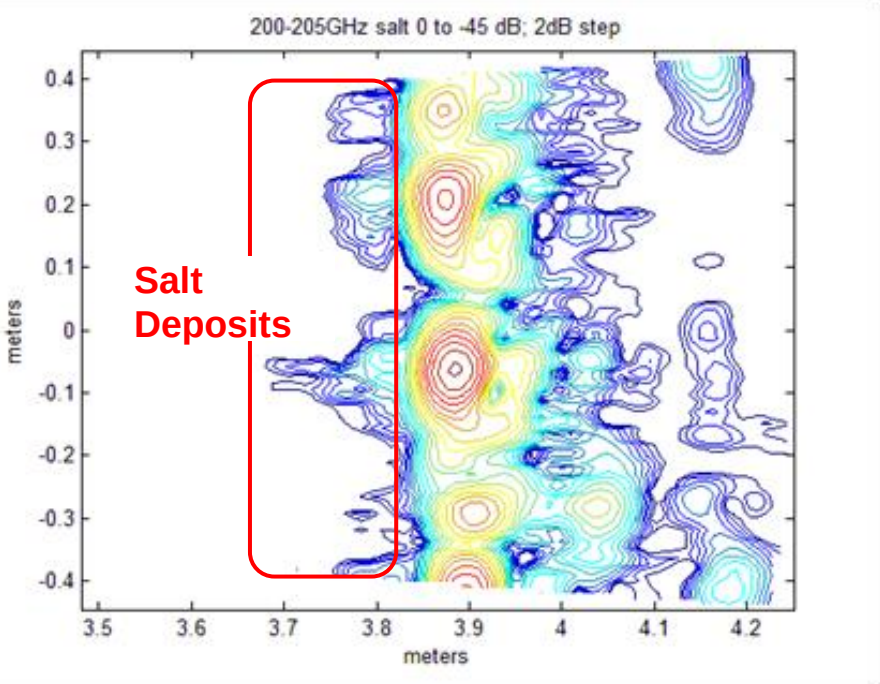
MM-Wave Stepped-CW Radar – Prototype System Output Contour Plots





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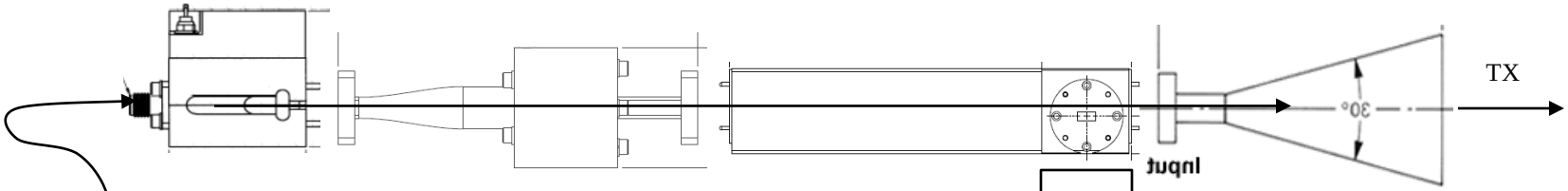
Early "Homodyne" Setup - Roughly $ 55k Part Cost - Including VNA

Millitech AMC-05-RFH00
(11.67 – 18.33 GHz N=12 $ 6.9k)

Millitech FBI-05-RSES0
($ 2.3k)

Millitech CL3-05-R1000
($ 3 k)

Custom Microwave RCH05R ($ .6k)



TX

Power Sensor
(roughly $2k)

Virginia Diode WR5.1ZBD

HP 8720D with Options 01 and 89 ($25-35k)
(Set to sweep between 12 and 18 GHz)

Generic Voltmeter ($ .5 k)

Amp
($.3k)

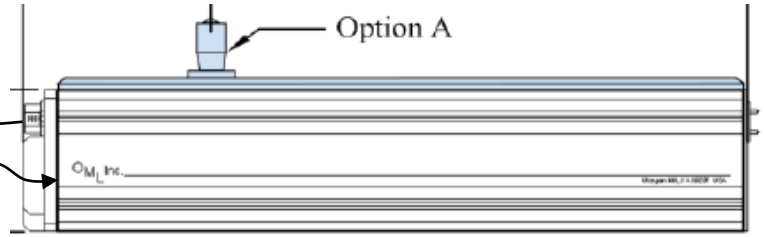
LO

IF

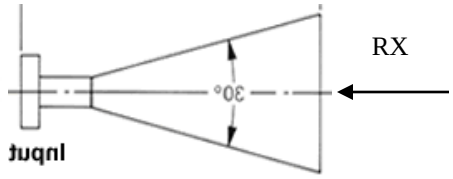
Power Splitter
($.3k)

Amp
($.3k)

OML V05VNA2-T (11.6 – 18.4 GHz LO N = 12 $ 13.6k)



Custom Microwave RCH05R ($ .6k)



RX

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Stepped-CW G-Band Radar (140-220 GHz) System Block Diagrams

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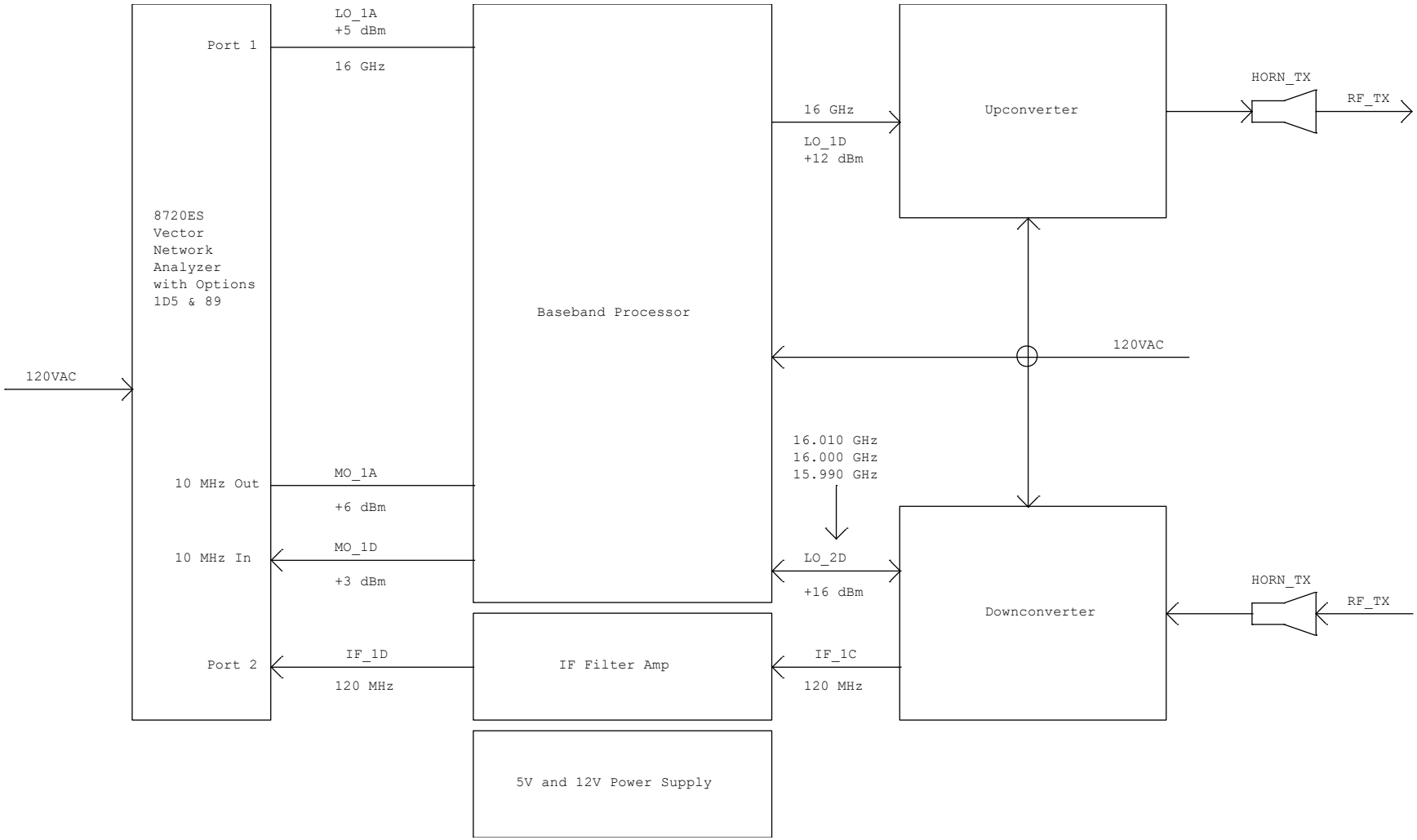
Stepped-CW Radar – Top Level System Block Diagram – Early Version



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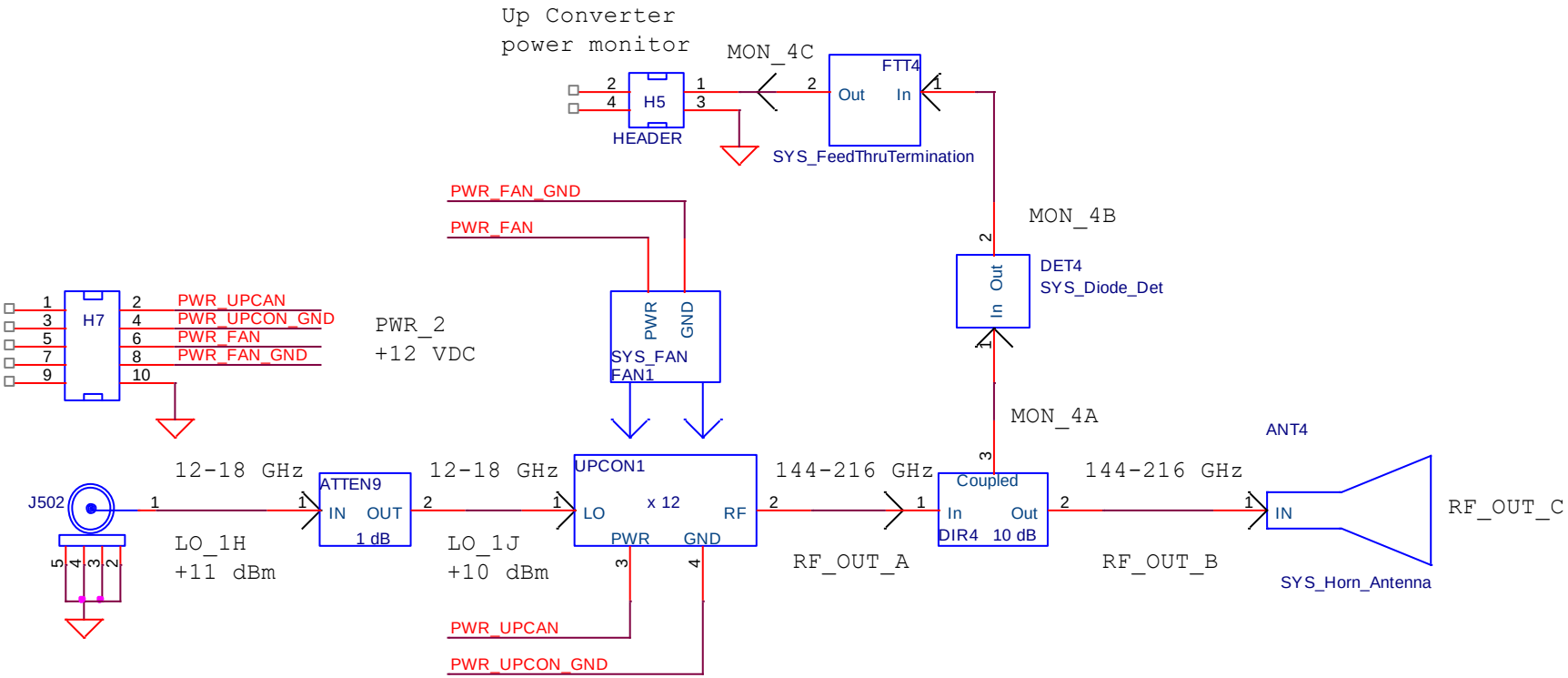
Stepped-CW Radar – Up-Converter – F_out = F_in x 12



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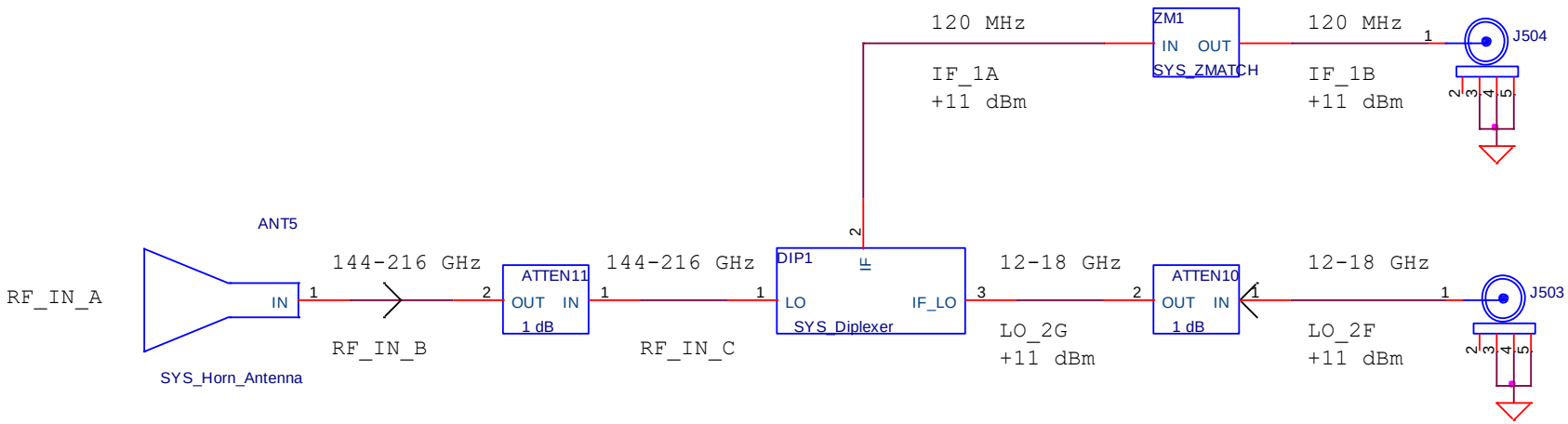
Stepped-CW Radar – Down Converter – 144-220 GHz in 120 MHz IF Out



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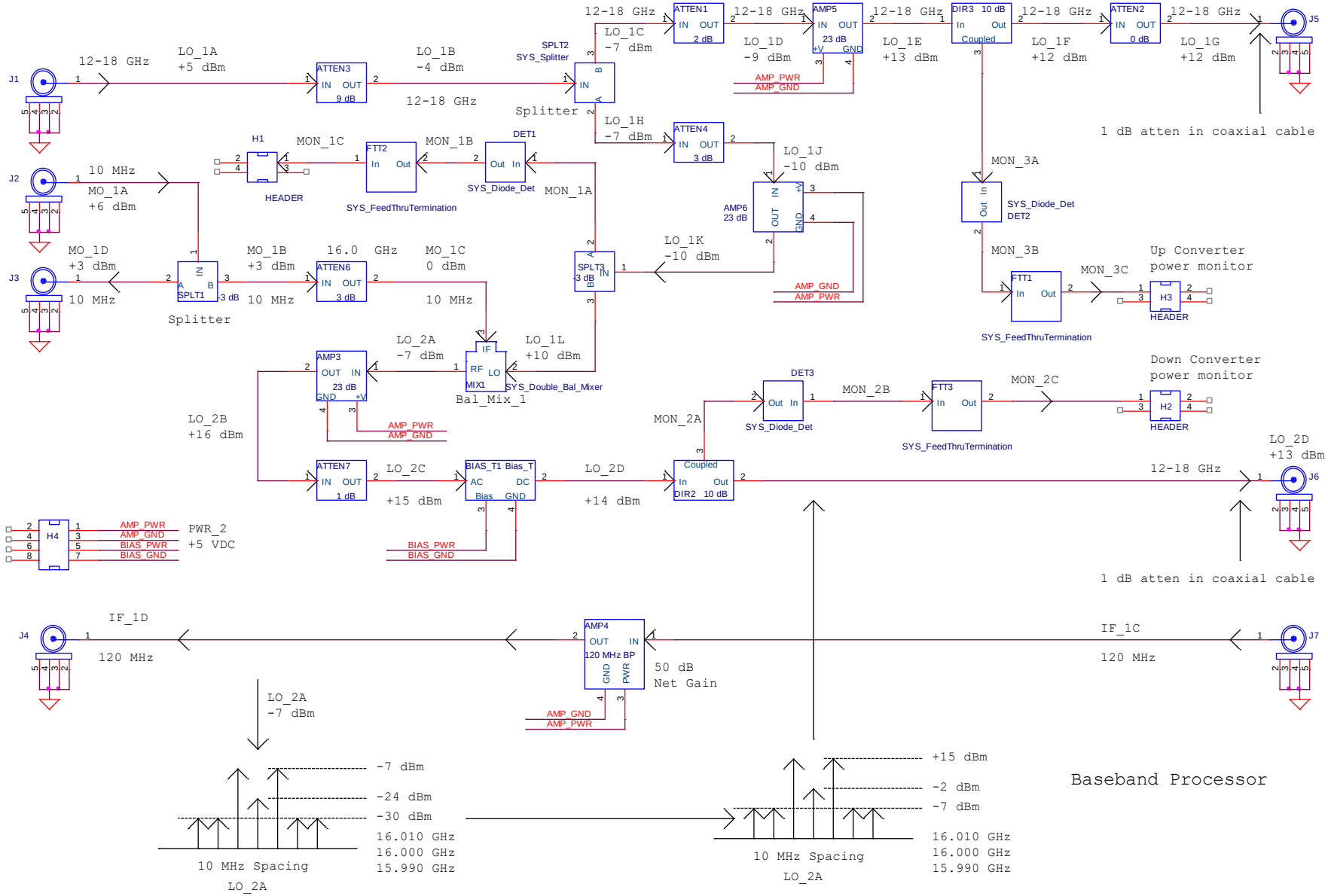
Baseband Processor Subsystem Block Diagram



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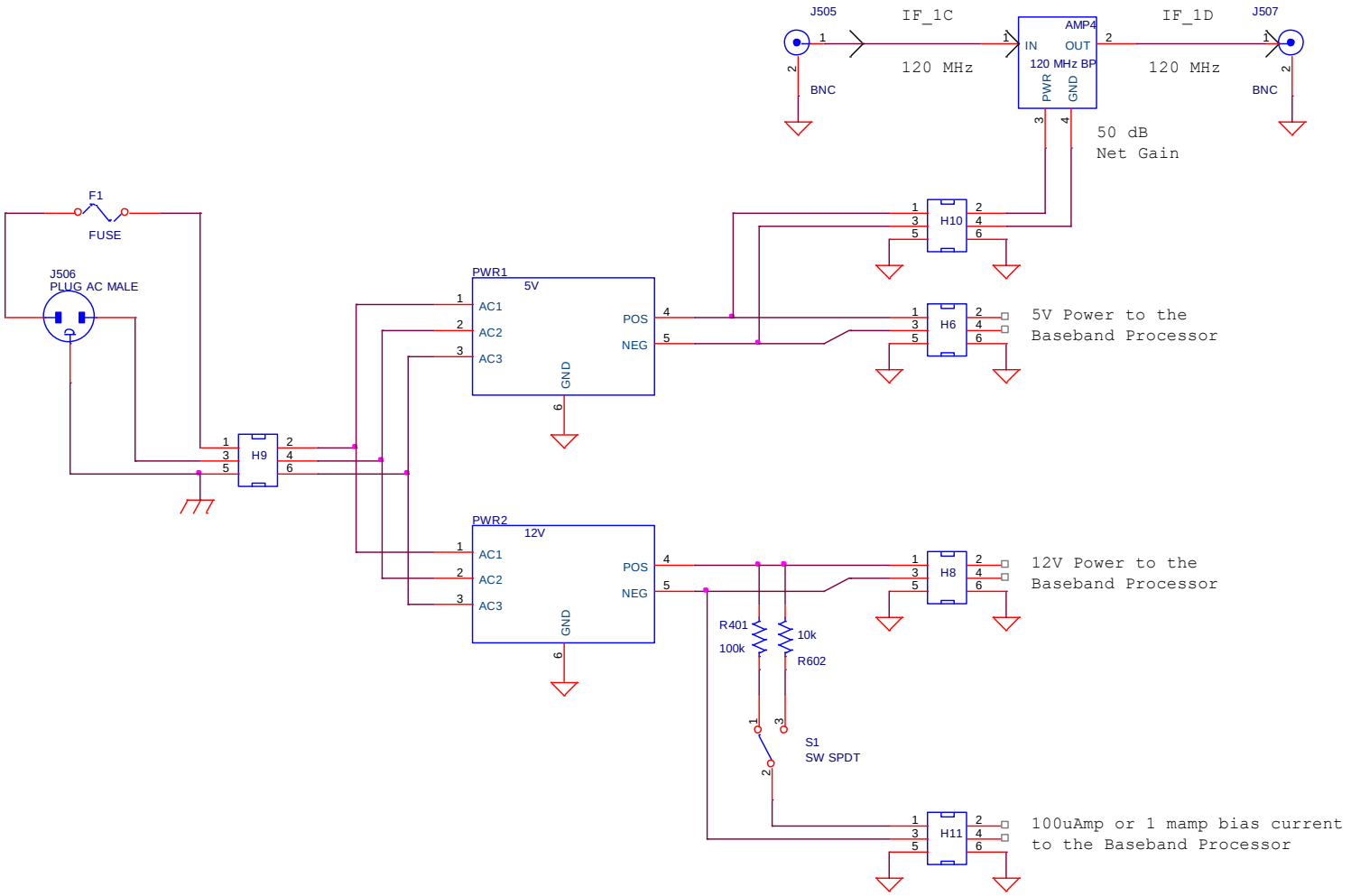
Stepped CW Radar – Power Supply and 120 MHz IF Filter Amp



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System Implementation Photographs

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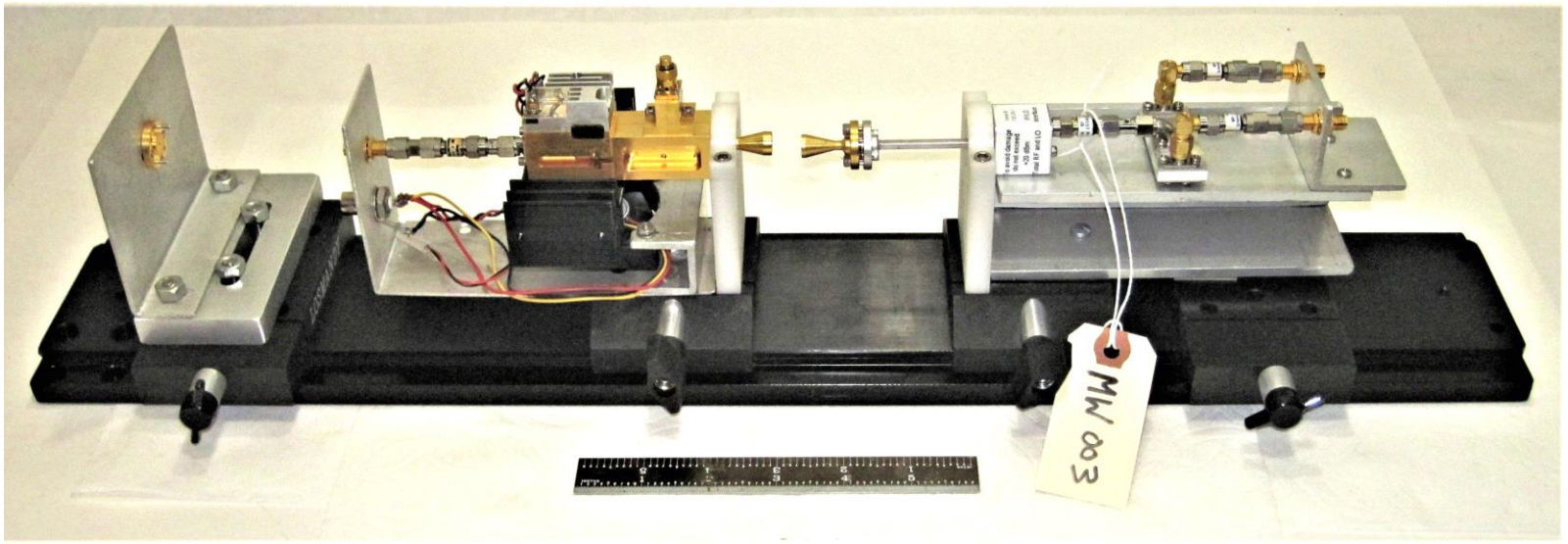
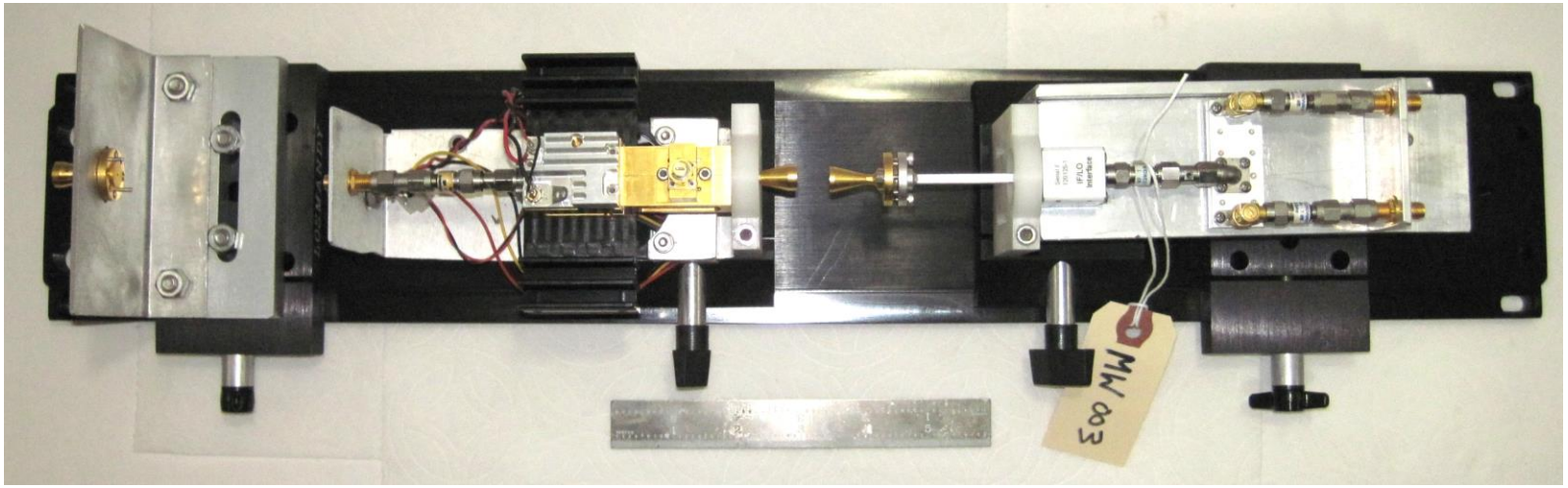
G-Band Transceiver Subsystem





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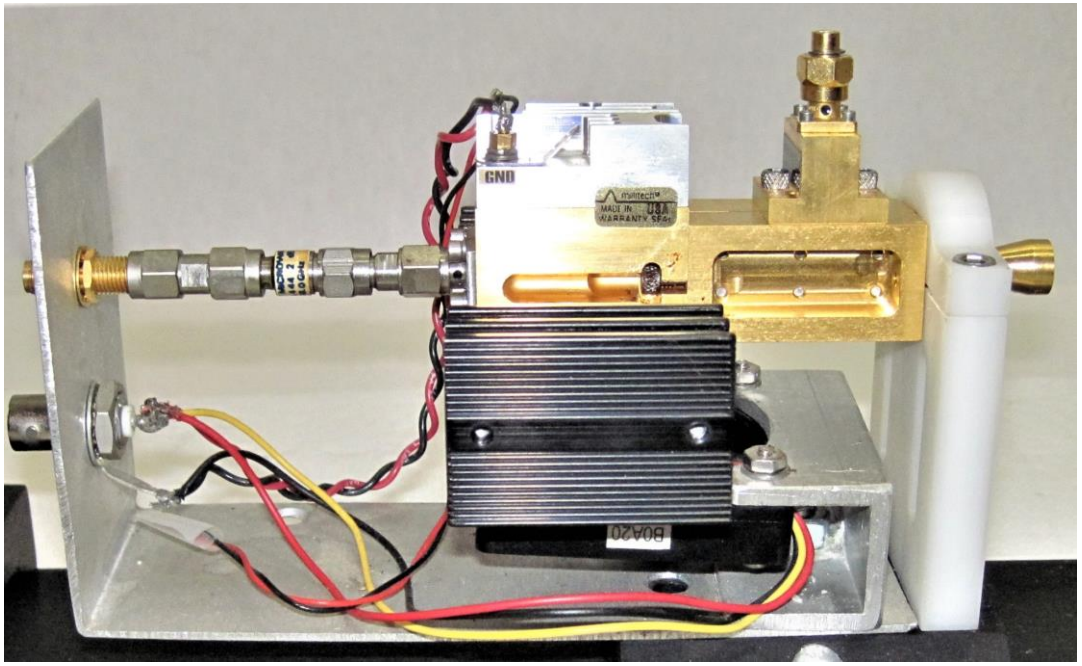
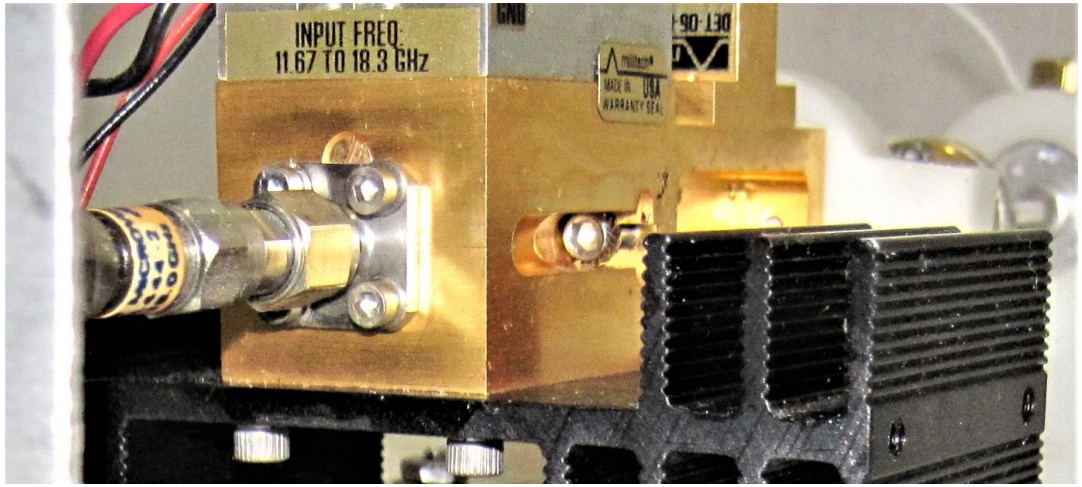
G Band x12 Multiplying Up-Converter





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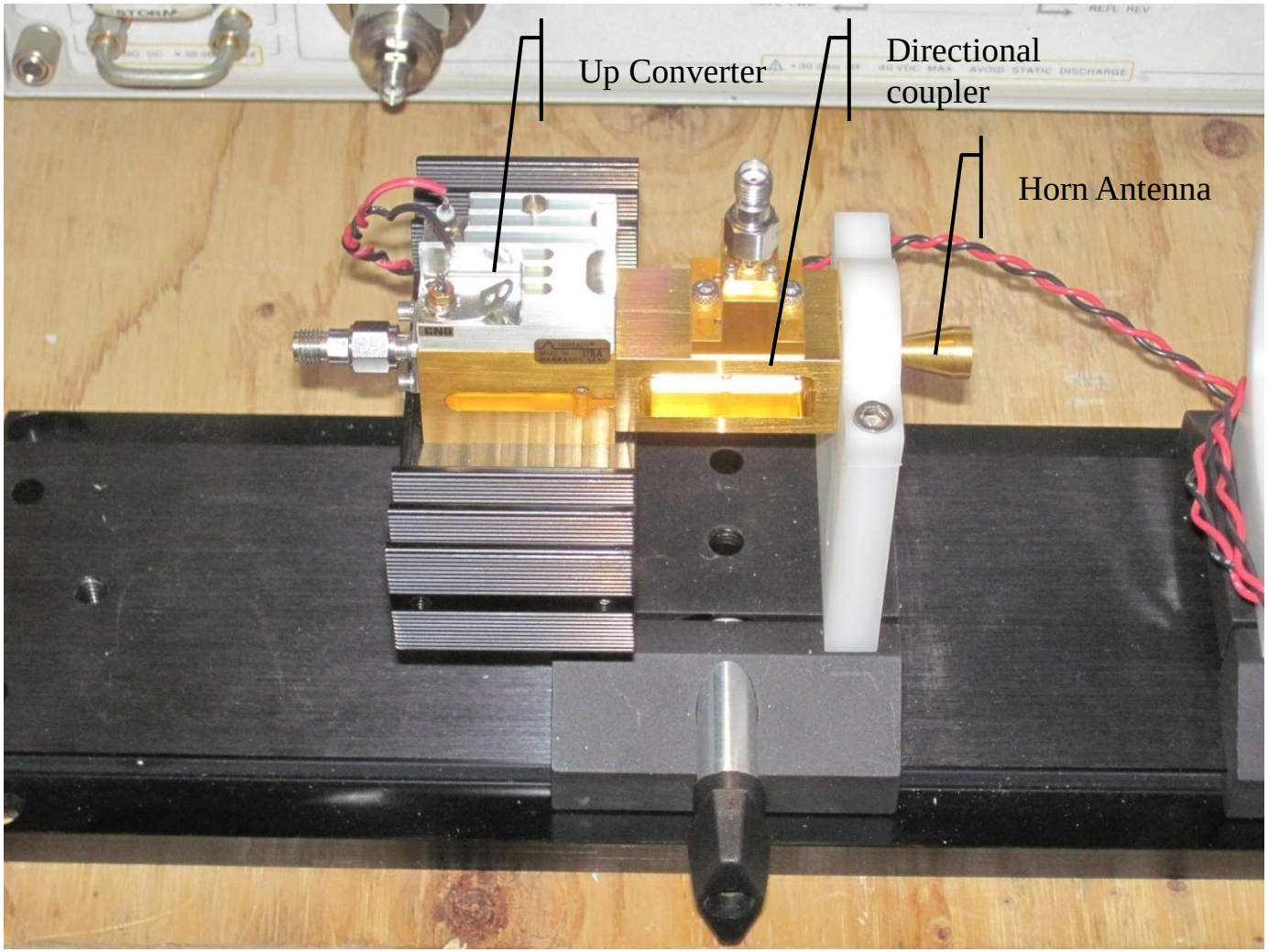
G Band x12 Multiplying Up-Converter



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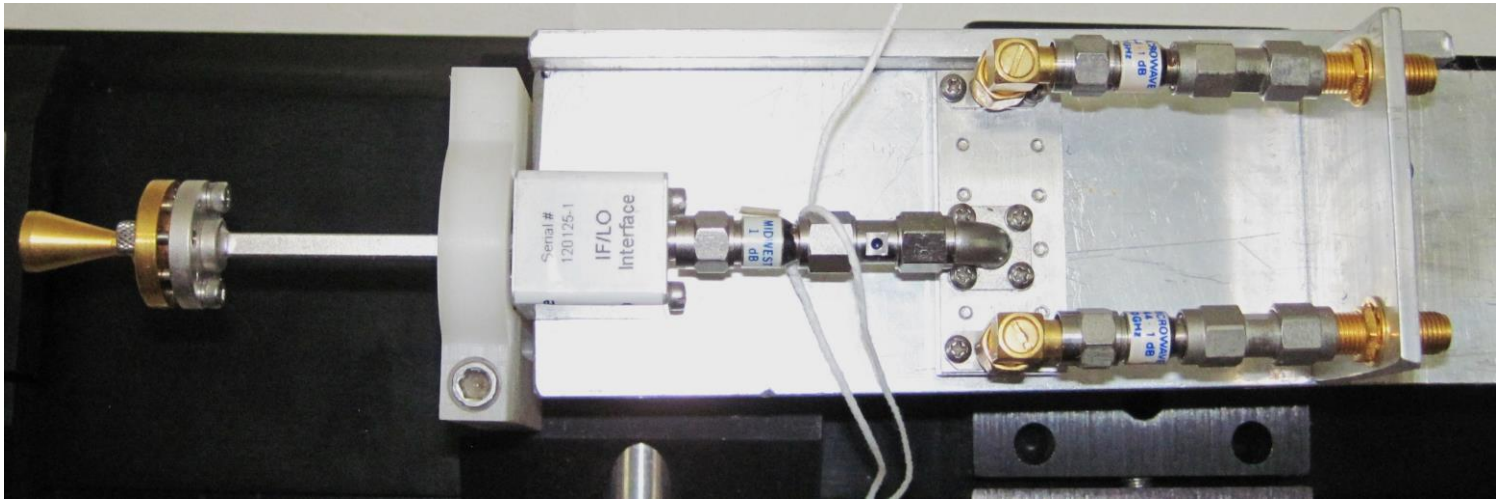
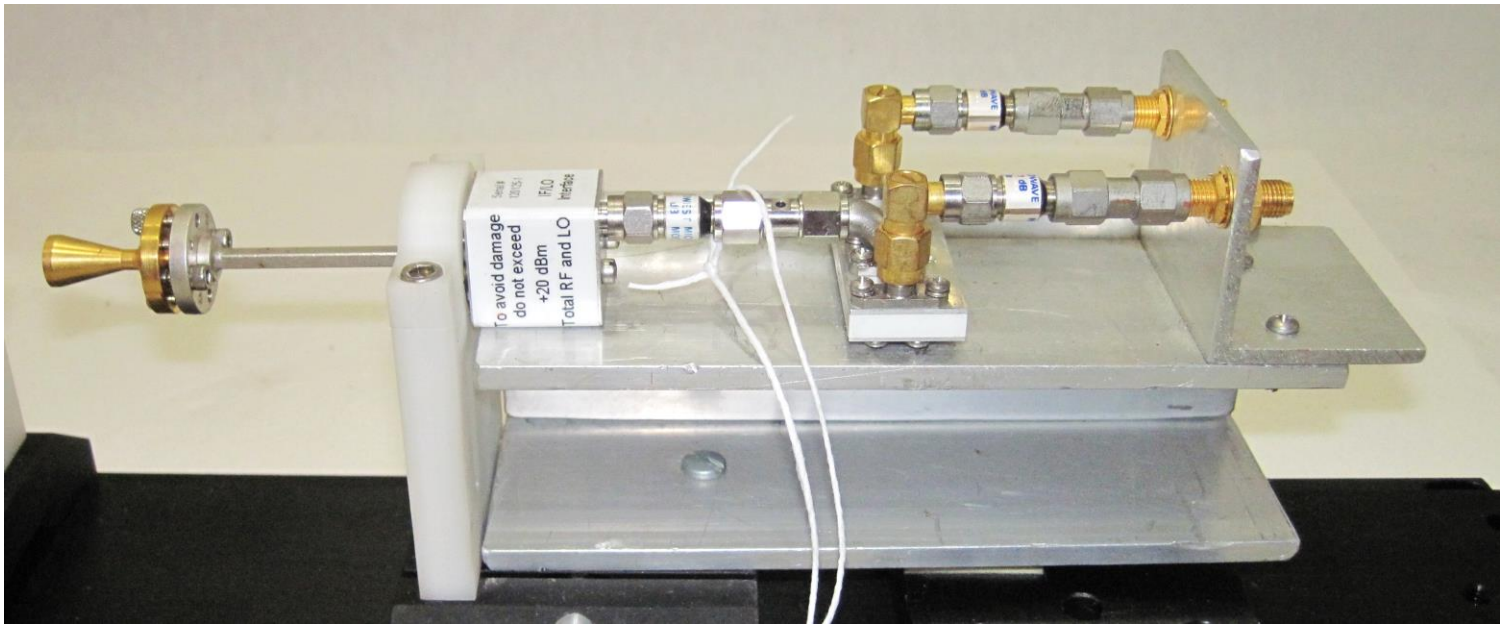
G-Band Down-Converter





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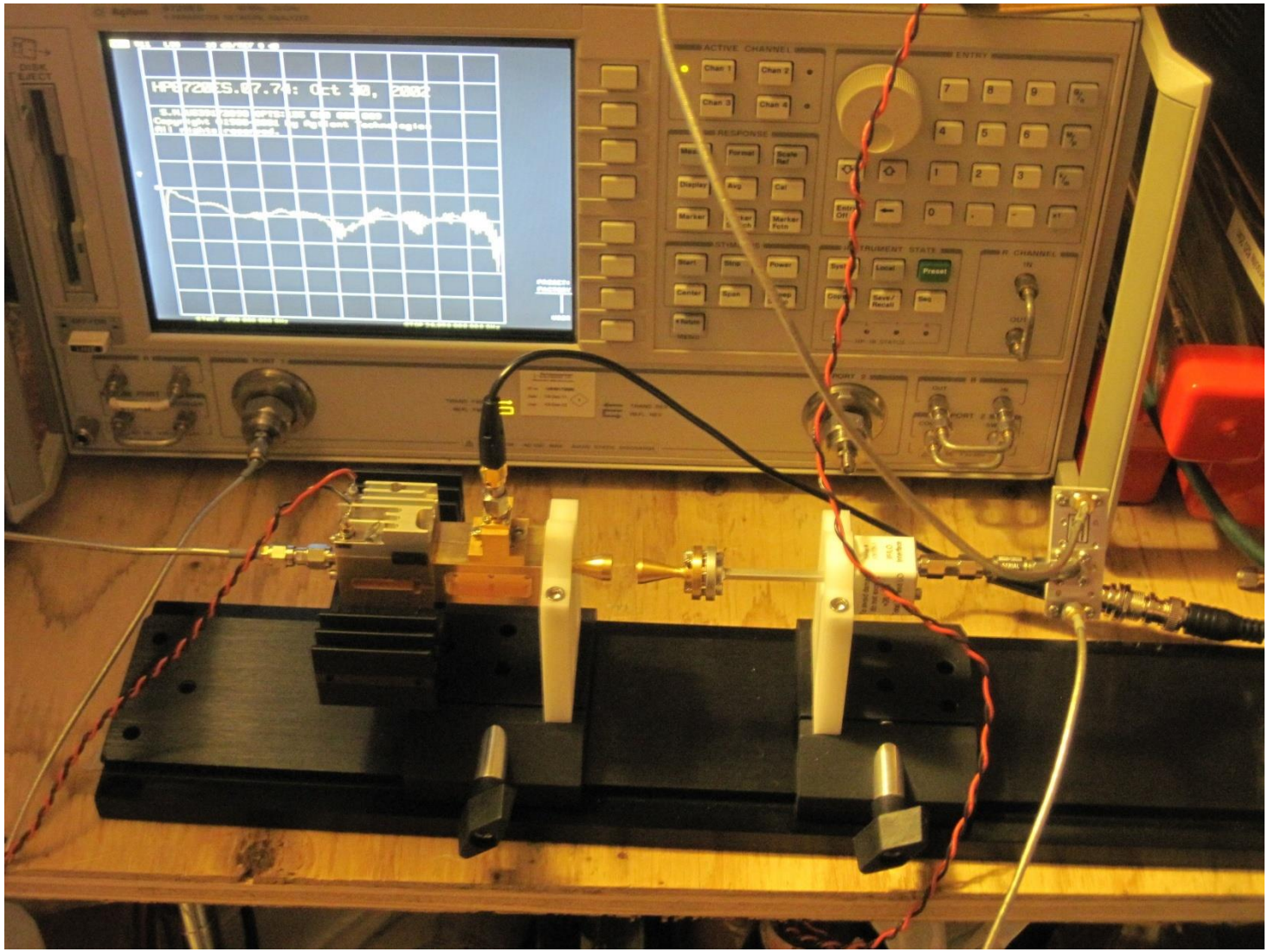
General Bench Setup – Simple Early Experiment



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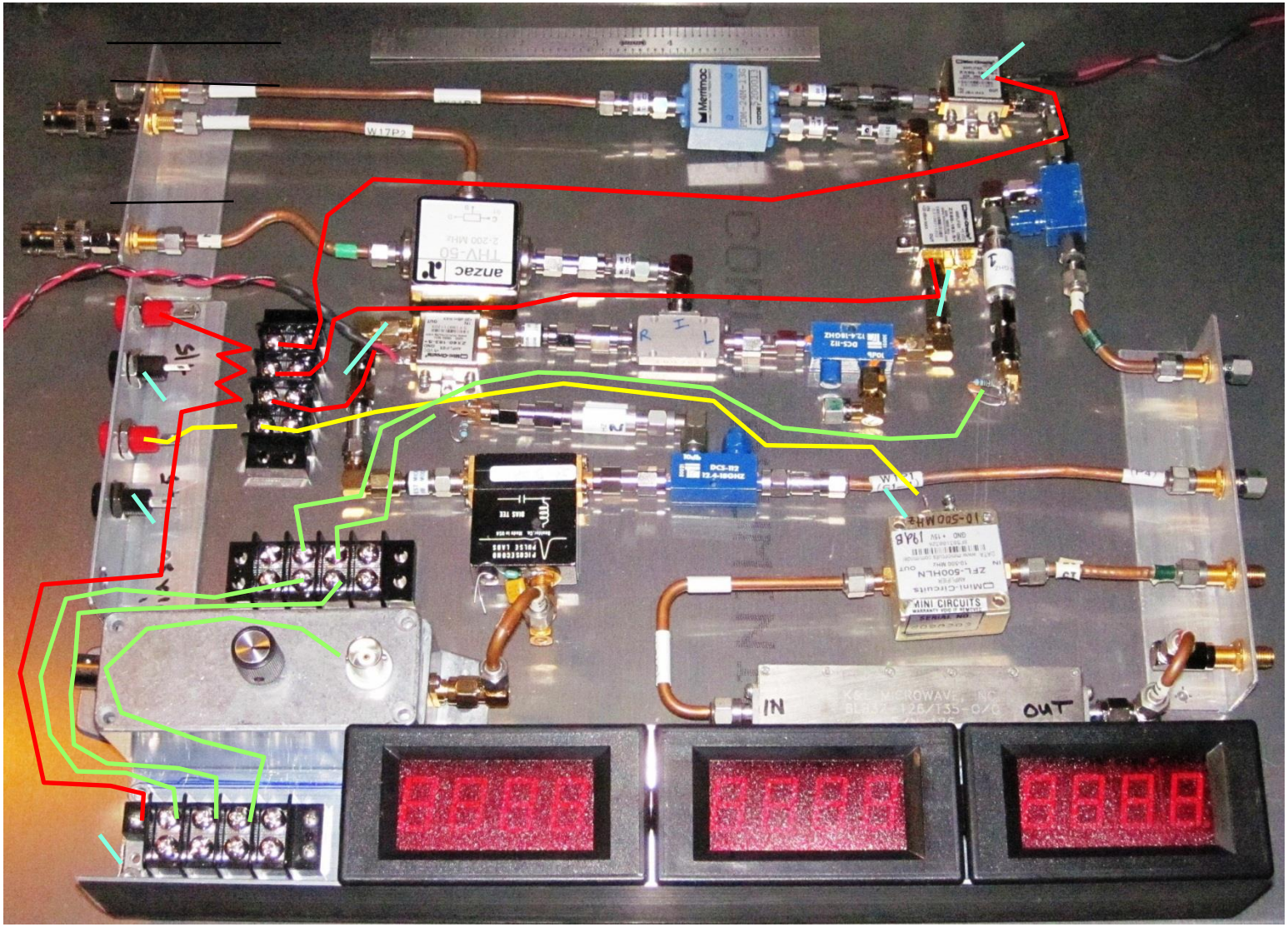
Stepped CW Radar – Baseband Processor – Early Version Layout



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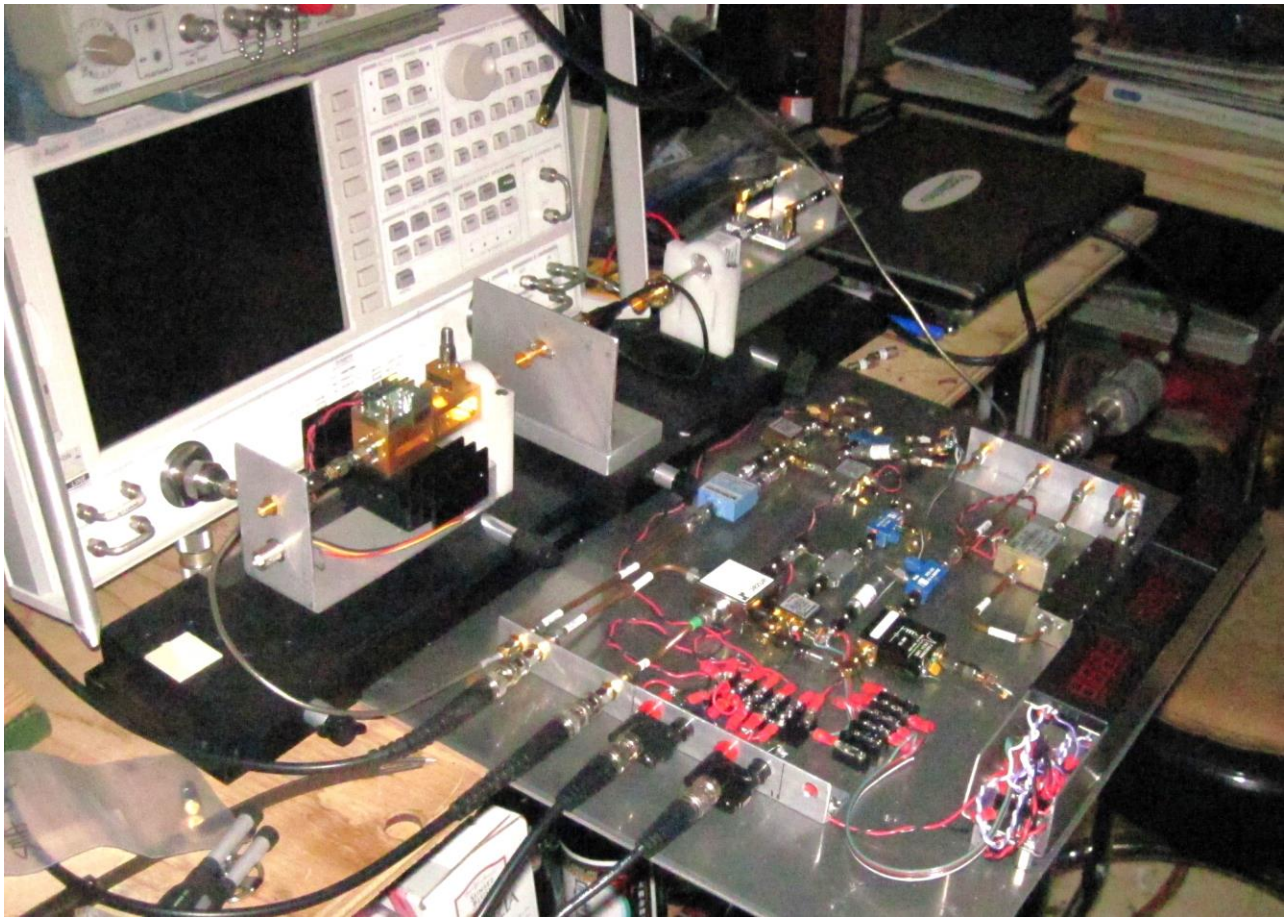
General Bench Setup – Second Generation



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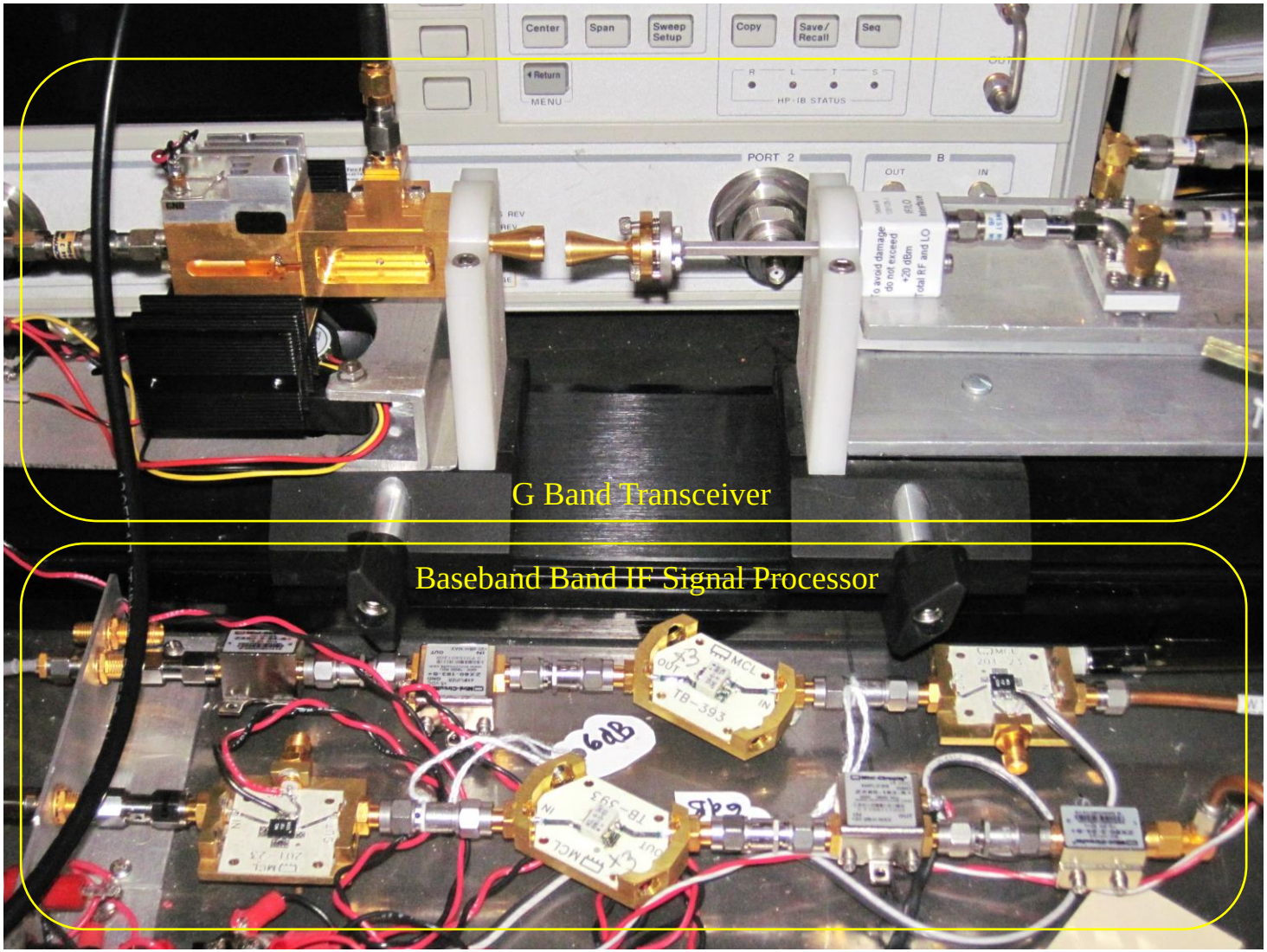
General Bench Setup – Final Configuration



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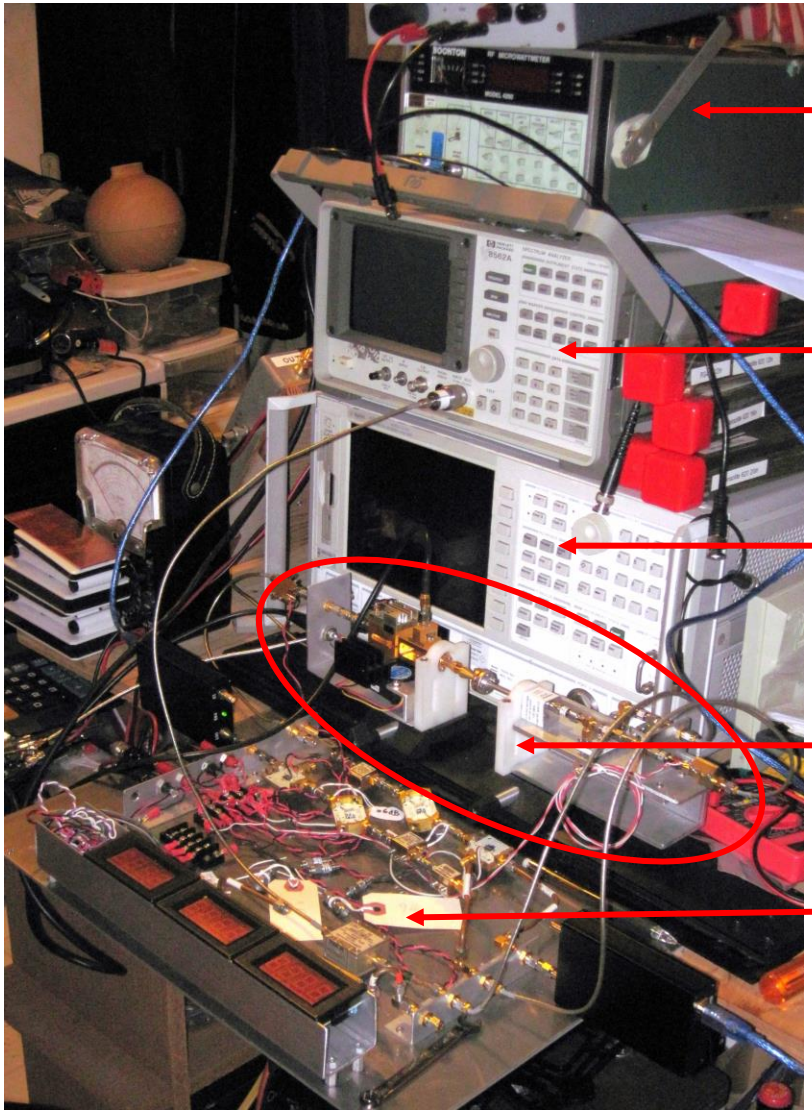
General Bench Setup – Test Equipment Infrastructure Stack



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G-Band Components

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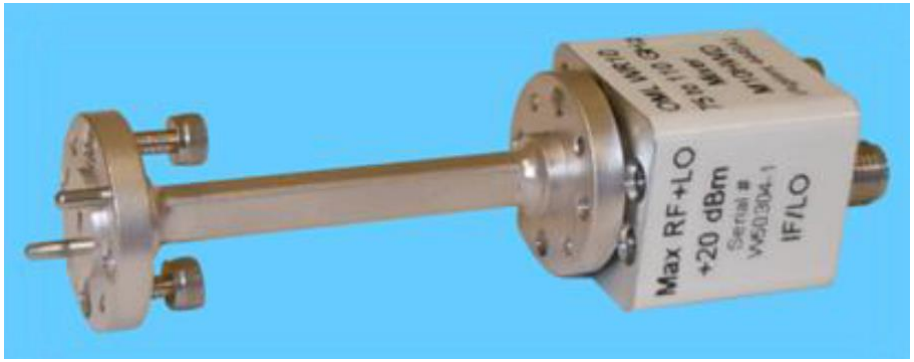
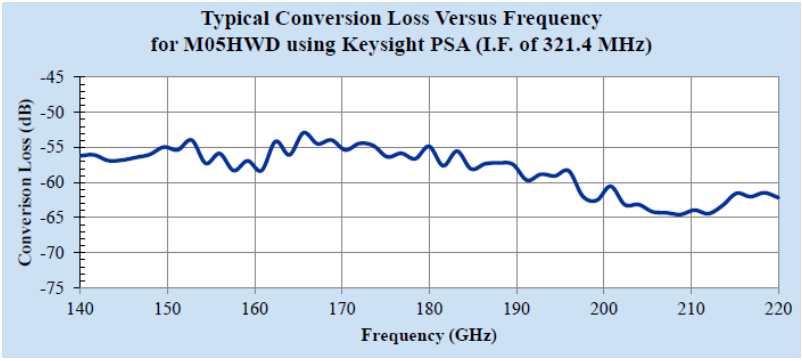
OML M05HWD G-Band Harmonic Mixer 140 – 220 GHz





ELECTRICAL AND PERFORMANCE SPECIFICATIONS (+25°C)

After a 0.5 hour warm-up period, the M05HWD will satisfy the following specifications.

Electrical Characteristics[1]	MIN	TYP	MAX
System Operating Frequency (GHz)	140	--	220
RF Port Match (dB)[2]	--	7.5	--
1 dB Compression (dBm)[2]	--	-10	--
Third Order Intercept (dBm)[2]	--	0	--
LO Input (dBm)	+12	+15	+17
Usable LO Input w/ Degraded Conversion Loss (dB)	+6	--	+18
IF Frequency Range (MHz)[3]	--	321	2,400
Mixer Bias (mA)[4]	-10	--	+10
Operating Temperature Range (°C)	20°	25°	30°

Module Characteristics[1]	Description
System Waveguide Interface (dB)[5]	WR-05
Conversion Loss (dB)[6]	59
System LO/IF Interface	SMA (f)
Sensitivity (dBm)[7]	-85
Typical RF Power to Avoid Compression (dBm)[2]	-20 dBm (10 µW)
Maximum Power, RF+LO (mW, dBm)	100 mW (20 dBm)
Size (L x W x H)	2.9" x 0.9" x 0.8"
Weight	< 6 ounces

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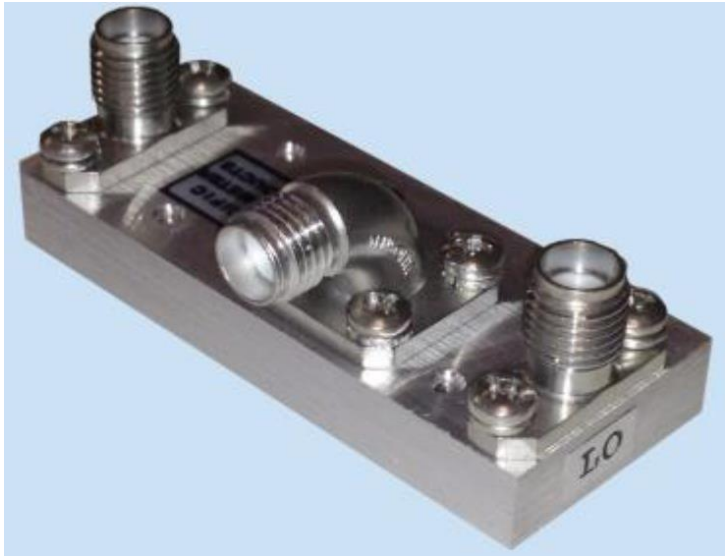
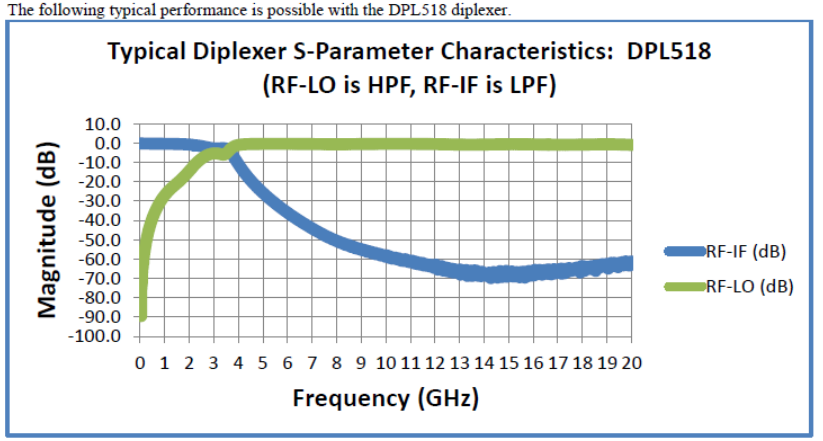
OML DPL518 Diplexer



TYPICAL PERFORMANCE

The following typical performance is possible with the DPL518 diplexer.



ORDER INFORMATION

DPL518	Diplexer, L.O. 5-18 GHz, I.F. DC to 2 GHz.

Standard accessories for each diplexer includes: RF cable (V00LOIF, 3 ft), IF cable (M00IF, 5") and Adapter (M00DLP, SMA(m-m)).

ELECTRICAL AND PERFORMANCE SPECIFICATIONS (+25°C)

After a one hour warm-up period, the following specifications are possible. Specifications are subject to change without notice.

Electrical Characteristics	MIN	TYP	MAX
L.O. Frequency Range	5 GHz	--	18 GHz
L.O. Insertion Loss		1.5 dB	
L.O. to I.F. Isolation		> 40 dB	
L.O. to VSWR		2.5:1	
I.F. Frequency Range	DC		2 GHz
I.F. Insertion Loss		1.5 dB	
I.F. VSWR		2.5:1	
Input Damage Level	+20 dBm		
Operating Temperature Range	+20 °C	+25 °C	+30 °C
Storage Temperature Range	0 °C		+50 °C

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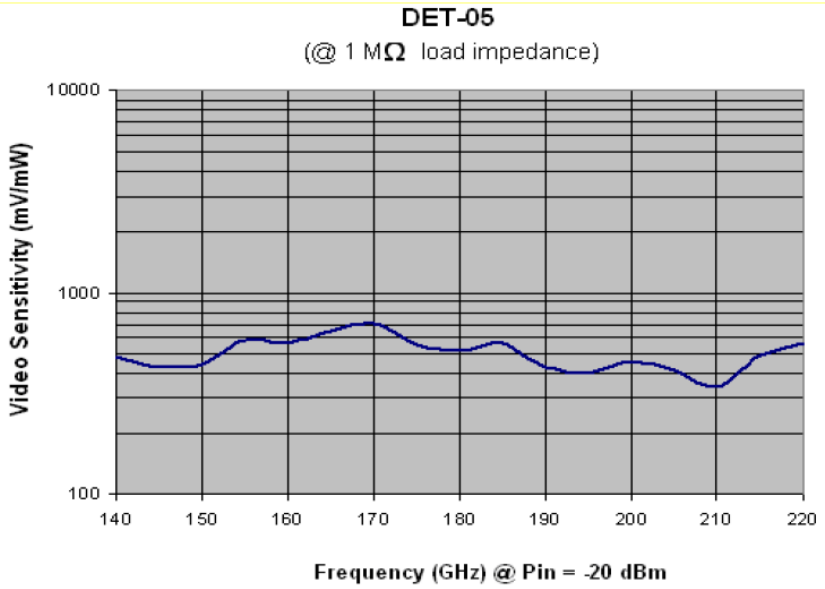
Milliteck DET-05 G-Band Diode Detector 140-220 GHz



Model Number	DET-42	DET-28	DET-22	DET-19	DET-15	DET-12	DET-10	DET-08	DET-06	DET-05
Frequency band and range (GHz)	K 18-26.5	Ka 26.5-40	Q 33-50	U 40-60	V 50-75	E 60-90	W 75-110	F 90-140	D 110-170	G 140-220
Video voltage (mV at -20 dB input) (typ)	50	40	30	18	13	13	17	9	6	4
Video sensitivity (mV/mW) (min into 1 MΩ)	2500	1800	1200	1000	850	700	1000	600	500	400
Flatness (dB) (typ)	±1.5	±1.5	±1.5	±1.5	±1.5	±2.0	±1.7	±3.0	±3.0	±2.0
TSS at 1 kHz (bw 40 Hz, dBm) (typ)*1	-55	-55	-50	-50	-50	-45	-45	-40	-40	-40
Video bandwidth (MHz) (typ)*2	10	10	10	10	10	10	10	10	10	10
Operating RF input power (dBm, CW max)	+16	+16	+16	+16	+16	+16	+16	+16	+16	+16
Absolute max rating (dBm)	+20	+20	+20	+20	+20	+20	+20	+20	+20	+20
Temp. Variation (%dev from 25℃/℃)	0.41% (typ. DET-28)									

*1- TSS is defined as the signal level at which the video output is 8 dB greater than the noise level. Detectors are not tested for TSS.
*2 - Video bandwidth is 1 GHz typical when terminated into a 50Ω load.

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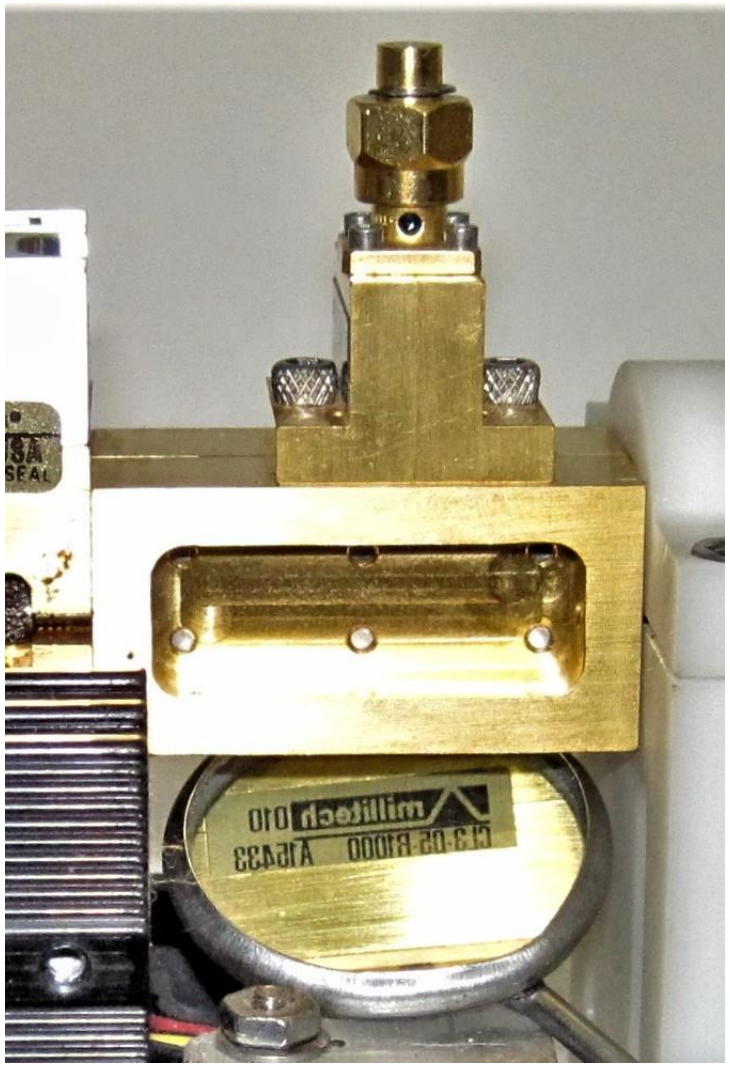
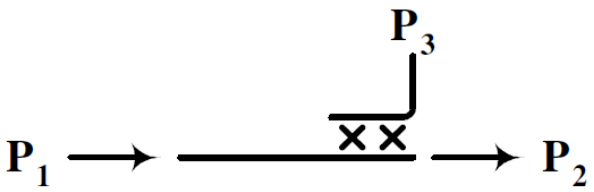
Milliteck CL-02-R1000 Directional Coupler - 140-220 GHz

Series CL3 couplers are produced using a rugged split-block construction. High directivity couplers are convenient for extracting or introducing a small fraction of power from and/or into a waveguide circuit without disturbing the operating characteristics of the circuit.



*1 – Coupling value =-10 $\log_{10}$ (P_3/P_1).
*2 –For power dividers, please see series CSS or CMT.
*3 – Insertion loss = -10 $\log_{10}$ [(P_2+P_3)/P_1].
*4 – Directivity = 10 $\log_{10}$ (P_3/P_1).
*5 - Typical for 10 dB units only.



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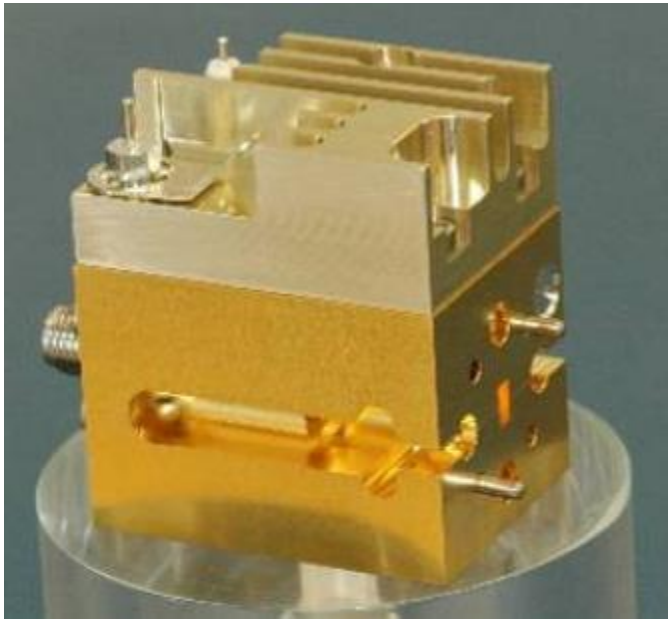
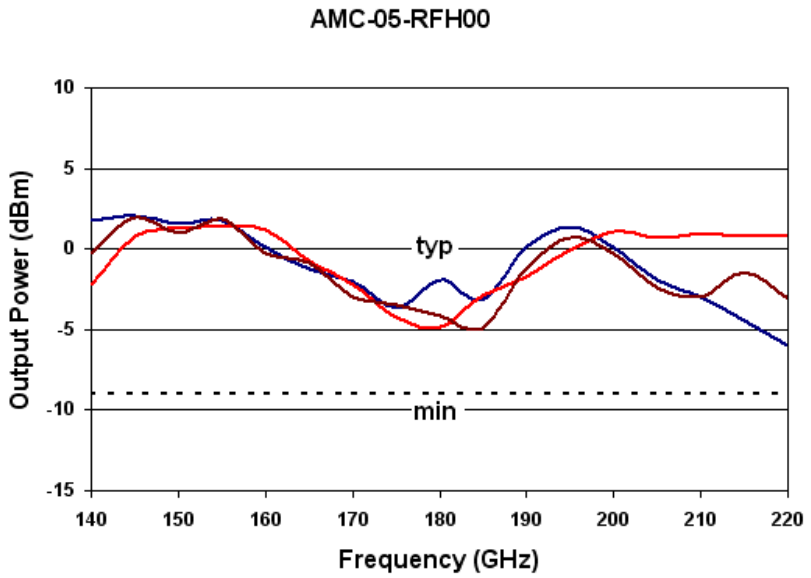
Milliteck x12 Multiplying Up-Converter - 140-220 GHz





Model Number	AMC-10-RFH00	AMC-08-RFH00	AMC-05-RFH00
Output frequency (GHz)	75 to 110	90 to 140	140 to 220
Input frequency (GHz)	12.50 to 18.33	7.50 to 11.67	11.67 to 18.33
Multiplication factor	6	12	12
Input Power	+10 dBm (nom)		
Output power	See plots below		
Maximum input power	+13 dBm		
Signal purity (max)	-20dBc		
DC input (typ)	8 – 12 V @ 600 mA	8 – 12 V @ 1A	8 – 12 V @ 1A

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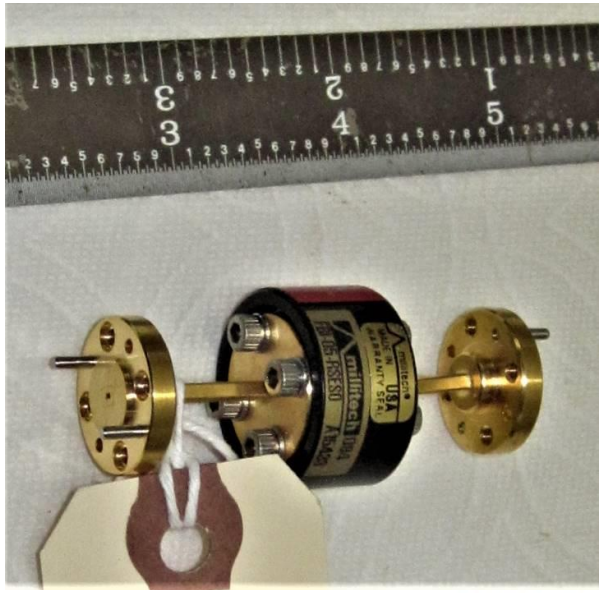
Milliteck FBI-05-RSESO G-Band Faraday Isolator 140-220 GHz



(FBI) Fullband Isolator

Electrical Specifications

Model	FBI-42	FBI-28	FBI-22	FBI-19	FBI-15	FBI-12	FBI-10	FBI-08	FBI-06	FBI-05
Frequency band and range (GHz)	K 18-26.5	Ka 26.5-40	Q 33-50	U 40-60	V 50-75	E 60-90	W 75-110	F 90-140	D 110-170	G① 140-220
Insertion loss (dB) (max)	1.5	1.5	1.5	1.7	1.8	2.0	2.5	3.0	3.5	4.5
Isolation (dB) (min)	25	27	27	27	27	27	27	20	20	20
Power rating (W) (max)	3.0	2.5	2.0	1.5	1.5	1.0	1.0	0.75	0.75	0.75

① The performance of G-Band (WR-05) isolators is measured at selected frequencies within the band. Performance specifications given above are typical values measured in the frequency band.

Note: Input/Output is 1.4:1 VSWR (max).

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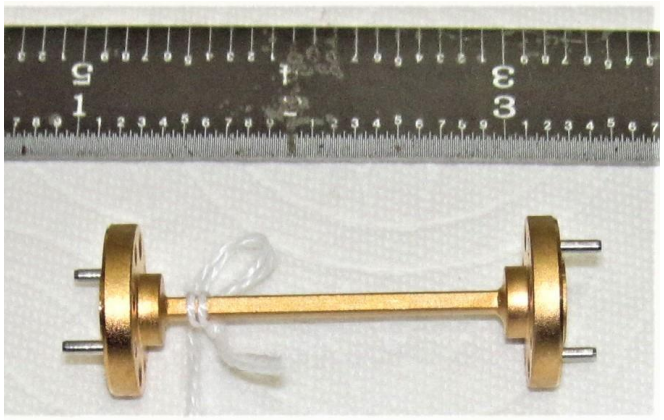
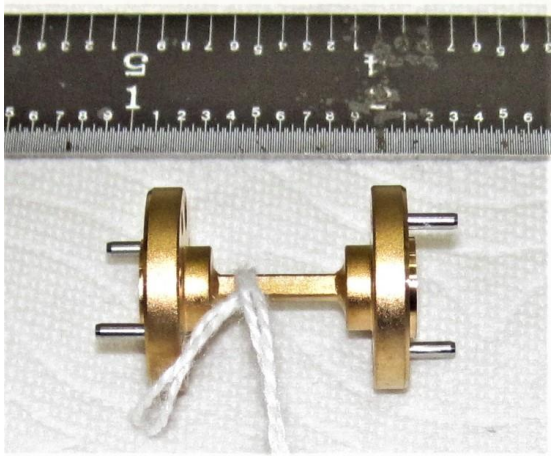
Straight G Band Waveguide



2 inch Flange-to-Flange



1 inch Flange-to-Flange

* With # 4-40 threaded holes.

EIA Waveguide		WR-08	WR-06	WR-05	W
Frequency band and range (GHz)		F 90-140	D 110-170	G 140-220	17
TE_{10} mode cutoff (GHz)		73.84	90.85	115.75	1
Inside waveguide dimensions (in/mm)		0.08 x 0.040 (2.32 x 1.02)	0.065 x 0.032 (7.11 x 3.56)	0.051 x 0.0255 (1.30 x 0.648)	1.3
Flange type and descriptive interface standards	Size / Type	.750/RD .375/RD	.750/RD .375/RD	.750/RD .375/RD	.7 .3
	Connective hole type	THD. Holes Pin Contact	THD. Holes Pin Contact	THD. Holes Pin Contact	TH Pin
	MIL-Spec flange MIL.F-3955	/67B-M08 /74-001	/67B-M06 /74-001	/67B-M05 /74-001	/67 /7
	UG-XXX/U Equivalent (reference)	UG-387/U-M	UG-387/U-M	UG-387/U-M	UG-

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Circular G Band Horn Antenna – RCHO5

Custom Microwave Inc April 4, 2018

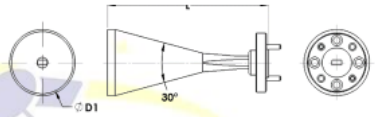
Circular Horns with Rectangular Input

Summary:

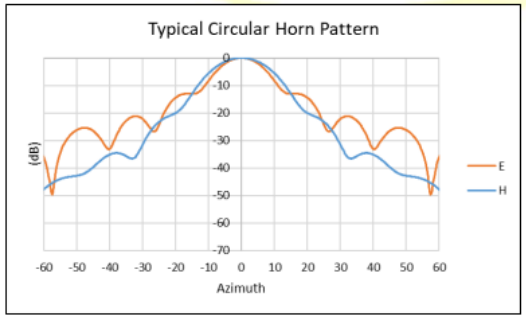
Circular Horns have a broad variety of applications in the aerospace industry and CMi is proud to provide these antennas of the highest quality. Each horn is precisely electroformed over a mandrel and gold plated. These horns have maximal return loss and gain ranging from 20 to 23 dB. Horns with different gain values can be special ordered. Rectangular Horns are available in sizes WR3 to WR42.

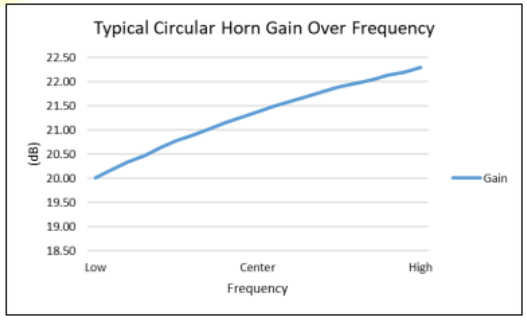
Ordering Example:

RCHO28S is a Conical Horn with a Rectangular input and Square flange



	RF Specifications			Mechanical Specifications				
Part Name	WR	Frequency (GHz)	Max VSWR	WG A DIM (in)	WG B DIM (in)	Aperture - D1 (in)	Length - L (in)	Flange
RCHO42S	42	18 - 26.5	1.1:1	0.4200	0.1700	2.300	5.000	S 0.875
RCHO28S	28	26.5 - 40	1.1:1	0.2800	0.1400	1.800	4.200	S 0.750
RCHO22R	22	33 - 50	1.1:1	0.2240	0.1120	1.440	3.200	R 1.125
RCHO19R	19	40 - 60	1.1:1	0.1880	0.0940	1.180	3.050	R 1.125
RCHO15R	15	50 - 75	1.1:1	0.1480	0.0740	0.950	2.400	R 0.750
RCHO12R	12	60 - 90	1.1:1	0.1220	0.0610	0.784	2.050	R 0.750
RCHO10R	10	75 - 110	1.1:1	0.1000	0.0500	0.643	1.400	R 0.750
RCHO8R	8	90 - 140	1.1:1	0.0800	0.0400	0.514	1.400	R 0.750
RCHO6R	6	110 - 175	1.1:1	0.0650	0.0325	0.418	1.150	R 0.750
RCHO5R	5	140 - 220	1.1:1	0.0510	0.0255	0.328	0.900	R 0.750
RCHO4R	4	170 - 260	1.1:1	0.0430	0.0215	0.276	0.750	R 0.750
RCHO3R	3	220 - 325	1.1:1	0.0340	0.0170	0.218	0.650	R 0.750





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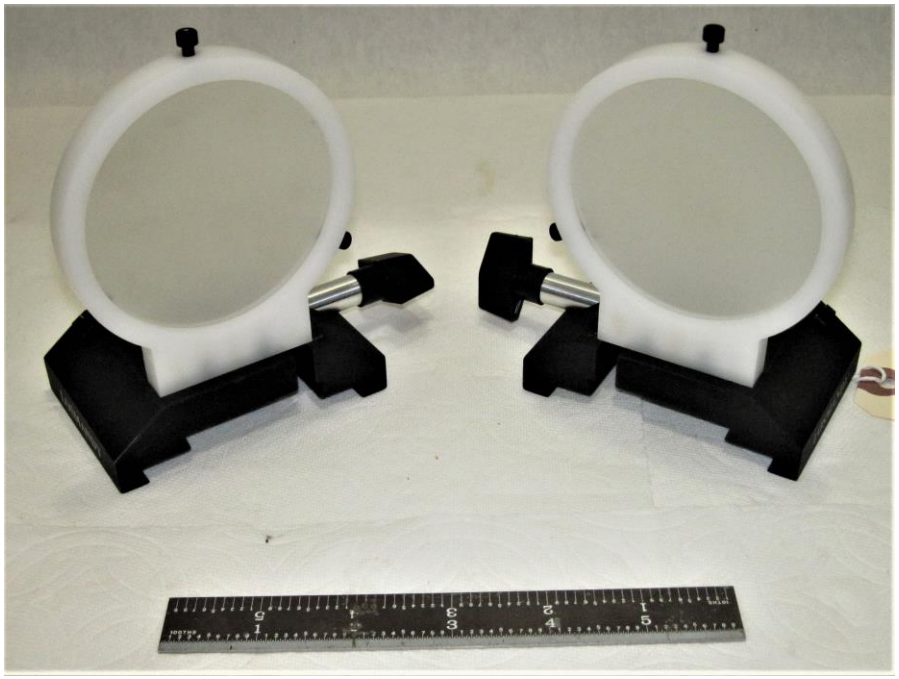
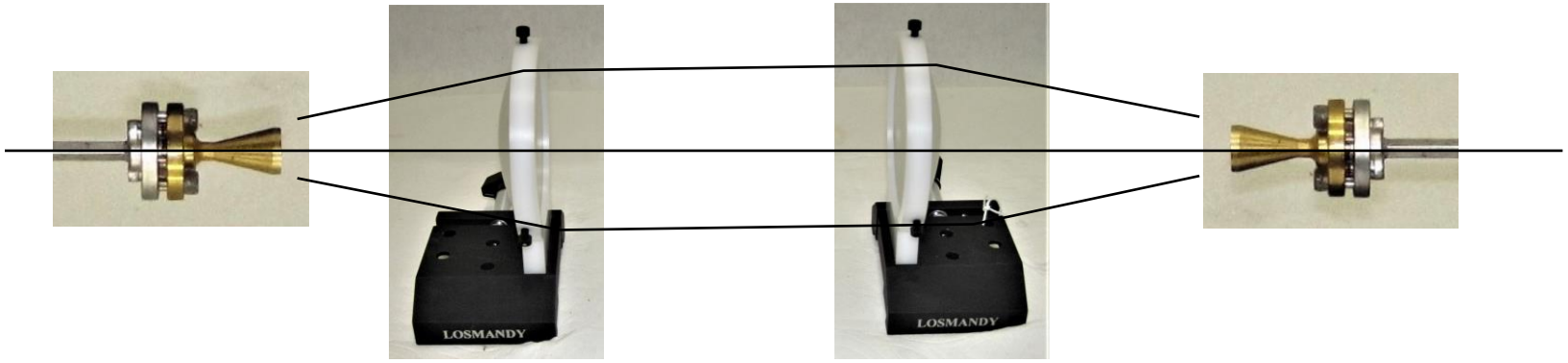
Custom 75 mm Diameter - F 1.5 - G Band Beam Collimating Lenses





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Original Purchase Order Quotes

2	**AMC-05-RFH00**	*Exp Lic.:* NLR	EACH	1.00	6,945.00	6,945.00

ECCN: EAR99 *SCHED_B:* *ITAR:*

ACTIVE MULTIPLIER CHAIN
Output Frequency Range: 140 to 220 GHz
Input Frequency Range: 11.67 to 18.3 GHz
Multiplication Factor: X 12
Input Power: +10 dBm typical, +13 dBm maximum
Input Connector: SMA
Output Power: -5 dBm typical
Waveguide: WR-05
Flange: MIL.F-3922/67B-M05

3	**FBI-05-RSES0**	*Exp Lic.:* NLR	EACH	2.00	2,306.00	4,612.00

ECCN: EAR99 *SCHED_B:* *ITAR:*

FULLBAND ISOLATOR
Frequency: 140 to 220 GHz
Insertion Loss: 4.5 dB typical
Isolation: 20 dB minimum
Input/Output VSWR: 1.4:1 maximum
Input Waveguide Configuration: Straight
Input-to-Output Configuration: E-plane to E-plane
Waveguide: WR-05
Flange: MIL.F-3922/67B-M05

7	**CL3-05-R1000**	*Exp Lic.:* NLR	EACH	1.00	2,980.00	2,980.00

ECCN: EAR99 *SCHED_B:* *ITAR:*

COUPLER, 3-PORT HIGH DIRECTIVITY
Frequency Range: 140 to 220 GHz
Coupling Value: 10 dB
Coupling Flatness: ±1.5 dB typical
Insertion Loss: 2.0 dB typical
Directivity: 25 dB typical
Main Line VSWR: 1.25:1 maximum
Secondary Line VSWR: 1.35:1 maximum
Waveguide: WR-05
Flange: MIL.F-3922/67B-M05
Ship Date: 90 DARO

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Original Purchase Order Quotes

1	**DET-05-RPFW0**	*Exp Lic.:* NLR	EACH	1.00	2,315.00	2,315.00

ECCN: EAR99 *SCHED_B:* *ITAR:*

GENERAL PURPOSE DETECTOR
Frequency: 140 to 220 GHz
Bandwidth: Fullband
Video Sensitivity: 400 mV/mW typical
Flatness: ±3.0 dB typical
Polarity: Positive
Amplifier Option: Without
Waveguide: WR-05
Flange: MIL.F-3922/67B-M05

7	**CL3-05-R1000**	*Exp Lic.:* NLR	EACH	1.00	2,980.00	2,980.00

ECCN: EAR99 *SCHED_B:* *ITAR:*

COUPLER, 3-PORT HIGH DIRECTIVITY
Frequency Range: 140 to 220 GHz
Coupling Value: 10 dB
Coupling Flatness: ±1.5 dB typical
Insertion Loss: 2.0 dB typical
Directivity: 25 dB typical
Main Line VSWR: 1.25:1 maximum
Secondary Line VSWR: 1.35:1 maximum
Waveguide: WR-05
Flange: MIL.F-3922/67B-M05

Ln	Qty	OML Model	Description	Unit Price	Extension
1	1	M05HWD	WR-05 Harmonic Mixer, 140 to 220 GHz	$3,110.00	$3,110.00
2	1	DPL518	Diplexer w/ L.O. cable, I.F. cable & SMA adapter	$1,328.00	$1,328.00

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Stepped-CW G-Band Radar "Front End" Module Price Tally

Item	Part number	Source	Quantity	Paid Price/each	Total Price
Up Converter					
x12 Frequency Multiplier	AMC-05-RFH00	Milliteck	1	6,945.00	6,945.00
Full Band Isolator	FBI-05-RSES0	Milliteck	1	4,612.00	4,612.00
3-Port High Directivity Coupler	CL3-05-R1000	Milliteck	1	2,980.00	2,980.00
G-Band Detector	DET-05-RFPW0	Milliteck	2	2,315.00	4,630.00
G-Band Detector - Not Working	DET-05-RFPW0	Milliteck	1	-	-
Down Converter					
Harmonic Mixer	M05HWD	OML	1	3,110.00	3,110.00
Diplexer	DPL518	OML	1	1,328.00	1,328.00
Antennas					
Circular G Band Horn Antenna	RCHO5R	CMI	4	585.00	2,340.00
75 mm Dia F1.5 Polymer Lens	NA	Custom	2	800.00	1,600.00
Waveguide					
WR5 waveguide	ST5R-1.0	CMI	3	245.00	735.00
Optical Bench					
Dovetail Plate - V Series - 24 inch		Losmandy	1	140.00	140.00
Dovetail Saddle Mount Carriers		Losmandy	6	40.00	240.00
				Total	**28,660.00**

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