The Hat Creek Radio Observatory

The IF Splitter

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1 General

This document outlines general information regarding the IF Splitter such as the design, parts, wiring and testing. This information is aimed at detailing the entire process of creating an IF Splitter from design to manufacturing and testing.

The purpose of the IF Splitter is to divide the incoming signal of one of the tuning (tuning "D" at the ATA) into three separate outputs. First, the signal is divided in two and one half goes directly to an output (3dB attenuation). The second output is divided in two again, leading to two more outputs with 6dB attenuation. This system allows to plug additional equipment (i.e. GNU radio, testing or monitoring devices) without unplugging the main data acquisition channel, making the ATA more polyvalent.

In this document, "IF splitter" designates the whole machine while a "power splitter" designate the ZX10-2-12-S+ module that divide a signal in half. One IF splitter contains 96 power splitter modules.

2 CAD Design and Drawings

This section includes a description of the CAD design. Figure 1 shows the outside of the IF splitter with the front panel containing the two groups of 6dB outputs. Figure 2 shows the IF splitter open, with the mounts and signal splitter modules but no cable. The left CAD drawing shows the back panel with the group of inputs on top and the group of 3dB Outputs below. Both the front and back panel look similar in the number and placement of the SMA connectors. As a visual reference, it can be noted that the two handles are on the front of the IF Splitter. The part list is available in appendix A. The Drawings are available in appendix B.

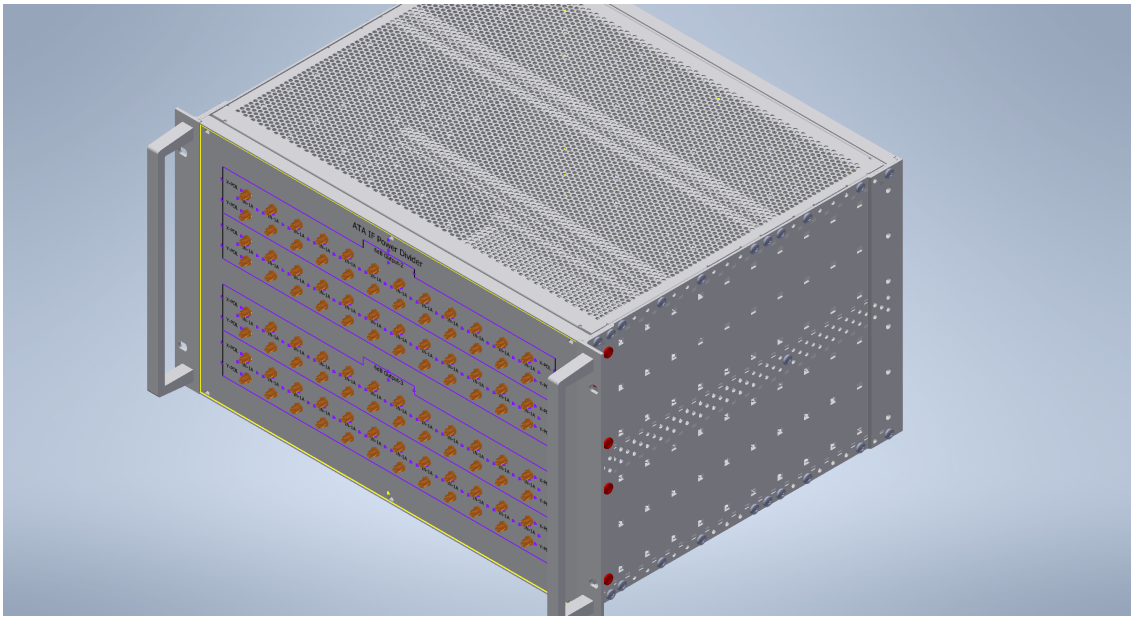


Figure 1: Outside CAD view of the IF splitter.

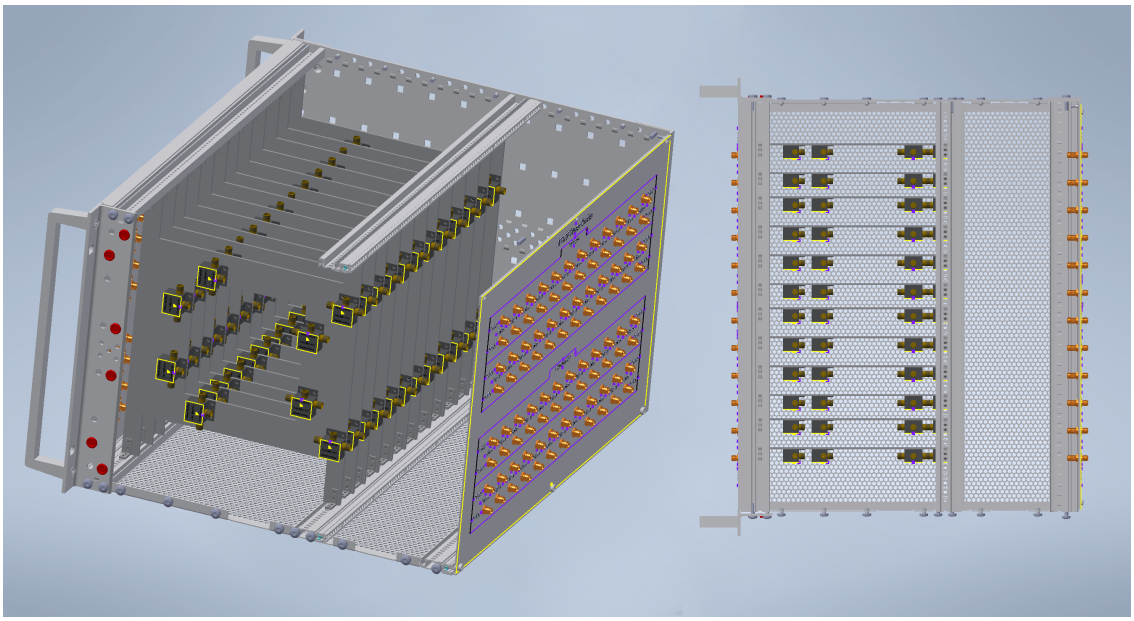


Figure 2: Inside CAD view of the IF splitter.

2.1 Design

The front and back panels each contain two groups of 12×4 SMA connectors. On the back panel, the top group is for the "IF Input" and the bottom for the "3dB Output-1". The front panel contains the two groups of "6dB Output-2" and "6dB Output-3" The front and back panel design are available in appendix B. A schematic of the IF Splitter for one input si shown in figure 3. Two inputs are used per antenna for the X and Y polarization signals. Each modules contains 48 input connections,

which allows to split the signal of 24 antennas. Thus two IF splitter modules are installed for the 42 ATA antennas, leaving 6 input pairs unused for spares.

All the components in the IF splitter are passive so the module doesn't require any power supply.

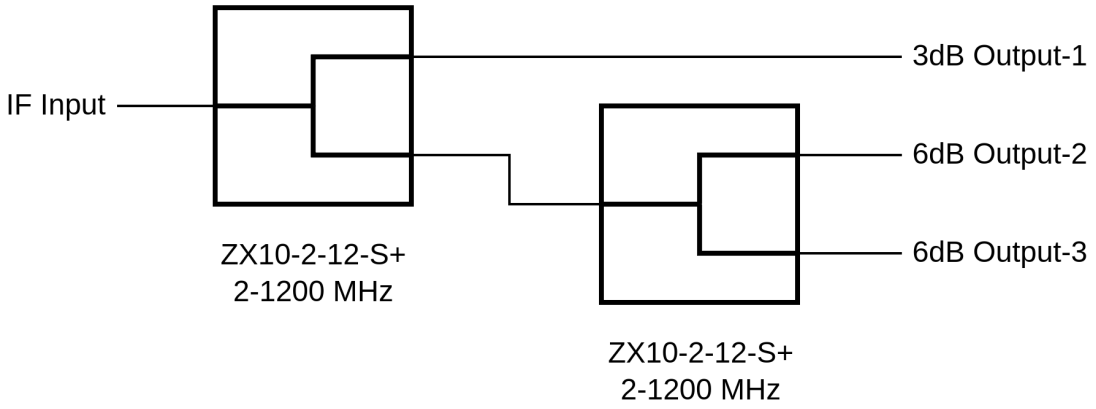


Figure 3: Signal splitter diagram for 1 input, repeated 48 times in the IF Splitter.

2.2 Wiring

The power splitter modules are screwed on 12 separate mounts. The wiring schematic of one mount is shown in figure 4 and a picture of the complete circuit in figure 5.

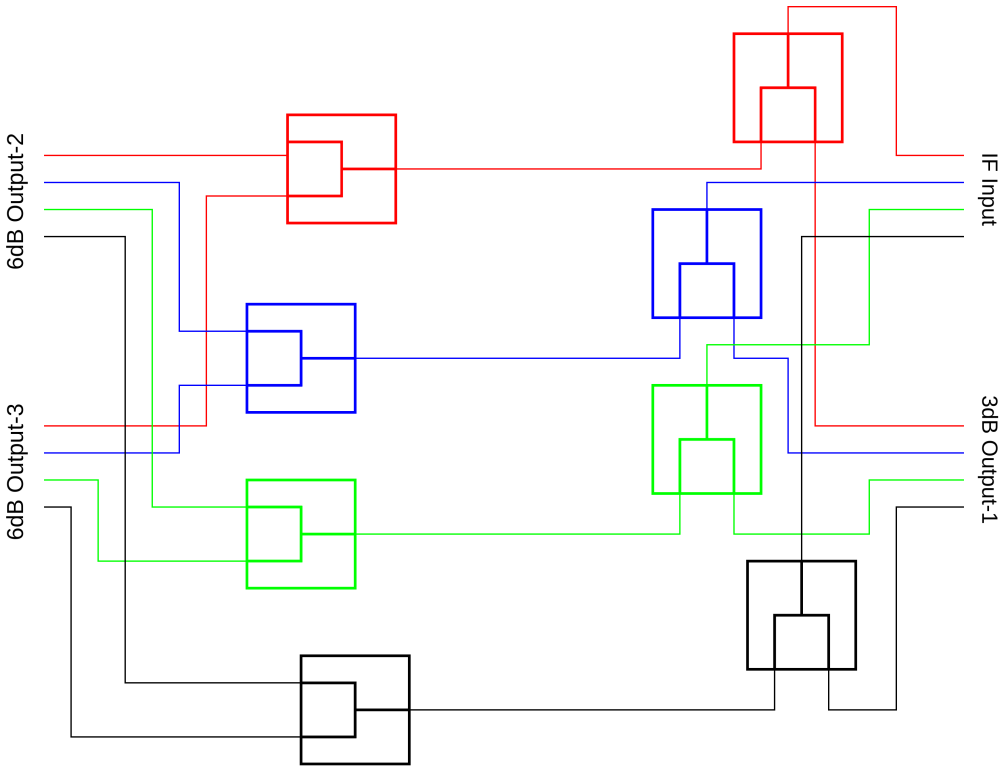


Figure 4: Wiring diagram for one mount.

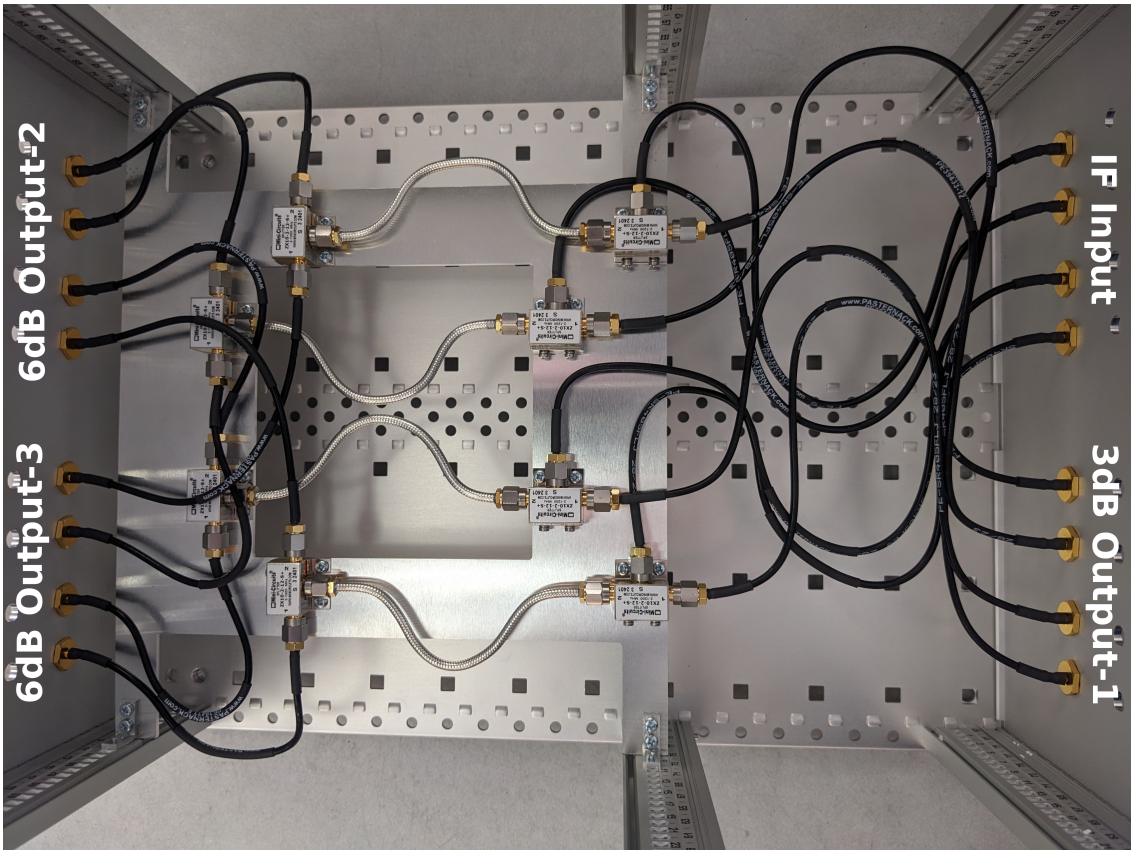


Figure 5: Picture of one of the completed mount containing 4 inputs.

3 Testing

3.1 Setup

The Vector Network Analyzer (VNA) is used to make a measurement of the scattering matrix. The pre-made "IFSplitter" preset can be selected on the HCRO VNA to get the relevant scale and information for the plots. Two 3-foot probe cables "ABC-CA18-SMSM-1.OM" are used. A special wrench that delivers only 0.9 N·m or 8 in·lbs of torque must be used to tighten all the SMA connectors in place.

The first step is to normalize the transmission plots of the scattering matrix. To do so, both probes are shorted wit a 1.2 cm male-male SMA connector, as shown in figure 6. Then select the scattering matrix plot elements S_{12}, S_{21} and select on the VNA: Memory→Normalize. The result should be $S_{12} = 0$ and $S_{21} = 0$ for all frequencies on the VNA plots, as shown in figure 7.

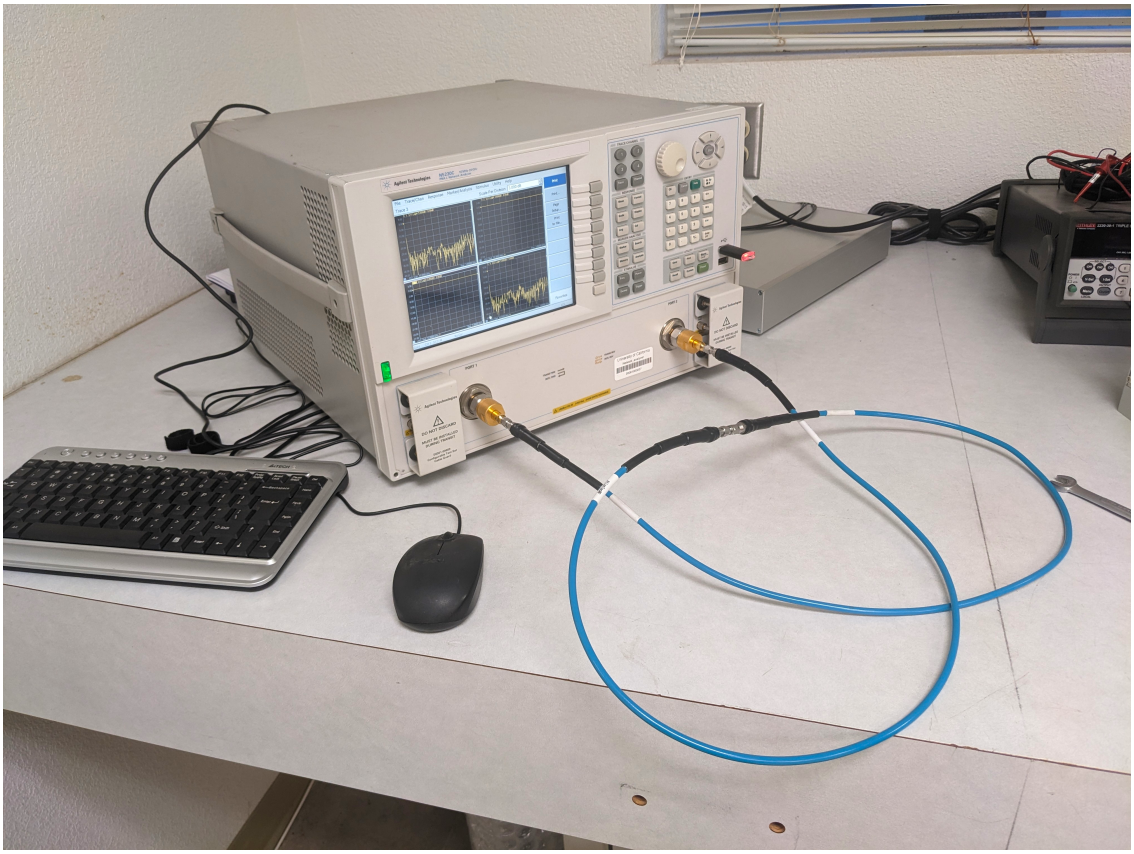


Figure 6: VNA setup for S_{11} and S_{22} normalization.

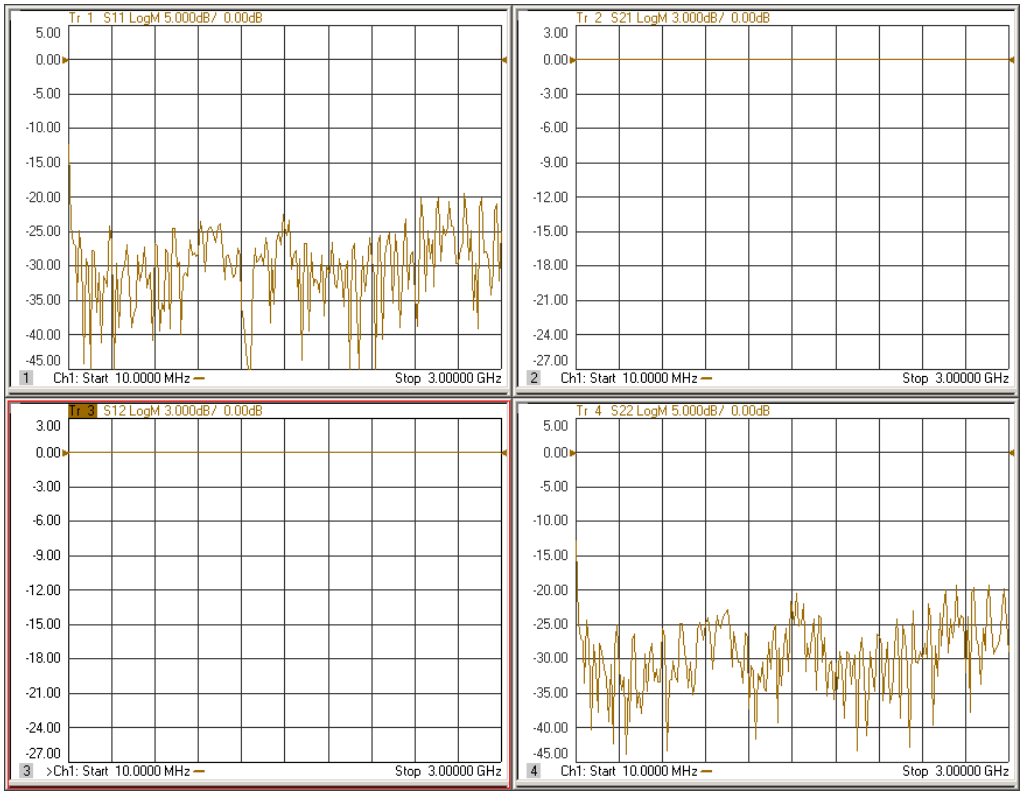


Figure 7: Scattering matrix after S_{11} and S_{22} normalization.

3.2 Method & Desired Results

The left probe stays connected to the "IF Input" while the right probe is connected in turn to "3dB Output-1", "6dB Output-2" and "3dB Output-3".Two 12 GHz 50 Ω terminators are used for the pair of SMA output connectors that are not connected to the probes. each time, the scattering matrix is recorded as the measurement. These steps have to be reproduced 48 times for all the channels of the IF Splitter module.

An example of the expected measurement of "3dB Output-1" is shown in figure 8. At 10 MHz, S_{12} and S_{21} are slightly below -3dB because of loss. The loss increases significantly after 1.8 GHz, which is above the rated value of 1.2 GHz from the "ZX10-2-12-S+" power splitter module used. The signal reflection (S_{11} and S_{22}) must be low in comparison of the signal.

The result of for both "6dB Output-2" and "6dB Output-3" must be similar to each-other, the difference being only the output of the second power splitter module. An example is given respectively in figure 9 and 10. Here again an increasing loss is observed with the frequency, that accelerate after 1.8 GHz. Here again the signal reflection must be low in comparison to the transmitted signal.

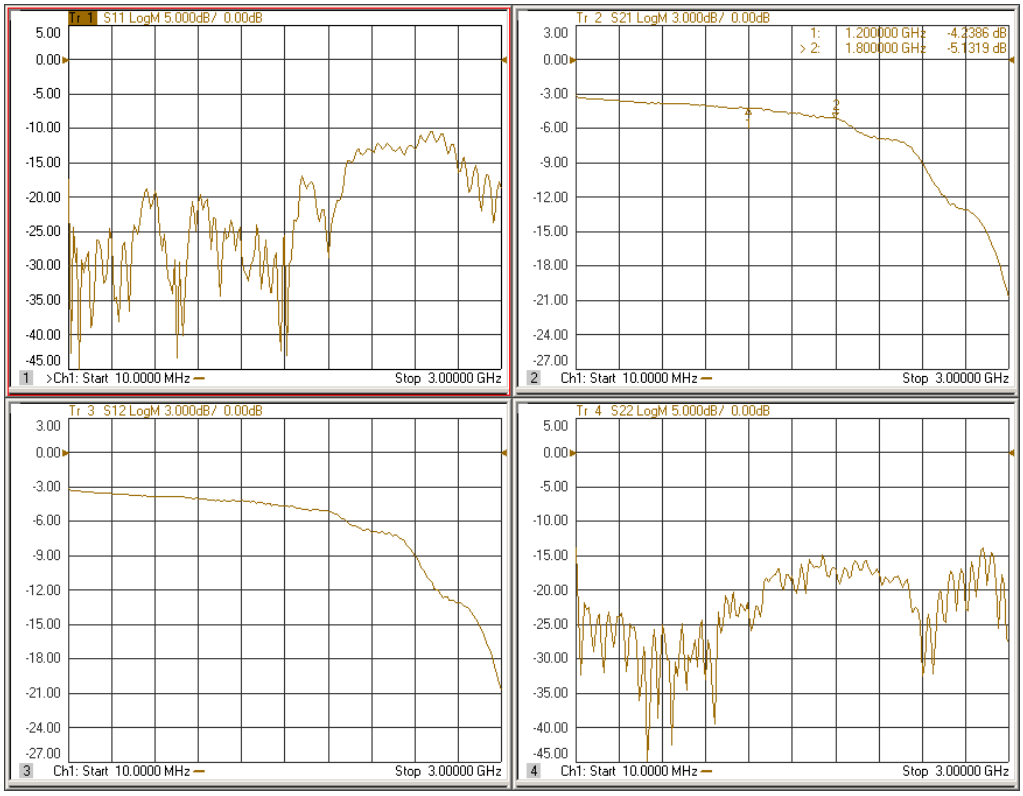


Figure 8: Scattering matrix for "3dB Output-1".

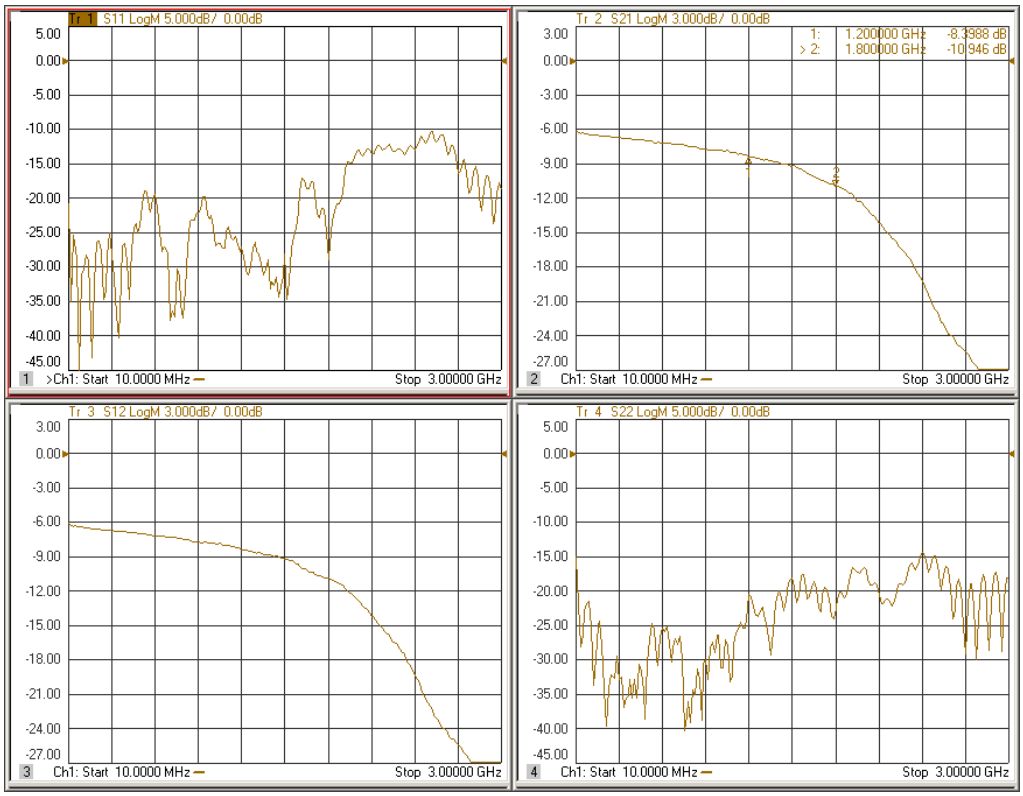


Figure 9: Scattering matrix for "6dB Output-2".

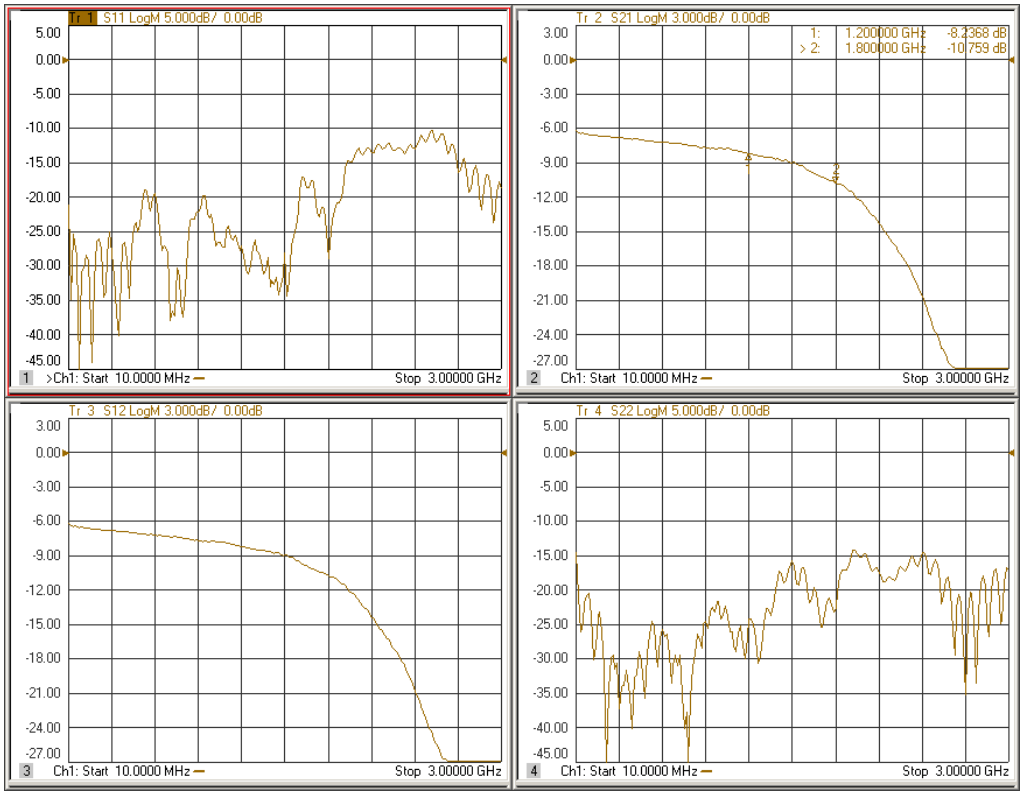


Figure 10: Scattering matrix for "6dB Output-3".

3.3 Troubleshooting

Look at the different output measurement for a same input to try to locate the problem with the schematic in figure 3. If there is no transmission, verify that the circuit corresponds to the schematic in figure 4.

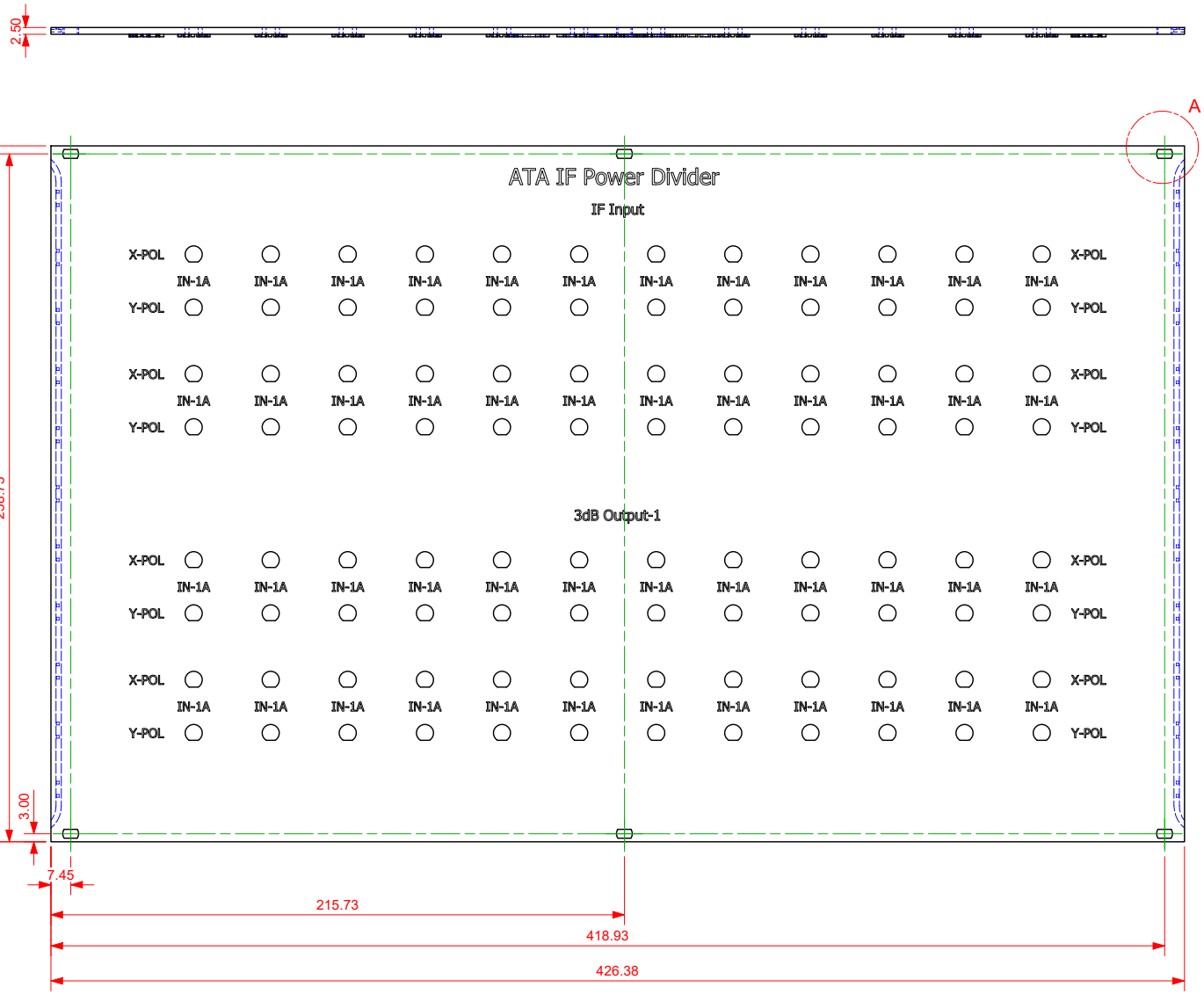
If the transmission signal curves of S_{12} and S_{21} aren't smooth (figures 8 to 10 show how they should look), there must be a bad connection along the circuit path. First verify that the probes and terminators are attached correctly on the front panel with the right amount of torque. Then have a visual inspection of the mount and connection to verify that no component is damaged or not mounted properly. If everything looks good, it can either be a bad cable connection or a bad power splitter module. If all the cables are connected and torqued properly, verify the power splitter modules themselves by plugging the VNA to their output directly. The unused third connector must be terminated. Finally, if the problem is still there, test the cables themselves with the VNA.

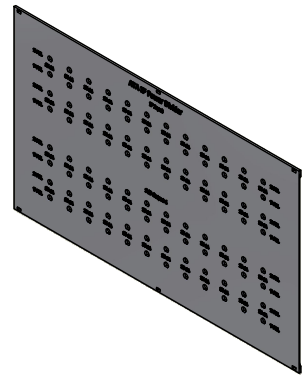
A Component List of the IF Splitter

Qty	Unit	Description	Manufacturer	PN Manufacturer	Distributor	PN Distributor
1	Each	6U EuropacPRO kit, heavy design, shielded, without front handles	Schroff	24563-474	Distrelec	110-28-346
1	Each	Front Panel	Front Panel Express, LLC	ATA-IFD-AP-24567274_100F.fpd		
1	Each	Rear panel	Front Panel Express, LLC	ATA-IFD-AP-24567274_100R.fpd		
12	Each	Mounting Panel	Front Panel Express, LLC	ATA-IFD-AP-24567274_200.fpd		
48	Each	Mounting Bracket	Front Panel Express, LLC	ATA-IFD-AP-24567274_201.fpd		
96	Each	2 Ways Power Splitter, 2 - 1200 MHz, 50Ω	MiniCircuit	ZX10-2-12-S+		
4	Pack	Machine Screw, M2.5, 5mm	TR FASTENINGS	173-202579H	Newark	25M0782
48	Each	5 Inch SMA coaxial cable	Atlantic Microwave	ASF1-005-520003-S4S4		
48	Each	6 Inch SMA Male to SMA Female Bulkhead cable	Pasternack	PE39433-6		
48	Each	12 Inch SMA Male to SMA Female Bulkhead cable	Pasternack	PE39433-12		

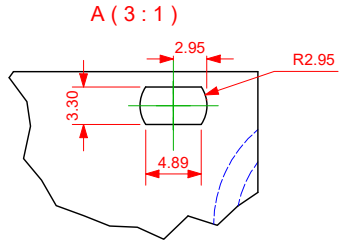
B Drawings

Below are the drawings of the back panel, Power Splitter Mount and L-shape attachment brackets.





ISOMETRIC VIEW OF REAR PANEL
(DO NOT SCALE)



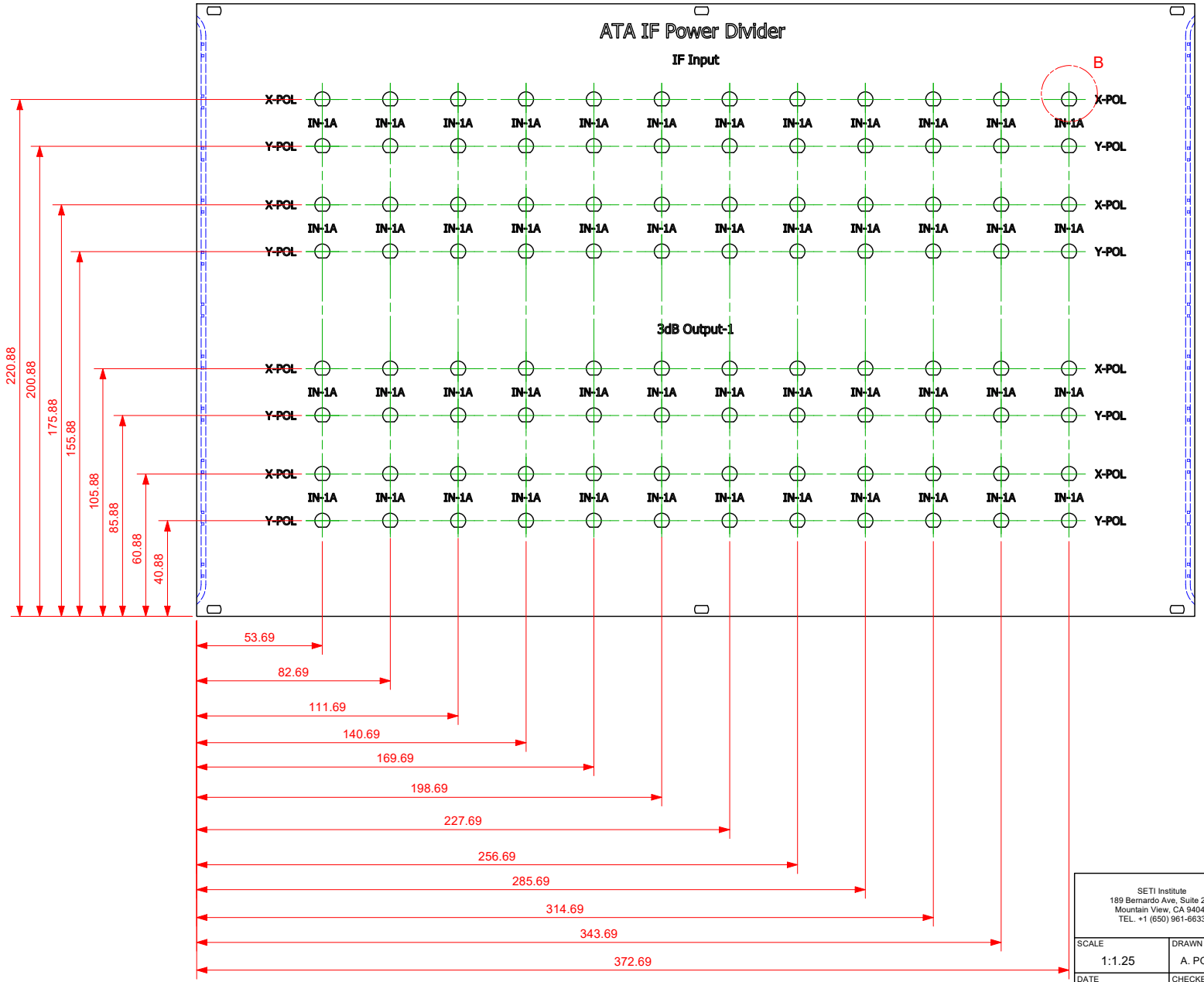
NOTES

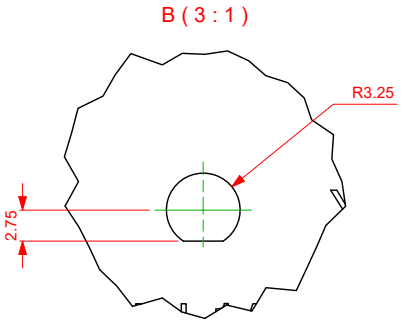
1. REFER TO 3D CAD GEOMETRY FOR ALL UNSPECIFIED DIMENSIONS
2. THIS SHEET SHOWS THE MODIFICATIONS FOR THE SUPPLIED FRONT PANEL. (SCHROFF:)
3. THE THIRD SHEET SHOWS THE TEXT FOR THE LASER ENGRAVING.

SETI Institute 189 Bernardo Ave, Suite 200 Mountain View, CA 94043 TEL. +1 (650) 961-6633		PROJECT/ORIGINATOR Allen Telescope Array	TITLE REAR PANEL IF Power Splitter Module	
SCALE 1:1.25	DRAWN BY A. POLLAK	GENERAL TOLERANCES UNLESS STATED X ± 0.3 X.X ± 0.1 X.XX ± 0.05 X.XXX ± 0.005	MATERIAL ALUMINIUM	COMPONENT WEIGHT
DATE 10/2/2023	CHECKED A. POLLAK		FINISH	NUMBER OFF 1
SOURCE FILE : 24567474_100.ipt		USED ON : 24567174.iam		JOB NO. / EST. TIME
DRAWN ACCORDING TO BS308 ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE STATED	3rd ANGLE PROJECTION	SIZE A2	DRAWING NUMBER 24567474_100	
THIS DRAWING MAY NOT BE USED FOR COMMERCIAL USE			SHEET 1 OF 3	

NOTES

1. Shows the SMA Feedthrough Holes





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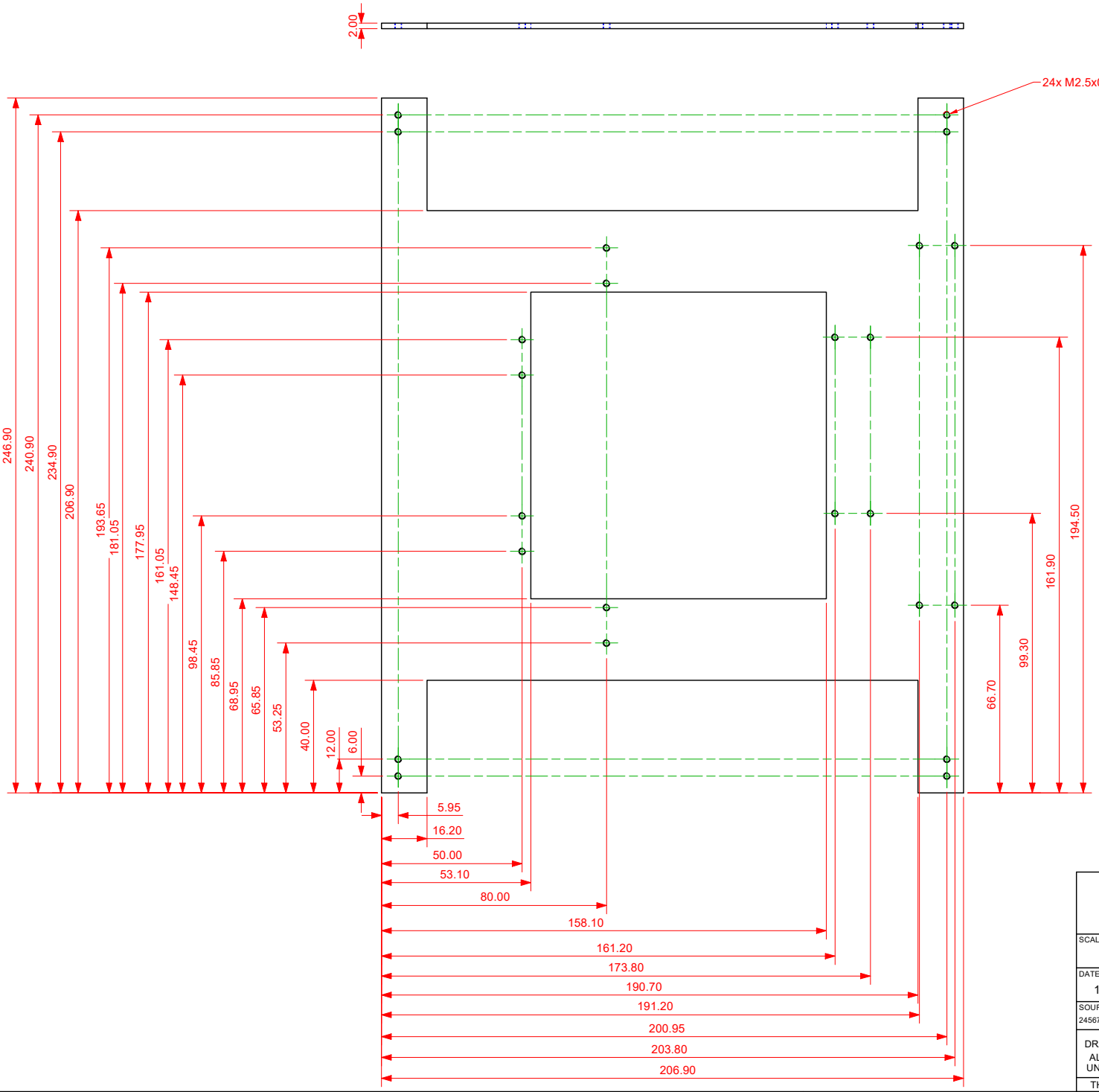

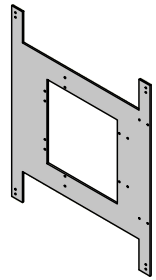

ISOMETRIC VIEW OF Power Splitter Mount
(DO NOT SCALE)

NOTES
1. REFER TO 3D CAD GEOMETRY FOR ALL UNSPECIFIED DIMENSIONS

SETI Institute 189 Bernardo Ave, Suite 200 Mountain View, CA 94043 TEL. +1 (650) 961-6633		PROJECT/ORIGINATOR Allen Telescope Array	TITLE 12x Power Splitter Mount IF Power Splitter Module	
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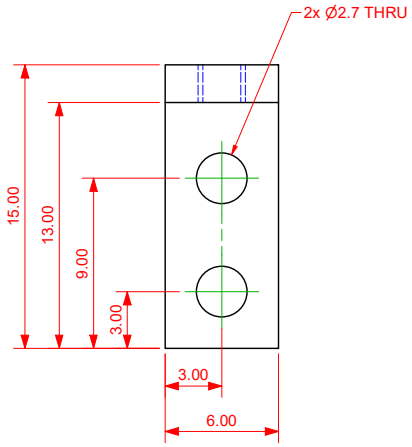

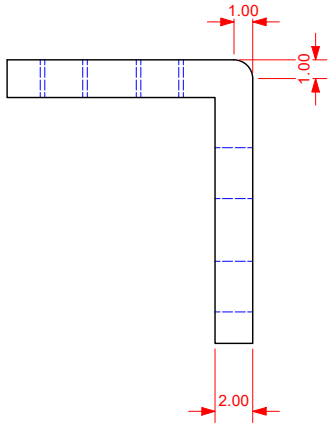

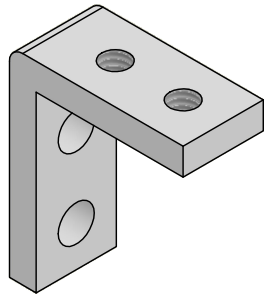

ISOMETRIC VIEW OF Mounting Bracket
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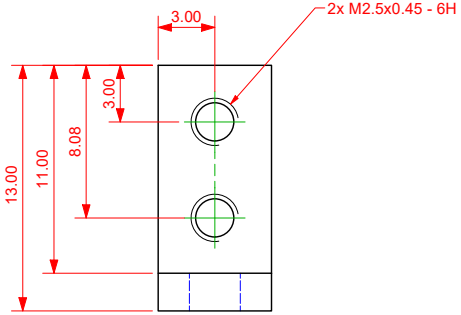

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1. REFER TO 3D CAD GEOMETRY FOR ALL UNSPECIFIED DIMENSIONS

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