Design of RFI-Proof Electronics Enclosures

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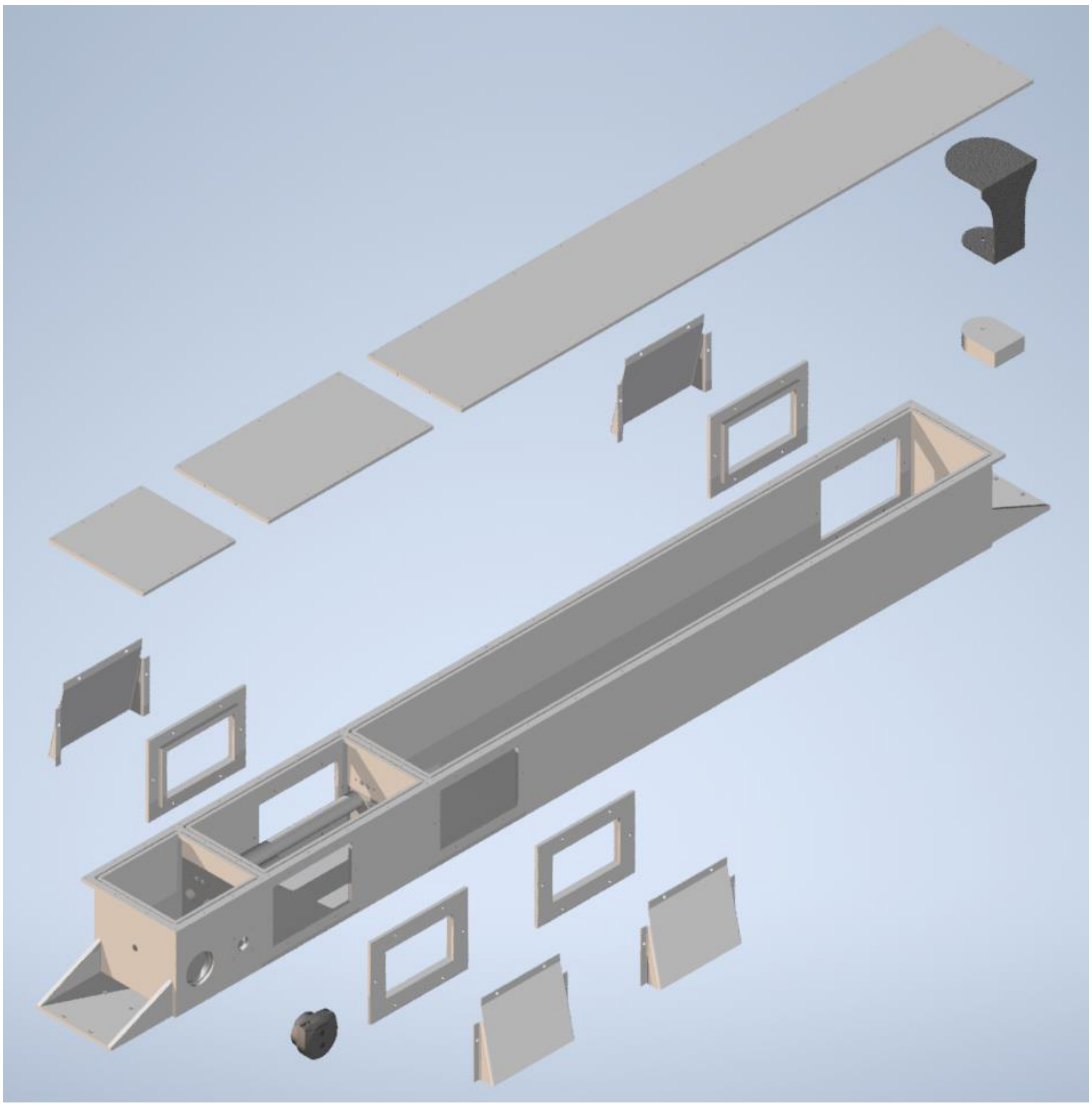


Table of Contents

1 Introduction

For as long as astronomers have turned to radio frequencies to examine the universe, interference has posed a significant problem. This interference is known as radio frequency interference, or RFI, and is generated by a vast number of man-made devices. To constitute problematic interference, emissions must be in the same frequency ranges that scientific observations are made in. For the purposes of this project, RFI is considered to be emissions in the range of 20MHz to 115GHz, since this frequency range encompasses all projects that take place at the Green Bank Observatory.

RFI emissions can be divided into two categories: intentional and unintentional emissions. Intentional emissions come from sources that are designed to be transmitters, such as satellites, cell towers, and wireless networks. These are some of the most prolific generators of RFI. Unintentional emissions are from sources not intended as transmitters, such as signals escaping the traces on circuit boards. Many digital electronics provide examples of unintentional emitters since they often generate emissions in radio frequencies. In recent years, Electromagnetic compatibility (EMC) consideration in the design phase of circuit boards has improved significantly, reducing the amount of unintentional emissions from such sources. However, conversely, spectrum use by intentional emitters has increased tremendously, making RFI an ever-growing concern in radio astronomy.

Since RFI is so prevalent in the modern day and can be so detrimental to radio astronomy, many efforts are made to keep the area around the Green Bank Observatory (GBO) as free from RFI as possible. One such major effort is the establishment of the National Radio Quiet Zone (NRQZ),[1] which helps to minimize RFI from licensed, terrestrial sources external to the observatory site. However, much of the equipment needed to operate the instruments at the Observatory and process astronomical signals also generates RFI. Some examples of RFI-emitting components that are also necessary to the Observatory include motor controllers for aiming telescopes and digital signal processors. To minimize this type of interference, RFI enclosures, or Faraday cages, are constructed for such components that operate in close proximity to the telescopes.

This report details the design of two RFI enclosures for electronic components associated with several projects in development at the Green Bank Observatory. The first is an enclosure for the front-end electronics of a new RFI monitoring station, and the second is for the electronics comprising a new proof-of-concept ultra-wideband DSP sampler. Both enclosures are designed using Autodesk Inventor, and the final products of this project are 3D models of the enclosures and drawings detailing their individual parts and assembly.

2 GBT RFI Monitoring Station Front End Enclosure

The first enclosure discussed in this report is an enclosure for electronics associated with a new RFI monitoring station in development for installation on the Green Bank Telescope (GBT). The enclosure is designed to house only the front-end electronics and provide mounting accommodations for the antenna.

2.1 The Monitoring Station

The GBT RFI monitoring station (GBTRFIMS) will use an omni-directional antenna with a receiving range of 20MHz to 40 GHz to collect RFI signals, which will be mounted on the top of the GBT's feed arm. From the antenna, the signal will be processed in two stages, passing through the system's front end and the back end. The front end electronics will be mounted on the GBT next to the antenna, and the back end will be located in the Jansky lab. Figure 1 shows a block diagram of the entire monitoring system representing the main components. As shown in the figure, the front end will contain mostly analog components (shown in black), such as low noise amplifiers and limiters. Some digital components (shown in blue) are also needed in the front end, however, such as a media converter. The electrical signals carrying the RFI data will be converted to optical signals, allowing fiber-optic cables to transfer the signals from the GBT to the Jansky lab; a distance of about a mile.

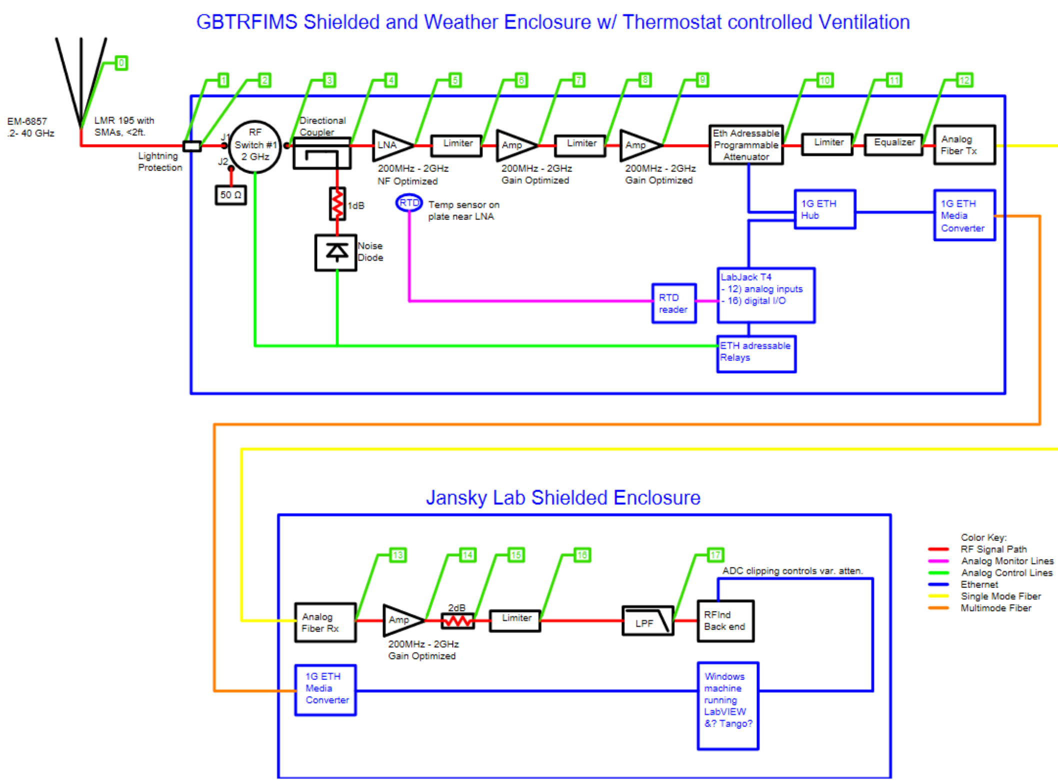


Figure 1. Block diagram of GBT RFI Monitoring Station

The goal for the new RFI monitoring system is to create a continuous profile of the RFI detectable from the Green Bank Observatory site over a wide frequency range, allowing astronomers to compare the RFI with their observation data collected over any given time period. The system could potentially be usable for monitoring RFI with the intent to find and eliminate the source, but sources of RFI are often sporadic or based in the community where they are difficult to control. A more likely use for the data collected would be to digitally subtract the RFI from observation data.

2.2 Design Considerations

2.2.1 Enclosure Structure

The first and foremost concern in the design of this enclosure is that it must prevent RFI generated by the devices inside from escaping and being detected by telescopes around the Observatory, or the antenna associated with the monitoring station itself. This means the it must act as a Faraday cage, while also accounting for all other necessary aspects of the enclosure.

Beyond being a Faraday cage, the design of the enclosure must include various features for practical use. Multiple openings are required to pass cables in and out of the enclosure, as well as for ventilation. Ventilation is essential since several of the electronic components to be housed generate heat and because the enclosure will be exposed to the sun. Additionally, wide openings are needed for assembling and accessing the components inside. Each of these openings has the potential to compromise the RFI-impenetrability of the enclosure, and must be designed with that in mind.

The location in which the enclosure will be mounted, on top of the feed arm of the GBT, also influences the design. The outdoor mounting location means the enclosure must also be weather-proof. Additionally, the enclosure must be properly secured in its location. Both the RFI antenna and front-end enclosure are planned to be mounted on the gimble, a component currently present on the GBT feed arm. The gimbal maintains its top surface in a horizontal position regardless of the tilting of the GBT and has existing mounting holes and structures attached to it from previous projects. Photographs and CAD models of the gimbal were studied to ensure that the new enclosure would work with the existing components, since physical access to the location was severely limited.

Another important consideration is the frequency range to which the enclosure must be impenetrable, since that theoretically determines the maximum allowable size of any openings. The frequency range encompassing all scientific projects ongoing at the Green Bank Observatory is 20 MHz to 115 GHz, meaning that is the range of frequencies that could interfere with observations. The hole size in a conductive material that a radio wave can pass through is directly related to its wavelength, which is in turn determined by the frequency.

Regarding the overall structure of the enclosure, the size of compartments is important since it must accommodate all the components inside with proper clearances for easy assembly and maintenance. Multiple internal compartments are required to minimize cross-interference between the electronics inside. The types of connectors specified for the various cables entering and exiting the enclosure determines the size and shape of holes cutouts in the walls. Connector cutouts are positioned based on the overall size of the connector and clearances needed for assembly. A method for mounting the antenna along with the enclosure while making use of existing accommodations on the gimble is included in the design. The manufacturing methods and material for physically constructing this enclosure are considered as well. The material is selected based on the criteria that it must be conductive in order for the enclosure to be a Faraday cage, and the method of fabrication is chosen to minimize opportunities for openings or discontinuities in the enclosure.

2.2.2 Wires

As previously mentioned, various cables are required to pass through the walls of the enclosure. A power cable is needed to power the internal electronic components, a coaxial cable transfers the signal from the antenna into the enclosure, and fiber-optic cables must leave the enclosure to carry the information from the GBT to the Jansky lab. Additionally, cables inside the enclosure must cross between the internal compartments. Having cables entering the compartments can pose several challenges to maintaining a Faraday enclosure. Conductive wires entering or exiting the enclosure can act as antennas, allowing RFI to pass freely out of the enclosure along the wire.

In dealing with this issue, the frequencies of the signals carried by a wire becomes important in determining if it could actually produce RFI, since that will determine the frequency of any radio emissions. For example, AC power in a power cable might only be 60 Hz; well below the range of radio observations. However, even if a power cable isn't generating any of its own RFI, it might still act as an antenna, picking up radio frequencies from the other electronics within the enclosure and offering them a path out into the open. And of course, the RFI signals collected by the antenna will be exactly within the interfering frequencies. Despite these problems, power cables are still necessary, and the signals collected by the antenna still need to be carried from the GBT to the Jansky lab.

Fortunately, special connectors are designed for the exact purpose of allowing cables to pass through a shielded enclosure while blocking RFI. This is accomplished with a circuit inside the connector that filters out high frequency noise in the signal. This circuit is known as a pi filter, a passive element capacitive-inductive circuit where the inductors and capacitors can be arranged to produce either a low pass or a high pass filter.[2] When designed as an RFI filter, the low pass version is used, and connectors that work this way are commercially available in a variety of sizes and terminal types. This solution works well for power cables, where any high frequency portion of the signal is extraneous. However, for carrying the RFI signals gathered by the antenna, such a filter would render the signal useless. One way to carry RF signals without allowing them to radiate is through shielded coaxial cable, which essentially acts as an extension of the Faraday enclosure. Over long distances, however, coaxial cables are very lossy, so the monitoring station only uses one for the short distance between the antenna and the Faraday enclosure, where the signal is amplified.

To transmit radio data collected at the observatory the long distances it must travel, such as from the GBT to the Jansky lab, the electrical signals are converted to optical signals. This allows them to be carried by fiber-optic cables which do not act as antennas or have the potential to emit

RFI, are not as lossy as coaxial cables, and do not need to pass through filtered connectors. The remaining difficulty with this solution is that the fiber cables must pass through a hole in the enclosure, creating a potential weak spot in the Faraday cage, since they cannot pass through an RFI filtering connector.

This problem is remedied by making use of waveguide beyond cutoff tubes. The concept of the waveguide beyond cutoff tube is as follows: a conductive tube having length greater than 5 times its diameter will provide sufficient attenuation to a radio signal at or below the cutoff frequency that it will be essentially impenetrable to RFI. The cutoff frequency is determined by the inner diameter of the tube. This means that fiber cables can pass into an RFI enclosure through a hollow tube, rather than a simple hole, without compromising the integrity of the Faraday enclosure.[3]

2.3 Enclosure Design

A snapshot of the Inventor 3D model designed in this project is shown in figure 2, providing a preliminary visual of the design for this enclosure. The important features and decisions leading to this design are discussed in detail in the following sections.

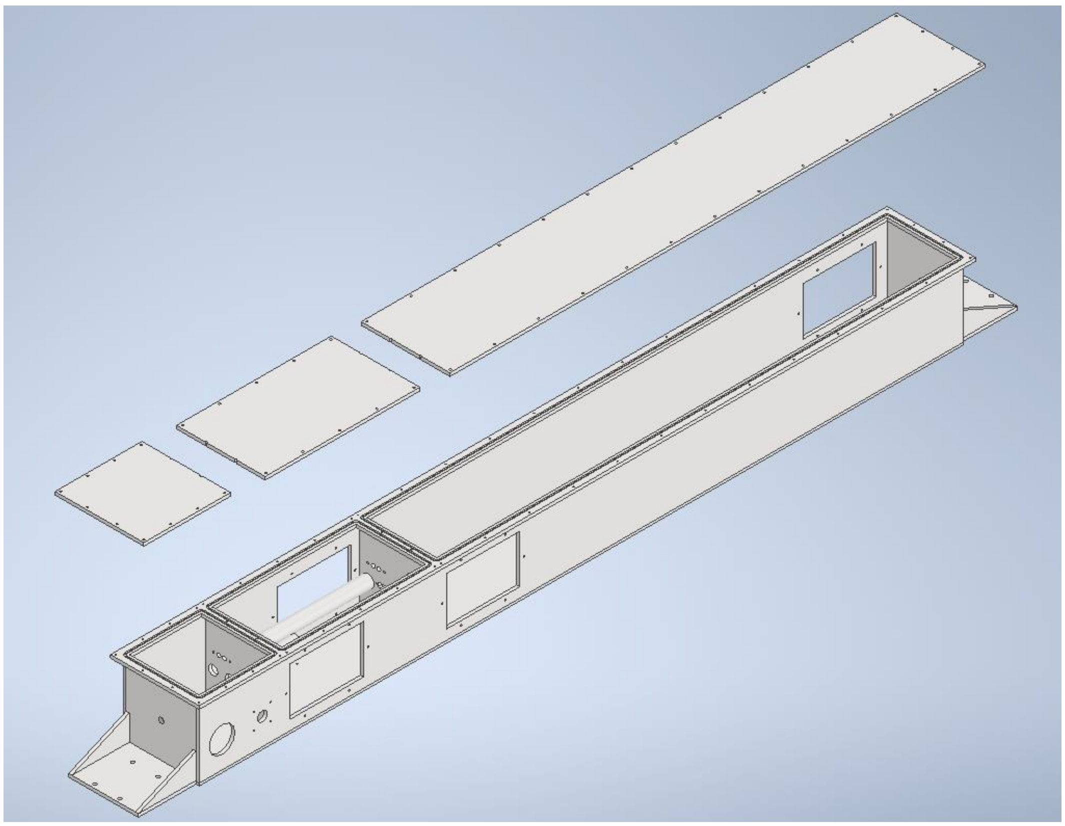


Figure 2. GBTRFIMS front end enclosure assembly

2.3.1 General Structure

The first aspects of the enclosure to be determined are the rough size and number of compartments, as well as the wall thicknesses. The size will ultimately be determined by the orientation and amount of equipment installed inside it, which has not yet been finalized at the time of this project. Therefore, the enclosure is designed to the maximum dimensions practical for its mounting location; on the GBT feed arm gimbal. The width is set to the same width as the gimbal to maintain a consistent top-down profile, and the length is set by the available length of the gimbal while accounting for mounting brackets.

Three separate internal compartments are required, all electromagnetically isolated from each other. Since the front end of the monitoring station requires both digital and analog components, these must be isolated from each other to prohibit interference between them. The purpose of the third compartment is to allow the enclosure to be weather-proof. Since the RFI filtered connectors for the power cable are not designed to be exposed to the weather, it must be installed in a dry environment. The third compartment serves to create this weather-proof environment, but is not RFI-proof. This is acceptable since none of the electronic components are to be located in the weather compartment.

The walls of the enclosure are set to be 0.25 inches thick. This is thicker than the walls of electronics enclosures often are, because this enclosure may have sections of wall without any internal support up to nearly four feet in length. Having thicker walls will reduce the likelihood of warping over those sections. This thickness also allows any tapped holes to have adequate depth for the threads.

2.3.2 Flange Design

To allow for access and assembly of the electrical components inside the enclosure, it is designed with removable lids. An RFI gasket is needed to ensure a good RF seal between the lid and the box is maintained. This gasket requires even compression to a specific percentage to function optimally, meaning a groove designed with the proper dimensions to allow for this compression is necessary. A flange is designed around the enclosure openings to provide enough surface area for a gasket groove and fastener holes. Closely spaced fasteners surrounding the groove are required to ensure there is good contact between the lid and the flange. The flange dimensions are determined in accordance with the dimensions of the chosen gasket and fasteners, and are finalized at 0.75 inches wide around the outside of the enclosure, and 0.875 inches wide between the compartments. The internal portions are wider because two gasket grooves are needed there, one for each of the bordered compartments. This flange design can be seen in figure 2 around the top edges of each compartment. It is made to be 0.25 inches thick since that is the thickness of the walls.

There are a variety of EMI/RFI gaskets available, including metallic finger strips, conductive elastomer O-rings, and knitted wire mesh gaskets, to name a few.[4] A conductive elastomer gasket is chosen since it will provide a weather-proof seal as well as an RFI-proof seal. A solid O cross-section is selected, with a 0.125-inch diameter since this is a commonly used size and is large enough that the groove will be relatively easy to manufacture. A larger size O-ring also allows for greater surface errors and greater variation in compression without compromising the seal, meaning larger fastener spacings around the flange can be used. This is desirable to minimize the number of fasteners required, facilitating assembly and internal access.

To accommodate this gasket, grooves are designed into the flange around each of the compartments. The groove dimensions are determined based on the manufacturer's recommended dimensions for ideal gasket compression. The manufacturer recommends that the groove allows for gasket compression of between 10 and 25 percent of the outer diameter, with 18 percent recommended as the nominal deflection. The width of the groove is recommended to be 110% of the gasket outer diameter to allow enough space for it to deform laterally without risking gasket damage. The recommendation for the bend radius of the groove is 1.5 times the outer diameter.[5] Based on these recommendations and a gasket diameter of 0.125 inches, the groove dimensions are 0.102 inches deep by 0.139 inches wide with a bend radius at the corners of .1875 inches.

To ensure adequate and even gasket compression by maintaining good contact between the lids and flange, the enclosure is designed with closely spaced tapped holes for UNC size 6-32 screws all the way around the each compartment for fasteners. The fastener spacing is chosen based largely on the experience of a senior engineer. Equation 1 is taken from the gasket manufacturer's design guide, and represents one method of determining fastener spacing based on the rigidity of the flange. However, this equation may underestimate the overall rigidity of the flange because it is difficult to accurately consider the contribution from the walls of the enclosure, so the final decision for fastener spacing is based more closely around practical experience from previous enclosure designs. The outer limits for fastener spacing are set between 2.5 and 3.5 inches.

$$\beta d = 2,$$

where

$$\beta = \sqrt[4]{\frac{\kappa}{4 E_f I_f}} \qquad \textbf{Equation 1}$$

k = foundation modulus of the seal
E_f = the modulus of elasticity of the flange
I_f = the moment of inertia of the flange and seal
d = spacing between fasteners

2.3.3 Mounting

The enclosure is designed to mount to the top surface of the gimbal using existing holes to minimize preparations for installation. On each end of the enclosure, brackets are positioned over holes that were originally intended for mounting pillowblocks in a previous project. These brackets can be seen in figure 2 with triangular supports for extra rigidity.

Another mounting concern is the antenna. The antenna is to be mounted beside the enclosure, rather than on top of it, so that the lid can be removed without first having to disconnect the antenna. To this end, a hole is included in the mounting bracket on the antenna end to allow for the antenna mounting base to be attached. The mounting base is a pre-manufactured part that came with the antenna, and when combined with a spacer as shown in figure 3, provides enough elevation for the antenna to remain above the top of the enclosure so as not to be shadowed by it.

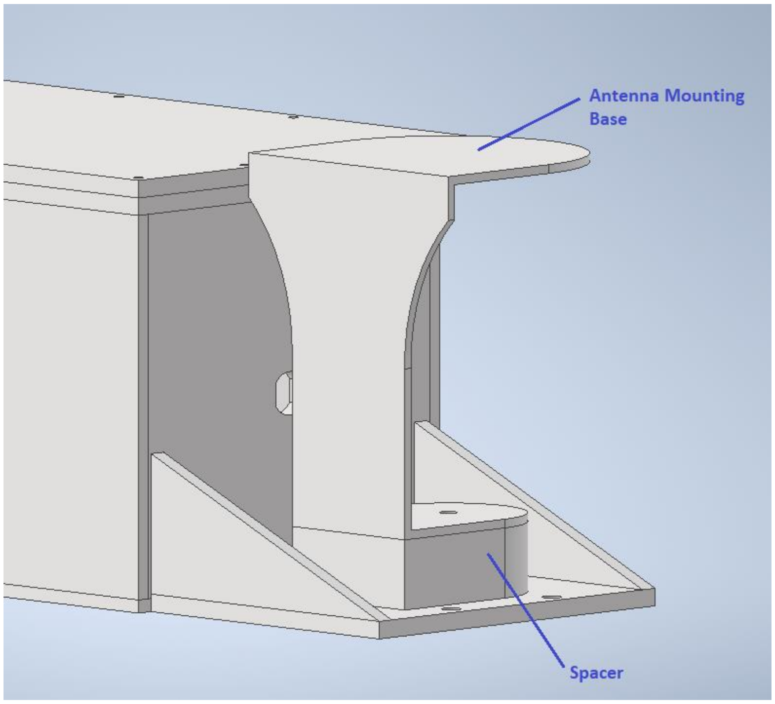


Figure 3. Mounting base for antenna with spacer.

2.3.4 Cables and Connectors

For this enclosure, the type and number of connectors was previously selected, so the size, shape and number of connector holes needed in each wall was already determined. The signal is passed from the antenna into the enclosure through a lightning arrestor, requiring a double D-shaped cutout in the wall at the antenna end. Six D-shaped SMA bulkhead connector holes are required in the next internal wall, as shown in figure 4, which are staggered and spaced out vertically to allow for easy installation. Also included in that wall are cutouts for two filtered 25-pin pin/socket adapters and a set of holes for a filtered terminal block. In the second internal wall, holes for the same filtered terminal block are included for the power cable. The third compartment is where the power cable will enter the enclosure and the fiber cables will exit. Holes are included here for a weather-proof low profile flange mounting power cable connector, as well as a large hole for a special weather-proof split cable gland allowing the connectorized fiber cables to pass through. The outer dimensions of all connectors are taken into account to ensure that there will be sufficient clearance between them. All holes are spaced at least 0.375 inches from the other walls so as not to interfere with the welding process.

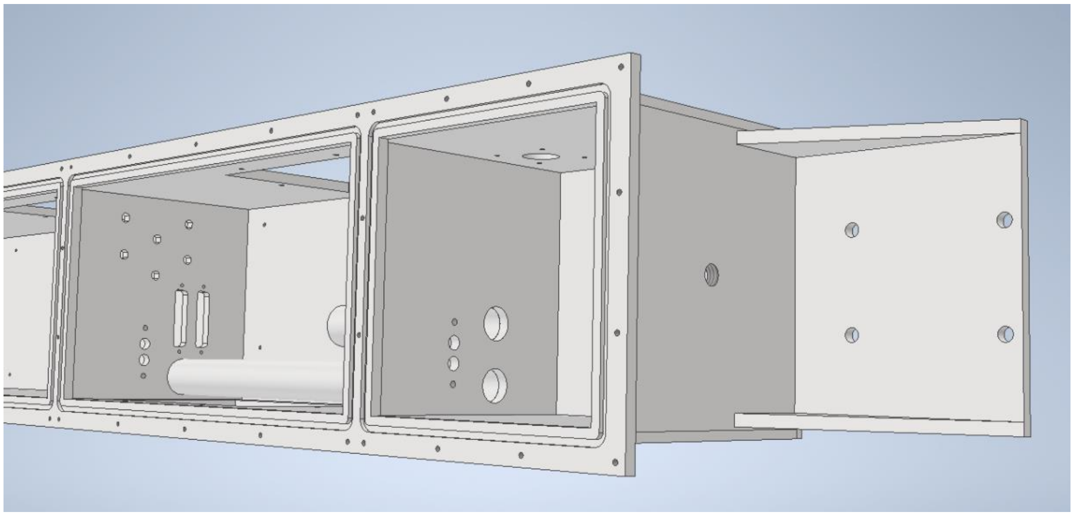


Figure 4. End view of enclosure showing cutouts for connectors in internal walls.

To allow the fiber cables to pass from the first weather-proof compartment into the RFI compartments, waveguide beyond cutoff tubes are used. An inner diameter of 0.75 inches is chosen to allow the connectorized ends of the fiber cables to be passed through, and the shortest length of the tube is 5 inches to ensure that the criteria for sufficient attenuation are met. Two such tubes are included for the two fiber cables, and holes for these tubes are included where necessary in the internal walls.

2.3.5 Ventilation

To properly ventilate the enclosure, rectangular openings are designed in the sides of each compartment containing electronics. These openings are to be covered by honeycomb vents specially designed for RFI enclosures. Honeycomb vents work as RFI-proof ventilation on the same concept as the waveguide beyond cutoff tube, since the honeycomb is essentially multiple tubes having length significantly greater than diameter, all stacked together. The size of the ventilation openings is determined by the size of honeycomb vents already in stock at the observatory, 5.25 by 7.25 inches, to minimize costs. The ventilation openings are located in opposite ends and opposite sides of each compartment to distribute airflow as evenly throughout the compartment as possible. One vent in each compartment is to be outfitted with an electric fan to drive airflow.

Vent covers are also designed to prevent rain from entering the enclosure through the honeycomb vents. The vent covers are designed to be manufactured from 0.0625-inch stainless steel sheet and mount to the enclosure through the same holes that attach the honeycomb vents.

2.3.6 Assembly and Manufacturing

The enclosure must be a conductive material in order to act as a Faraday cage. The metal chosen is 6061 aluminum because it is widely available, light weight, easy to machine and weld, and conductive. Each individual panel of the enclosure is designed with 0.0625-inch deep grooves where a connecting piece will be placed so that the pieces can be easily located and positioned during assembly. The pieces of the enclosure will be manufactured on site in the Green Bank Observatory machine shop. To ensure a completely RFI-tight enclosure, the walls are to be welded together with a continuous weld bead along all seams.

2.3.7 Allowance for Future Changes

The RFI monitoring station this enclosure is designed for is still in the development stage at present, meaning this enclosure may not be physically constructed for several years. Many aspects of the monitoring station are not yet finalized, such as the exact quantity or orientation of the internal electronic components in the front end. This means that the dimensions of the enclosure may need to be modified before it is actually constructed, so it is important that these modifications be easy to make.

To allow for future changes within the design, all the important dimensions, such as the length of the analog compartment, are defined as parameters in the Inventor part files. Changes to the dimensions can be made by simply locating the desired parameter and altering the corresponding number. Also within the Inventor part files, iLogic rules were created to ensure that the number of fasteners will change to maintain a spacing within the rage of 2.5 and 3.5 inches for any changes to the dimensions. This range is also modifiable within the iLogic rule if such changes become desirable in the future.

3 Ultra-Wideband DSP Sampler Enclosure

The second enclosure detailed in this report is designed for an ultra-wideband DSP (digital signal processing) sampler; a proof-of-concept project also still in the design phase at present. The ultra-wideband DSP sampler will theoretically allow for signals from receivers to be processed immediately, rather than requiring the signal to be converted from electrical to optical multiple times and travel long distances, as is done with most of the current receivers. These conversions and travelling provide multiple opportunities for signal loss, whereas the ultra-wideband DSP sampler would offer improved data quality, albeit at the expense of increased complexity, weight, and heat at the receiver.

3.1 Requirements

This enclosure is designed to be mounted inside a receiver box, so it does not need to be weatherproof. The circuit-boards and electronic components needed inside the enclosure were already selected, resulting in a known hole pattern and internal clearance requirements. The number and type of connectors required are also predetermined. The biggest constraint is the maximum outer dimensions, determined by the available space inside the receiver box. These dimensions are 15 inches by 15 inches by 4 inches. The enclosure also must be a Faraday cage since it will be located in close proximity to the telescopes at the Observatory and will house noisy electronics.

3.2 Design

The Inventor 3D model of the enclosure designed for the ultra-wideband DSP sampler is shown in figure 5. Its specific design and features are further discussed in the following sections.

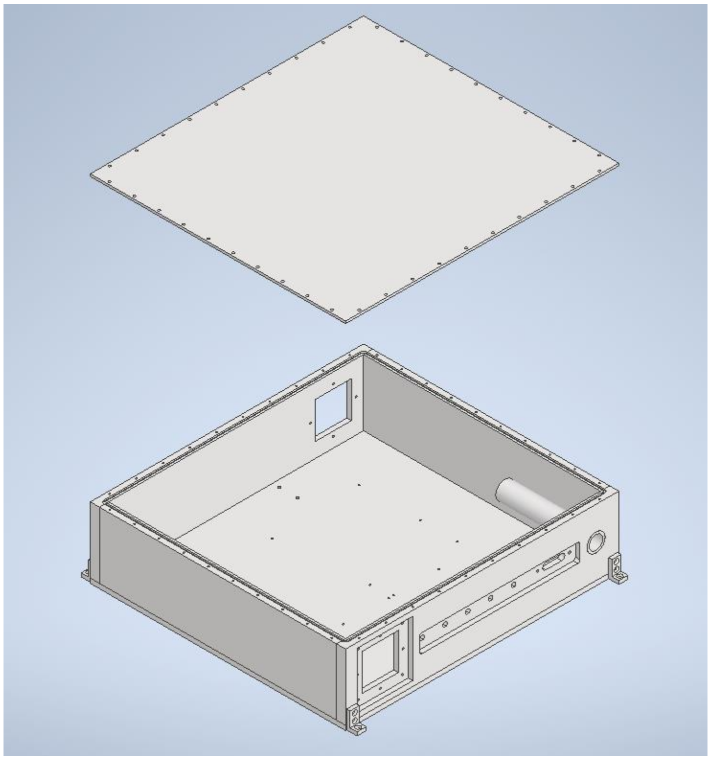


Figure 5. 3D model of ultra-wideband DSP sampler enclosure.

3.2.1 Basic Structure

To best accommodate the circuit boards in this enclosure, it is designed with only a single compartment. The walls are set to be 0.5 inches thick to allow for a gasket groove as well as holes for the lid fasteners. A flange is not used because the enclosure would exceed the maximum allowable dimensions once internal clearances around the circuit boards are accounted for if the additional width of a flange was included. The bottom of the enclosure is 0.25 inches thick to allow sufficient depth of the tapped holes for standoffs needed to mount the circuit boards. The lid is set to be 0.125 inches thick since it doesn't need to have any tapped holes in it.

3.2.2 Additional Features

This enclosure exhibits many of the same features as the GBTRFIMS enclosure since they are designed for similar applications. The front and back walls are designed with openings for honeycomb vents, as ventilation is also important for this enclosure. To ensure that the enclosure remains within the maximum outer dimensions when the thickness of the honeycomb vents is included, the vent cutouts are recessed into the walls by 0.25 inches. The vent opening in the front panel includes mounting holes for a small fan to drive airflow.

A groove is designed into the top edge of the walls for the gasket, also a conductive elastomer gasket with a solid O profile. The gasket diameter chosen for this enclosure is 0.093 inches because it must be small enough to fit into the 0.5-inch wall edge, and 0.093 inches is a commonly used size in the desired range. Similarly to the GBTRFIMS enclosure, frequent fastener holes are designed around the outside for proper gasket compression and to ensure the RFI seal is maintained. The screws for holding the lid down are UNC size 4-40 so that they will fit into the remaining width of the edges of the walls.

To accommodate the necessary cables, a waveguide beyond cutoff tube is included for the fiber cables to pass through and connector holes are designed into the front panel. Five D-shaped SMA Bulkhead connector cutouts are included, along with one cutout for a filtered terminal block. These cutouts are also recessed into the wall by 0.25 inches so that the connectors will be accessible on both sides of the wall despite its thickness of 0.5 inches. All the cables are designed to enter and leave the enclosure through the front panel for easy access and to facilitate maintenance.

Custom mounting brackets are also designed for this enclosure. They are right angle aluminum brackets allowing for two screws going into the walls of the enclosure and one screw into the surface the enclosure will be mounted on. The holes are countersunk for flat head screws so that the mounting screws will not interfere with each other. One bracket is to be placed at each of the four corners. All of these features are visible in figure 5.

4 Summary

Two RFI enclosures were designed for separate on-going projects at the Green Bank Observatory over the course of this project. Both were designed to be assembled from machined aluminum panels and solidly welded at the seams to ensure a good RFI seal.

The first enclosure was designed to house the electronics for the front end for a new RFI monitoring station in development for the GBT. This enclosure was designed to mount on the gimbal on top of the GBT feed arm using existing holes in the gimbal. The enclosure has three compartments, one for the digital electronics, one for the analog components, and one for weather proofing. The enclosure seals using a conductive elastomer EMI gasket, and incorporates honeycomb vents for ventilation. The conductive cables entering the enclosure pass through RFI-filtering connectors, while the fiber optic cables pass through waveguide beyond cutoff tubes to maintain the RFI seal. Care was taken in the design of this enclosure to ensure that future changes to the design could be made easily by simply modifying the parameter of the dimension to be altered, since future expansion of the monitoring station design is anticipated.

The second enclosure was designed to house electronics for an ultra-wideband DSP sampler, also in development. This enclosure is to be mounted inside a receiver box, and therefore has rigid constraints on the maximum allowable outer dimensions. This enclosure was designed with only one compartment since weather proofing is not a concern. It was also designed to seal with a conductive elastomer gasket and incorporates honeycomb vents for ventilation. A hole pattern was designed in the bottom of the enclosure to allow the necessary circuit board and other components to be mounted and care was taken to ensure there would be sufficient clearance for connectors. Mounting brackets were also included in the design.

The Inventor parts, assemblies, and drawing files produced at the end of this project provide the potential final forms for these enclosures. While they may need minor modifications when the projects they are designed for move into the implementation stages, the additional design work necessary before they can be manufactured will be minimal. The results of this project will facilitate the development of improved RFI detection and methods for minimizing signal loss in data processing, helping to further the capabilities of GBO as a radio astronomy observatory.

5 References

[1] https://greenbankobservatory.org/?s=nrqz

[2] https://resources.pcb.cadence.com/blog/2020-passive-pi-filter-design-and-simulation

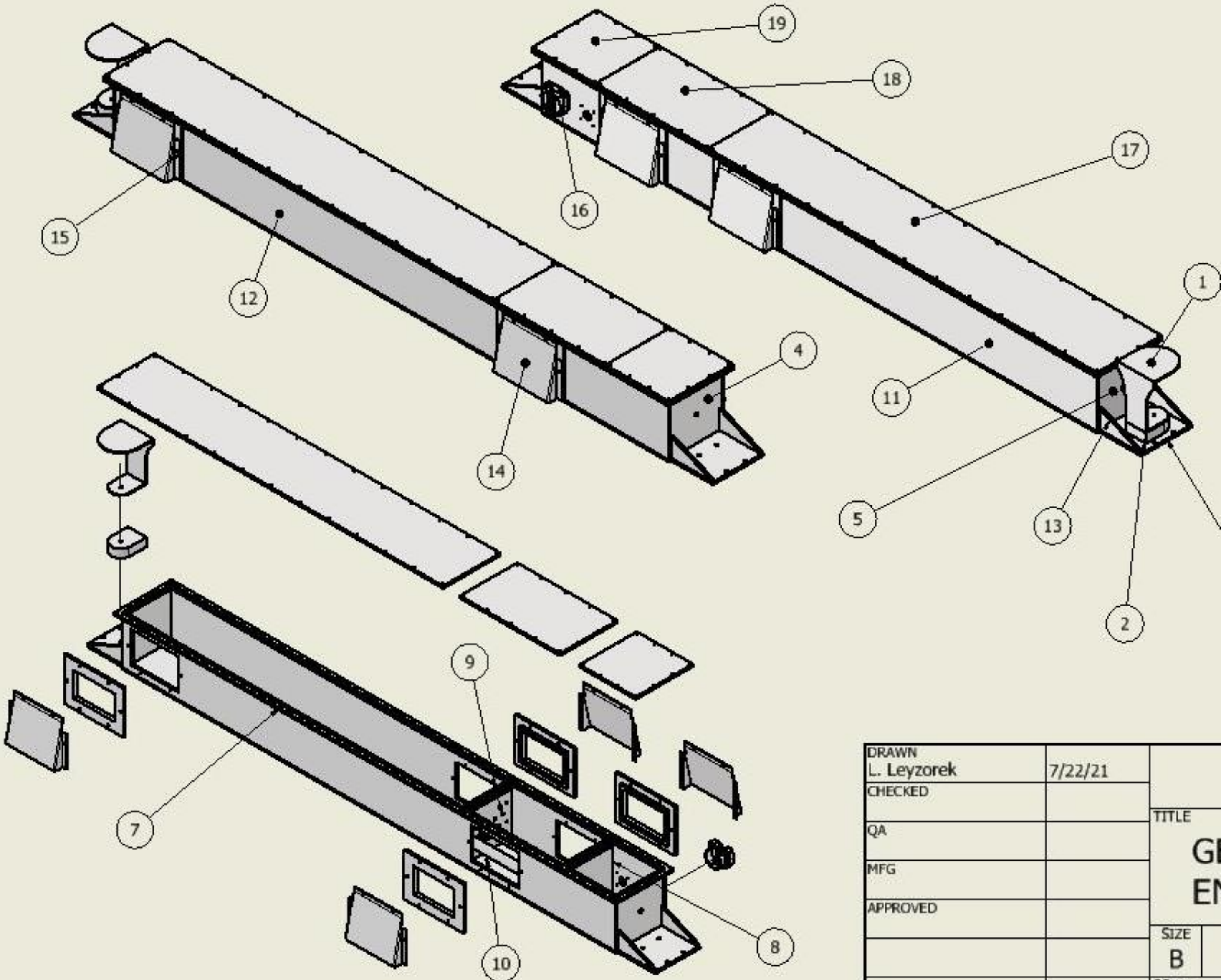
[3] https://www.pasternack.com/t-calculator-waveguide-circular.aspx

[4] https://hollandshielding.com/EMI-RFI-shielding-gaskets-with-or-without-water-seal

[5] https://www.parker.com/Literature/Chomerics/Parker%20Chomerics%20Conductive%20Elastomer%20Engineering%20Handbook.pdf

6 Appendix

Assembly Drawings for GBTRFIMS and Ultra-Wideband DSP Sampler Enclosures



PARTS LIST

ITEM	QTY	PART NUMBER
1	1	Antenna Mount
2	1	Antenna Spacer
3	1	Bottom
4	1	End Wall With Eye Bolt
5	1	End Wall With Lightning Arrestor
6	1	Five Inch Tube
7	1	Flange
8	1	Inner Wall 1
9	1	Inner Wall 2
10	1	Long Tube
11	1	Long Wall 1
12	1	Long Wall 2
13	4	Triangle Support
14	4	Vent Weather Cover
15	4	Honeycomb Vent
16	1	icotek Weather Gland
17	1	Long Lid
18	1	Medium Lid
19	1	Short Lid

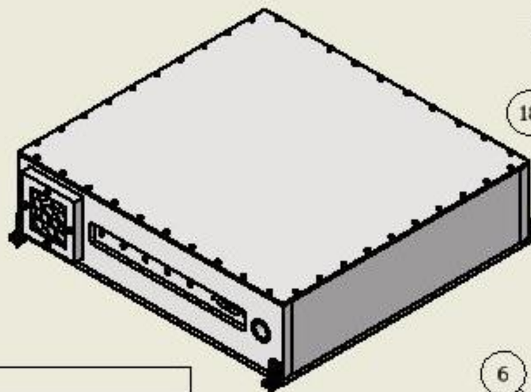
NOTE:

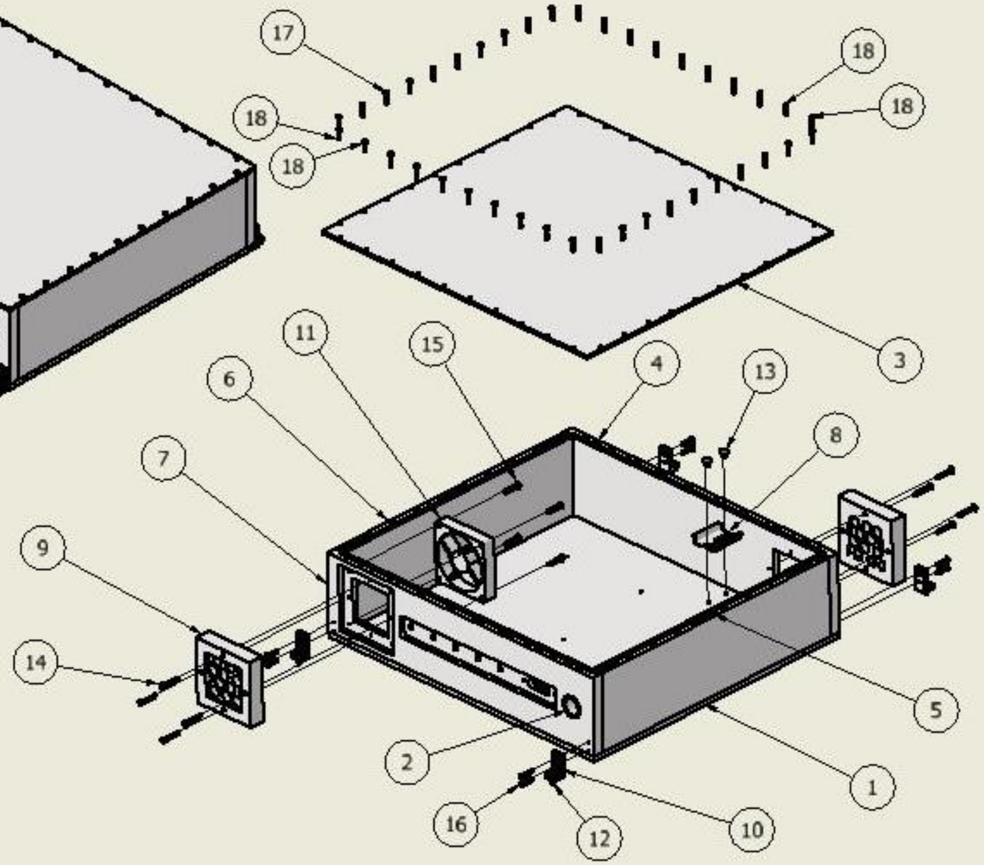
ITEM 6, FIVE INCH TUBE, NOT VISIBLE LOCATED INSIDE NEXT TO LONG TUBE

ITEMS 1, 15, AND 16, ANTENNA MOUNT, ICOTECH WEATHER GLAND, AND HONEYCOMB VENTS, ARE ALREADY EXISTING PARTS. SHOWN ONLY FOR FINAL ASSEMBLY PURPOSES

DRAWN L. Leyzorek	7/22/21	
CHECKED		TITLE GBTRFIMS ELECTRONICS ENCLOSURE
QA		
MFG		
APPROVED		SIZE B — DWG NO GBTRFIMS_enclosure — REV
		SCALE 1 / 8 — SHEET 1 OF 11

COMPONENTS NOT SHOWN		
COMPONENT	QTY	DESCRIPTION
Male-Female Threaded Hex Standoff -- 11/32"	11	McMASTER-CARR part no. 91075A468
Male-Female Threaded Hex Standoff -- ??????	3	Longer standoff, length TBD
Black Box DIN rail Clip	1	CDW part no. 3187631
Barrier Strip Filtered Terminal Block -- 3 circuits	1	SPECTRUM CONTROL INC part no. 52-160-003-A
SMA BULKHEAD FEMALE TO FEMALE ADAPTER	5	Amphenol RF part no. 132170
0.093" diameter conductive elastomer gasket	1	Parker Chromerics part no. 10-04-2865-XXXX, approx. 60" needed





PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	Bottom	
2	1	Fiber Tube	1" OD, .75" ID aluminum tubing cut to 5" in length
3	1	Lid	
4	1	Back Wall	
5	1	Side Wall 1	
6	1	Side Wall 2	
7	1	Front Wall	
8	1	DINrail	Standard 35mm DIN rail, cut to 1.5" in length
9	2	Honeycomb Vent	Purchase from MOUSER, part No. 861-9100-0001-94
10	4	Mounting Bracket	
11	1	70mm 12V DC Fan	Purchase from MOUSER, part No. 490-CFM7015V13331520
12	4	ANSI B18.6.3 - 6-32 x 1/2, CRFCHMSTII(5)	Countersunk Flat Head Screw (OR WHATEVER TYPE IS PREFERRED)
13	2	ANSI B18.6.3 - No. 10 - 24 - 1/4, CRPHMSTII(2)	Cross Recessed Pan Head Machine Screw - Type I (OR WHATEVER TYPE IS PREFERRED)
14	8	ANSI B18.6.3 - No. 6 - 32 - 7/8, CRPHMSTII(2)	Cross Recessed Pan Head Machine Screw - Type I (OR WHATEVER TYPE IS PREFERRED)
15	4	ANSI B18.6.3 - No. 6 - 32 - 3/4, CRPHMSTII(2)	Cross Recessed Pan Head Machine Screw - Type I (OR WHATEVER TYPE IS PREFERRED)
16	8	ANSI B18.6.3 - 6-32 x 5/8, CRFCHMSTII(5)	Countersunk Flat Head Screw
17	36	ANSI B18.3 - No. 4 - 40 UNC - 1/2 HS HCS	Hexagon Socket Head Cap Screw (OR WHATEVER TYPE IS PREFERRED)
18	4	ANSI B18.3 - No. 4 - 40 UNC - 3/8 HS HCS	Hexagon Socket Head Cap Screw (OR WHATEVER TYPE IS PREFERRED)

DRAWN L Leyzorek	8-13-21	
CHECKED		TITLE Ultra-wideband DSP Sampler Enclosure
QA		
MFG		
APPROVED		SIZE B · DWG NO UWB DSP Sampler Enclosure · REV
		SCALE 1 / 5 · SHEET 1 OF 8