AREG Repeater & Linking System General Description Version 0.2

Written By Peter Cockburn

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1 Introduction

The function of voice and data repeaters assists to extend the communications range of handheld, mobile and base stations utilising the VHF and UHF Bands. Experiments that AREG is conducting with repeaters also provide a service to the Amateur Radio Community.

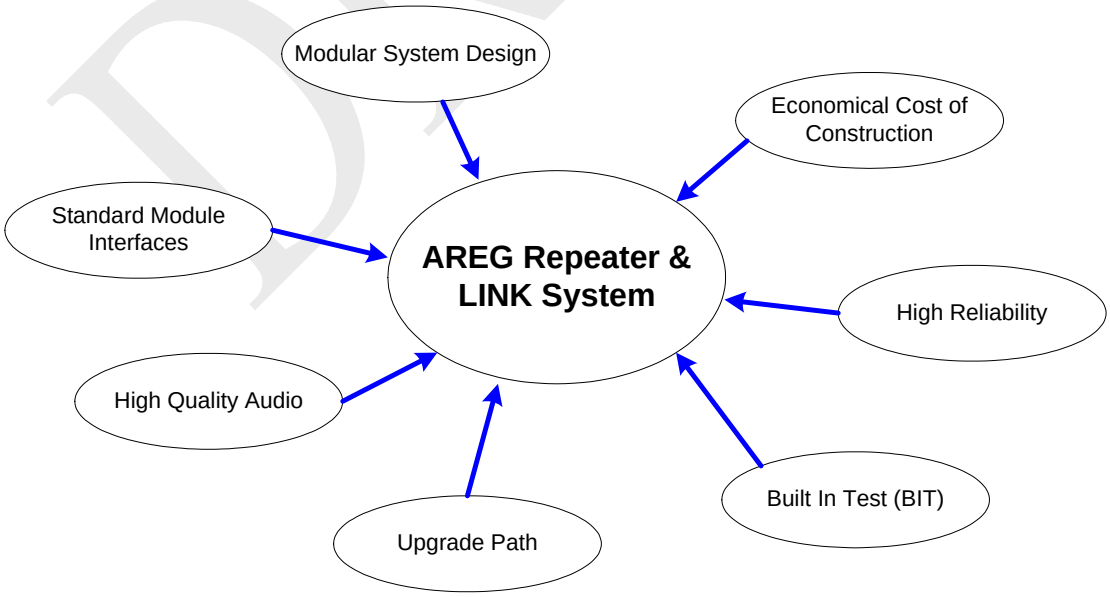
The choices that were made by AREG in following a particular implementation of a voice repeater system may not be suitable in your situation.

The following pages discuss some of the aspects important to have a good balance between experimentation and service providing with respect to Amateur Radio Voice and Data Repeaters.

We hope you gain some useful information from the following pages and the type of things that AREG did during our experimentation with repeater systems.

2 Design Philosophies

Designers of the repeater system as part of their experiment wanted to include many concepts that are commonplace in the commercial and scientific worlds. The major design philosophies that have been incorporated in the repeater system are listed below.



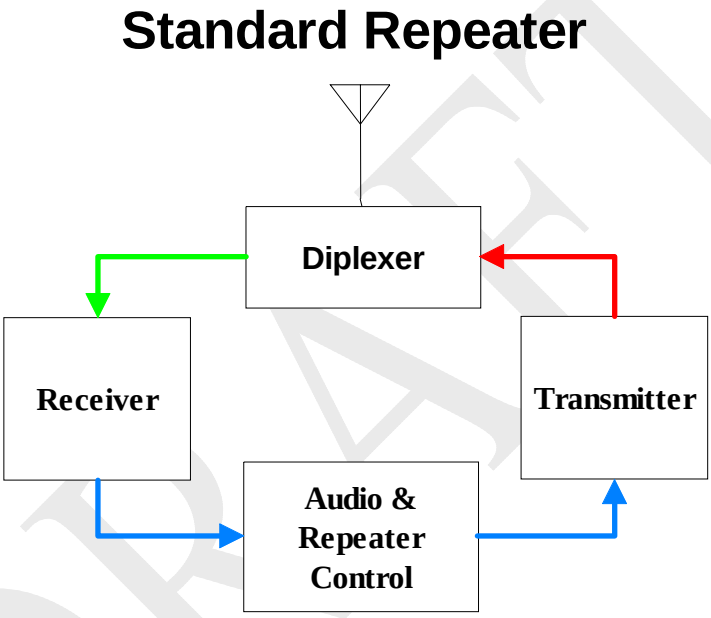
The ability to link repeaters together at some time in the future was also considered as one of the design philosophies. As there is a number of different methods to link

repeaters together, each method has is advantages / dis-advantages. The possibility of using different methods of linking was considered and has been incorporated into the repeater design.

For detailed description of the design philosophies refer to ***AREG Repeaters Design Philosophies HTML V0.1.doc***

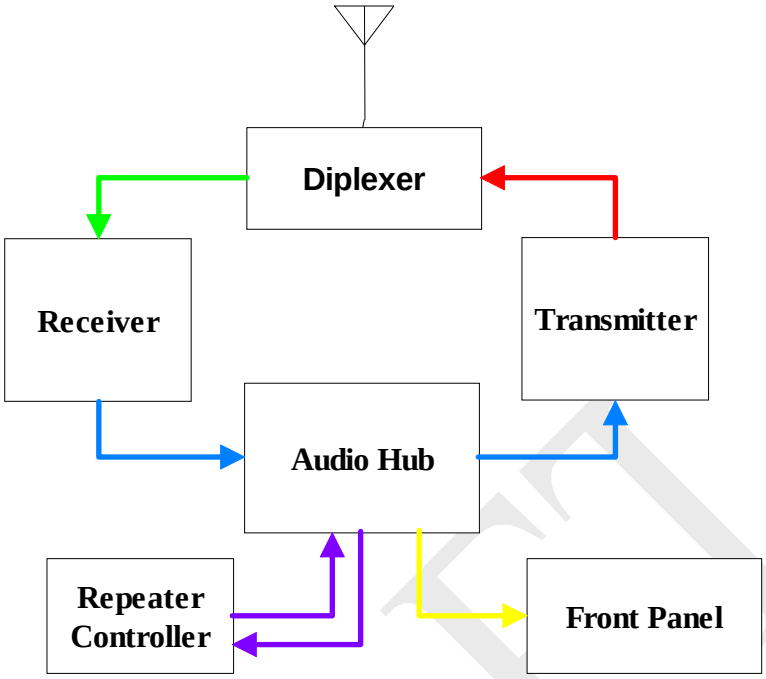
3 Standard Repeater Modules

The voice repeater is usually considered to have a Receiver, Transmitter and a Control System. The figure below shows the standard Amateur Radio Voice / Data Repeater block diagram and the signal flow.



The standard repeater can be further expanded with more modules allowing greater flexibility in upgrades and faster repair time. The following figure shows the Modular Repeater System.

Modular Repeater System



The designers of the repeater system have taken the standard modules of a repeater to be as described in the above diagram and are listed below.

- Repeater Antenna
- Diplexer
- Receiver
- Transmitter
- Audio Hub (Audio Mixing – Switching Module)
- Repeater Controller
- Front Panel (BIT Display)

The modules in the repeater are described in more detail in the following section.

3.1 Repeater Antenna

The repeater antenna is always going to be a point of great discussion. The fact remains it is a very important part of the repeater system. The antenna is the finial output device for the repeater and the input device for the repeater. A poor performing antenna system will not only degrade the Transmit repeater coverage but the Receive repeater coverage as well.

The operation of the repeater in a single antenna type of configuration has a number of advantages over the use of a dual antenna system.

- Lower cost for installation
- Easier tower access in shared sites (commercial / amateur site)
- Only require one Antenna
- Only require one Helix coax run.

- Receive / Transmit fringe signal coverage is the same
- Decreased wind loading on towers compared to dual antenna systems.

The dis-advantages is a full diplexer will be required. The commercially manufactured diplexer come up from surplus suppliers / auctions from time to time and can be easily modified for Amateur Radio use at low cost. With this in mind the designers of the repeater system have chosen a single antenna type configuration for the repeater system.

3.2 Diplexers

The diplexer used in a voice repeaters installation has two main functions.

- Provide Isolation to the Receiver from Transmitter Carrier.
- Provide Isolation to the Receiver from Transmitter Sidebands / Noise.

The commercial diplexer usually only incorporates a band pass or band notch type filters. A different approach must be taken in relation to amateur radio repeater systems. A voice or data repeater with less than 5Mhz split between Transmit and Receiver will require a combination of Band pass and Band Notch type diplexer.

The 6m and 2m bands have splits of 1MHz and 600KHz respectively, this is not a problem as a commercial diplexer can easily be modified to provide a band pass and notch arrangement.

The commonly available surplus diplexers are either 4” cavities or 6” Cavities. The 4” cavities provide about 35dB notch per cavity and the 6” cavities provide around 45dB to 50dB or greater depending on their type.

A good diplexer can provide around 90dB of notch at the Transmit frequency through the Receiver diplex side and a the same at the Receive frequency through the Transmit diplex side.

An example of a Diplexer is shown in the photo below, this is a UHF Diplexer, which is being used on VK5RSB 70cm Repeater in Adelaide.

For full details on types of cavities and how to modify them please consult the relevant pages.

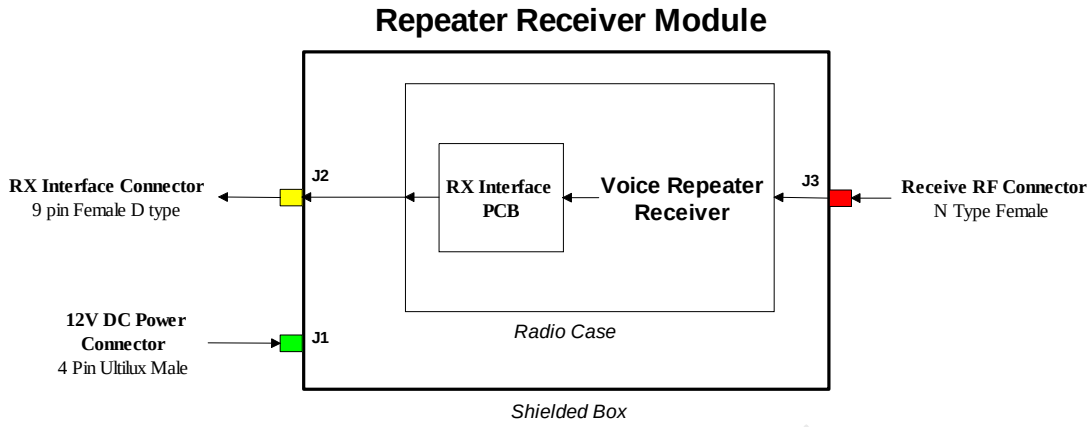
3.3 Receiver

The repeater Receiver has to operate with the repeater Transmitter only separated by a few % of the operating frequency. The factors affecting the operation of a duplex repeater are:

- Transmitter to Receiver Isolation
- Receiver Selectivity
- Receiver third order intercept
- Transmitter output power
- Transmitter carrier sidebands

The designers of the repeater system also wanted to incorporate the modular approach to the repeater design and construction. In the case of a large government department or commercial organization the transceiver could be specified to come with a standard interface that would allow easy connection to other equipment.

In relation to a amateur radio repeater where the numbers to be constructed will generally be in the order of one to two. The requirement to maintain a modular system will usually mean a custom interface board will be required to provide a standard connection point to the repeater receiver. The Diagram below shows the Repeater Receiver & RX Interface inside a shielded box.



The custom interface is referred to as the RX interface, the interface PCB is usually installed inside the repeater Receiver or inside the secondary shielded enclosure. As most transceivers when used, as repeater receivers don't have adequate shielding for repeater applications. The system designers usually implement a double-shielded receiver design. Typically around 100dB of isolation is desirable to be provided by the receiver shielding.

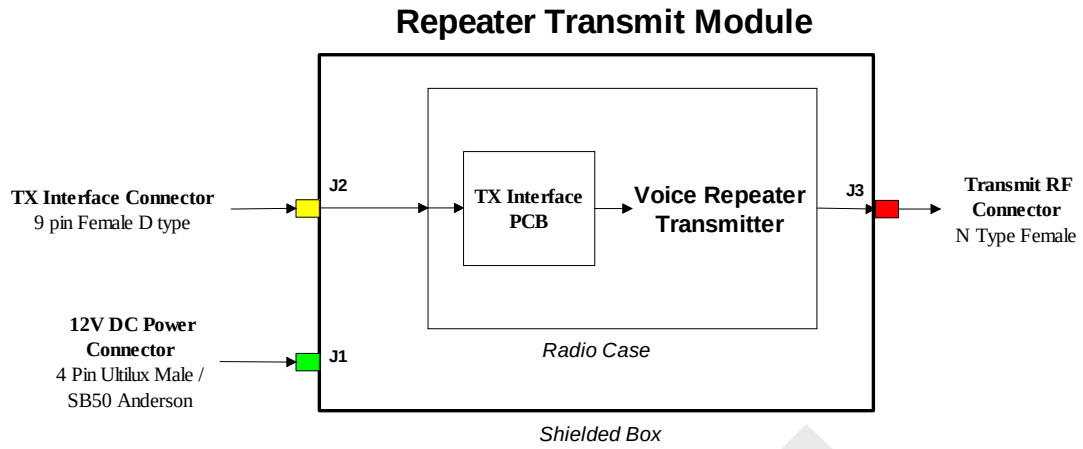
3.4 Transmitter

The standard transceiver that is common place in the radio shack is not a suitable radio for use as a repeater Transmitter. A number of factors have to be taken into account that would normally not apply to the ham shack radio:

- Continuous Transmit Operation
- Operation at high ambient temperatures (40degres C or greater)
- Low Spurious Output
- Protection against intermodulation / re-radiation of RF signals

The designers of the repeater system also wanted to incorporate the modular approach to the repeater design and construction. In the case of a large government department or commercial organization the transceiver could be specified to come with a standard interface that would allow easy connection to other equipment.

In relation to a amateur radio repeater where the numbers to be constructed will generally be in the order of one to two. The requirement to maintain a modular system will usually mean a custom interface board will be required to provide a standard connection point to the repeater transmitter. The diagram below shows a repeater Transmitter inside a secondary shield.



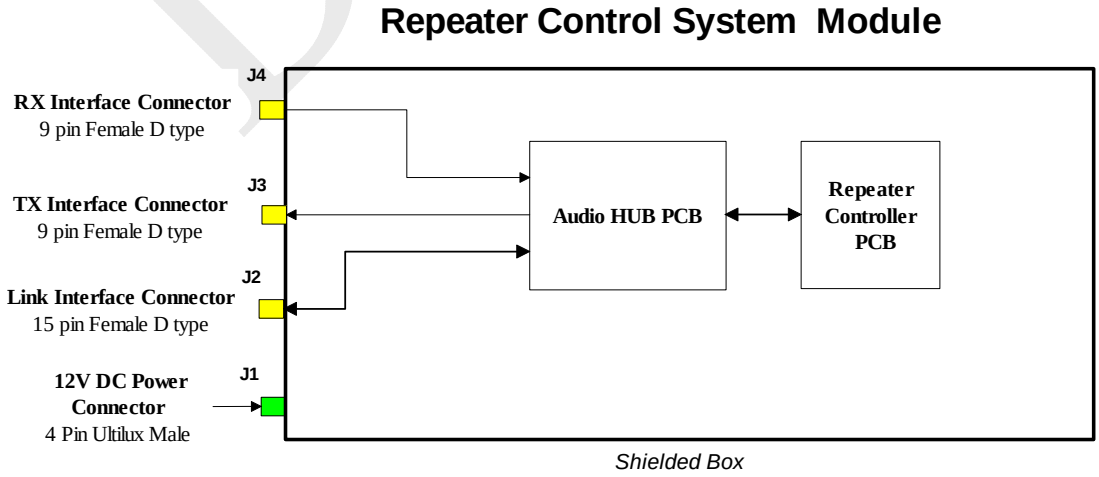
The custom interface is referred to as the TX interface, the interface PCB is usually installed inside the repeater Transmitter or secondary shielded enclosure. As most transceivers when used, as repeater transmitters don't have adequate shielding for repeater applications. The system designers usually implement a double-shielded transmitter design. Typically around 100dB of isolation is desirable to be provided by the transmit shielding.

3.5 Repeater Control System

The unlike the normal operations of a Amateur radio transceiver. The voice repeater is un-manned and requires a control system that will facilitate automatic control of the repeater transmitter in accordance with ACMA requirements. The repeater control system consists of two components.

- Audio switching & mixing.
- System control logic.

AREG have decided to split these functions into two separate PCB's. The Audio Hub handles the Audio switching and Repeater Controller handles the system control function. For detail on the interconnections see the following diagram.



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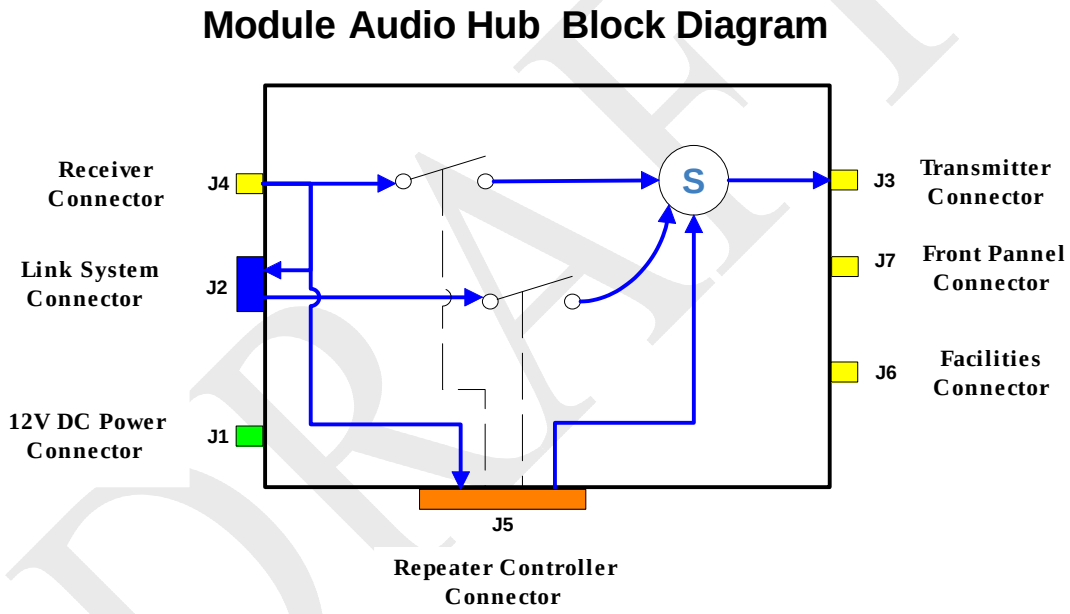
3.5.1 Audio Hub

The system designers also wanted to incorporate the modular approach to the Audio Hub section of the repeater. A set of standard interfaces for the Receiver, Transmitter, Repeater Controller and Front Panel were developed. At a later stage a Link port was also added to assist with the linking of the voice repeater to other repeaters.

The Audio Hub provides a number of functions as described below:

- Isolation of Identification & control tones to local transmitter
- Provides a standard connection point for Repeater Controller
- Receiver Audio Switching (enable / dis-able)
- Audio Mixing of RX, Link Port and Controller Audio to be feed to Repeater TX
- Cross connect for BIT functions between repeater Modules to Front Panel

The block diagram of the Audio Hub is shown below.



As indicated by the Audio Hub block diagram, the audio from the local repeater receiver is outputted on the Link Port without change. The receiver audio is also mixed with audio from the repeater controller (identifications tones / beeps) and from the Link System. The output from the summer is sent to the repeater transmitter. Thus keeping the link free of local repeater identification tones and audio which would otherwise be relayed by other systems.

3.5.2 Repeater Controller

The repeater controller is the heart of the voice repeater control system. As all voice repeaters operated in Australia have to comply to a standard set of operating conditions, a set of base functions is required for the Amateur Radio Voice Repeater Controller.
The base functions are as follows:

- Transmitter Timeouts
- Identification
- Remote System Control

As many more functions can be added to voice repeater controllers and usually are by their designers. All repeater controllers designed to comply with the Australian Radiocommunications Licence Conditions (Apparatus Licence) Determination 2003 (Apparatus LCD) will have the base functions.

3.5.2.1 Additional Controller Features

The implementation of microprocessor based repeater controllers the capability to add a number of features to the system is easily achieved. Such features may included,

- Tail Timer
- RX Signal to TX ON delay
- Transmitter Timeout
- Repeater Call Sign
- Identification Mode
- Identification Timer
- Messages
- Transmitter enable / dis-able
- Time adjustment
- Time out disable (broadcast mode)
- Linking enable
- BIT (built in test)

The number of possible features that could be implemented are only limited by your imitation and the type of CPU used for the controller.

3.6 Combined Enclosures

In some implementations it would be appropriate to incorporate a number of modules together. This is usually dependent on the physical shape and size of the radio equipment being used for the as the voice repeater receiver and transmitter and the space available for the repeater to be housed in.

The modular approach that AREG has taken to the system design promotes this type of combined enclosure. Listed below are the different types of combine enclosures that AREG has used.

- Repeater Receiver & Control System
- Repeater Receiver, Transmitter & Control System.

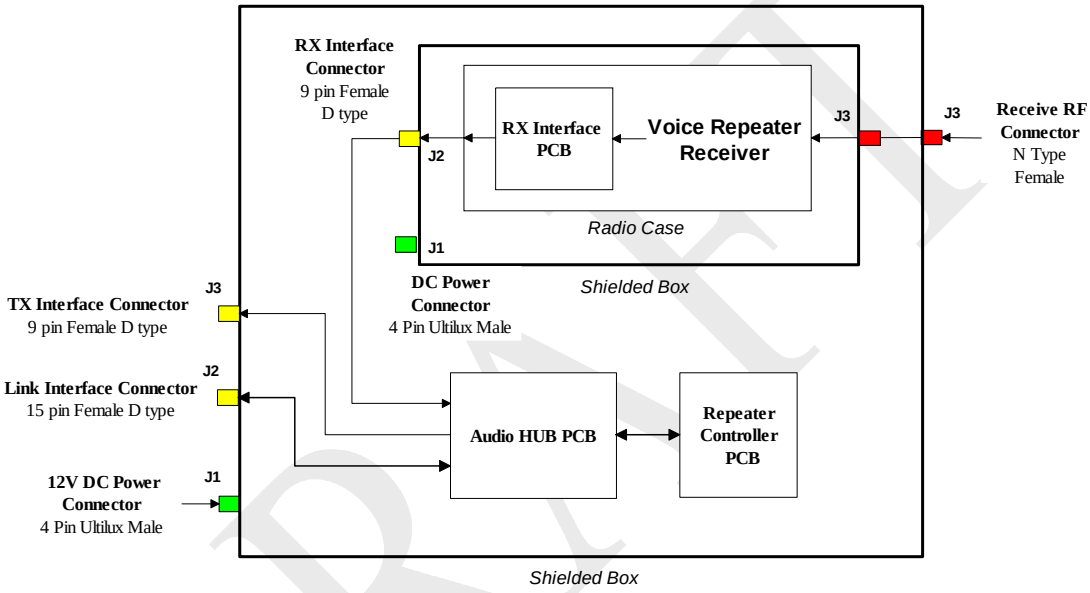
The types of connectors on the outside of the enclosure will depend on the combined enclosure of the voice repeater is dependant on the type of combined configuration. The following sections explain the two different types of combined enclosures.

3.6.1 Repeater Receiver & Control System

The Repeater Receiver and Control System combined enclosure is commonly used with the repeater receiver is small to medium size. As AREG generally constructs equipment to be rack mounted for convince of installation and maintenance.

When using boxes that are multiples of one rack unit (RU) or 45mm high. Enough space may be available to install the receiver shield box in the same enclosure as the Audio Hub and Repeater Controller PCB's. The following diagram shows how the various components would be connected.

Repeater Receiver & Control System Module



The Transmitter is connected to the Audio Hub via a 9 pin D type female connector marked as J3 on the outside of the enclosure. The Link Interface connector J2 is a 15 pin female D type and allows for connection of the repeater to other repeater / link systems.

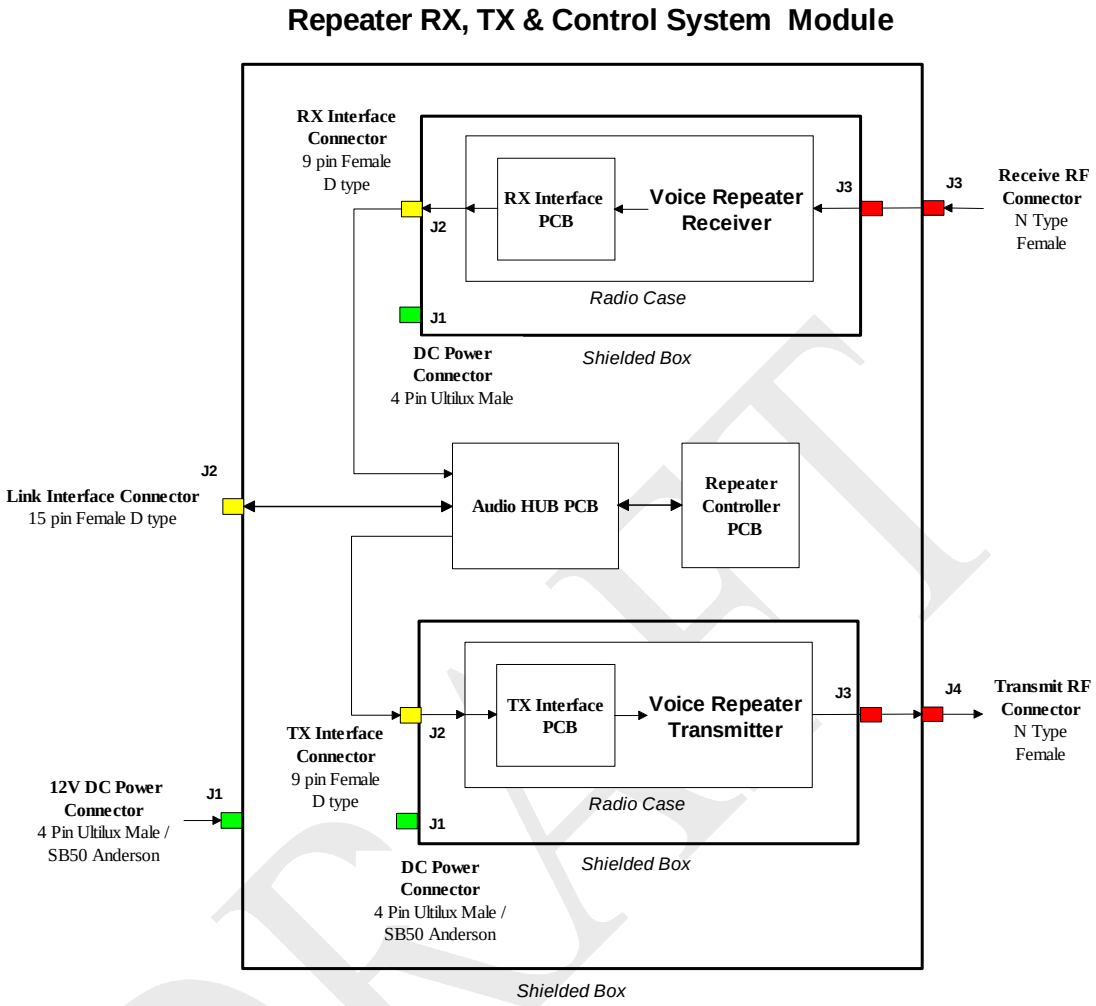
3.6.2 Repeater Receiver, Transmitter & Control System

The Repeater Receiver, Transmitter and Control System combined enclosure is commonly used with the repeater receiver and transmitter are small to medium size. The repeater transmitter does not require large external heat sinks to cool the transmitter or the heat sink is made part of the over all enclosure.

This advantage of this type of repeater configurations is that all components are located in one enclosure. AREG will apply the same methodology to the repeater enclosure and will construct the repeater using a rack mount box this is a multiple of one rack unit.

The disadvantage of this type of enclosure is it can be large and will not fit in may racks that all ready have lots of equipment in them. Unless the transceivers are of a

small size and the repeater transmitter is low powered. The following diagram shows how the various components would be connected.



The Transmitter and receiver are connected to the Audio Hub using internal cabling. The connectors on the out side of the repeater receiver and transmitter are configured the same as they would be for a single module as showing in sections 3.3 and 3.4.

The Link Interface connector J2 is a 15 pin female D type and allows for connection of the repeater to other repeater / link systems.

4 Physical Layout & Construction

The physical construction of the repeater will vary from one repeater to the next. AREG members have built a number of different repeaters over the years with each one usually being different to the next. AREG members have also built a number of repeaters that are the same as each other as well. The determining factor to how may repeaters that are constructed of a various type usually depends on the availability of the same type of radio equipment.

The modular system that AREG has developed allows for various components to be interchanged between repeater systems. The key to this portability of system components is the standard interface. As each part may be constructed from different radio equipment, but as long as the component conforms to the standard interface. It can be interchanged into another system with minimal effort and not re-alignment required.

The interchange ability works best in the configurations shown in section 3.5 where the repeater transmitter and receiver are in separate enclosures to the control system. The combined systems will rely on the exchanged receiver or transmitter physically fitting inside the enclosure. For a short term repair, it would be possible to still connect a receiver or transmitter to the combined enclosure and have it mounted outside the combined enclosure.

4.1 Receiver Enclosure

Shielding
Frequency stability
RF connectors & Coax
Receiver performance

4.1.1 Receiver Shielding

4.1.2 Frequency stability

4.1.3 RF connectors & Coax

4.1.4 Receiver performance

4.2 Transmitter Enclosure

Shielding
Frequency stability
RF connectors & Coax
Transmitter performance
Inter-modulation suppression

4.2.1 Transmitter Shielding

4.2.2 Frequency stability

4.2.3 RF connectors & Coax

4.2.4 Transmitter performance

4.2.5 Inter-modulation suppression

5 Summary

I hope you have enjoyed what you have read so far, this document is still under development with much more to be added, so please treat the draft copy as it is intended. It is to provide some insite into what the thoughts of the AREG repeater & link system designers were thinking of when the various parts have been designed.

Over the years that these ideas have been tried and tested, various changes have been implemented to improve the functionality of the system.

Stay tuned for further updates, all the best from AREG.

