Enhancing reception with the WA-TX-03S and WA-RX-03S audio modules

By John Bell

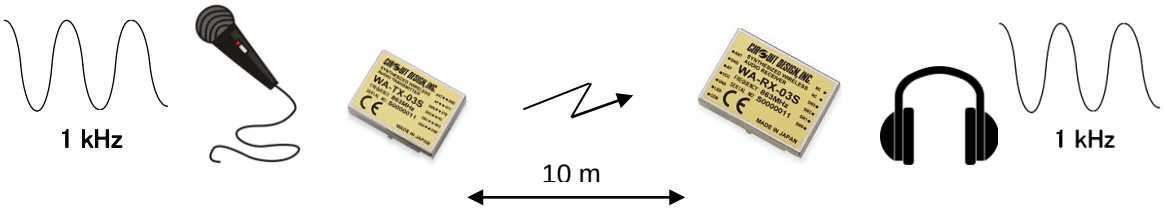
Introduction:

Circuit Design 863 MHz WA-TX-03S and WA-RX-03S modules have a RF power output of up to 10 mW. Even so satisfactory communication is only able to reach 50 m line of sight which can limit its applications. The purpose of this document is to investigate (without increasing ERP or RF power of the module) if communication can be achieved beyond 50m.

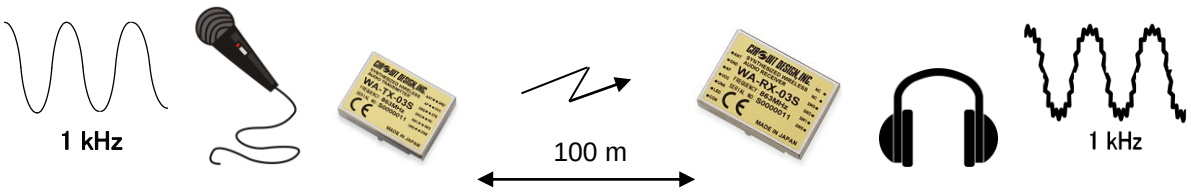
It is not just range that affects communication, also antenna placement and receiver position relative to the ground can determine reception quality.

How do we measure the quality of communication?

As the modules use analogue communication, there is no error correction in the receiver to clean up the signal. For example consider transmitting an audio sound using the WA-TX/RX-03S.



If the space between the transmitter and receiver is increased, the received RF signal diminishes, noise level increases and this manifests itself in our audio signal without any way of removing it.



The difference between the noise and desired signal levels is the Signal to Noise Ratio (SNR). If the SNR can be increased (i.e. increase the desired signal or reduce the noise), the result will be a better quality signal.

Receiver Sensitivity

As regulations limit the transmission power and if the device is designed for portable operation (e.g. not possible to use gain antenna) - the only method we have is to find a way of increasing the sensitivity of the WA-RX-03S. In other words, how to increase the sensitivity to the signals we want while reducing as much as possible the noise.

Reducing noise

Noise is any unwanted signal that interferes with the signal we want to receive. Imagine standing in a room listening to one person speak. Now imagine trying to listen to the same person in the presence of a hundred voices. That person's voice will be drowned out and we would not be able to hear what he/she is saying.

Now if that person's voice had a distinct pitch, we can imagine a filter that only let that pitch through and rejected everything else. This reduces the noise and we could then hear that person more clearly.

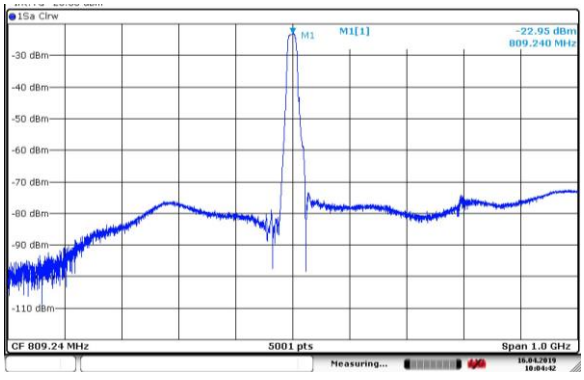
So for the WA-RX-03S receiver, can we apply an external filter to only let the signals of interest through?

SAW filter and the low noise amplifier (LNA)

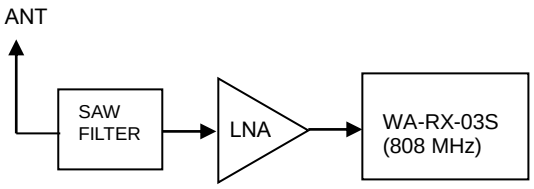
The solution is to use a LNA / SAW filter combination where the LNA works to improve the SNR. If the LNA is wideband, it will amplify all frequencies - including frequencies we don't want. Inputting this directly will overload the module's internal filter. The job of the SAW filter is to only let in the signals of interest (at the designated frequencies for the audio band) from the receiving antenna before presenting it to the LNA.

A SAW (surface acoustic wave) filter converts incoming electrical signals to an acoustic wave which is then allowed to propagate along a surface. At the output, the wave is converted back to an electrical signal. The way the SAW filter is designed determines its frequency response.

For example if using Japanese 808 MHz audio modules a suitable SAW filter centred on the 809.240 MHz can be used to only let in the 808 MHz audio band.



Frequency response of the SAW filter



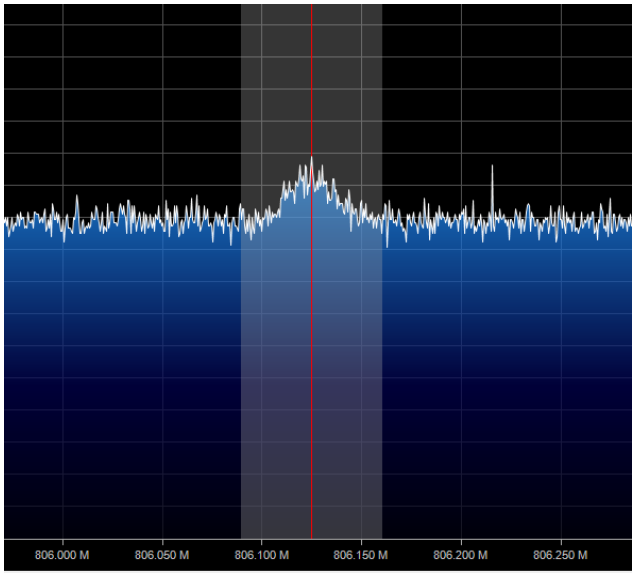
Receiver with external LNA and SAW filter

As the filter is likely to introduce some attenuation, the LNA brings the signal up to the receiving range of the module.

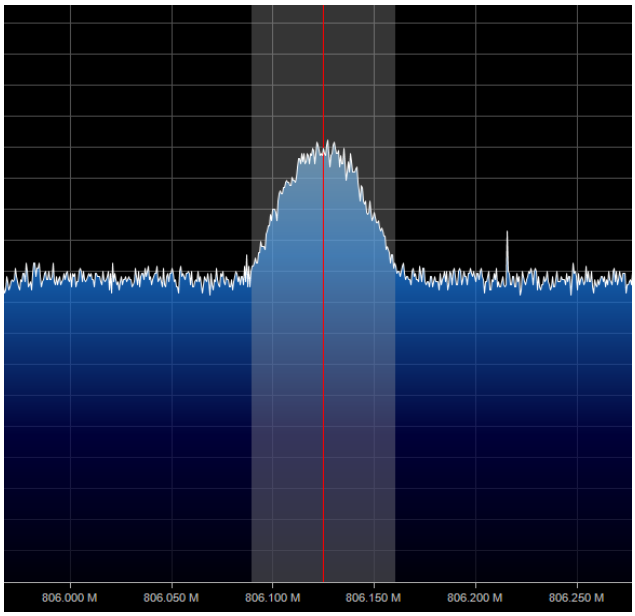
Also as the noise figure (see "notes") of the external LNA is likely to be much lower than the module, an additional effect is reduction of overall noise at the receiver.

Comparison of SNR at the receiver

By using a SDR dongle, we can view the transmitted signal from the WA-TX-03S. This is the signal that would be picked up by the WA-RX-03S during normal operation.



Without LNA and SAW filter: transmitted signal viewed on SDR Sharp tuned to 806.125 MHz



With LNA and SAW filter: transmitted signal viewed on SDR Sharp tuned to 806.125 MHz

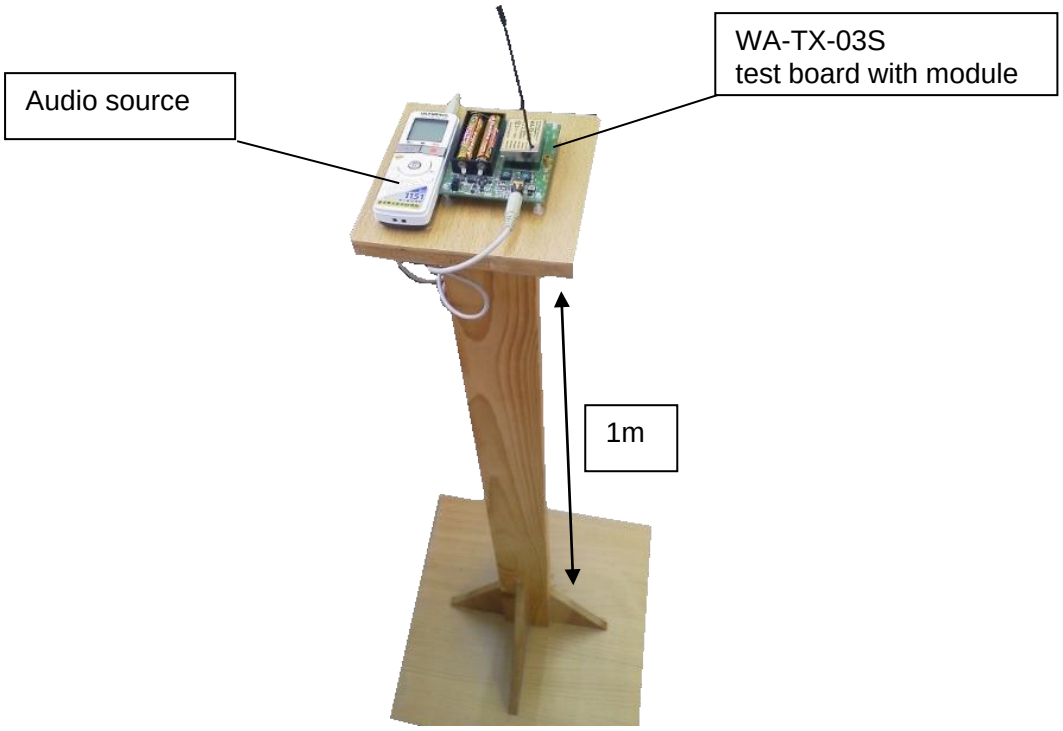
This comparison of SNR shows that with the LNA and SAW filter, the difference between the noise and desired signal is now much higher. This results in a higher reception quality as the noise becomes less audible.

In the next section, we can see how much this improves range and also reception stability.

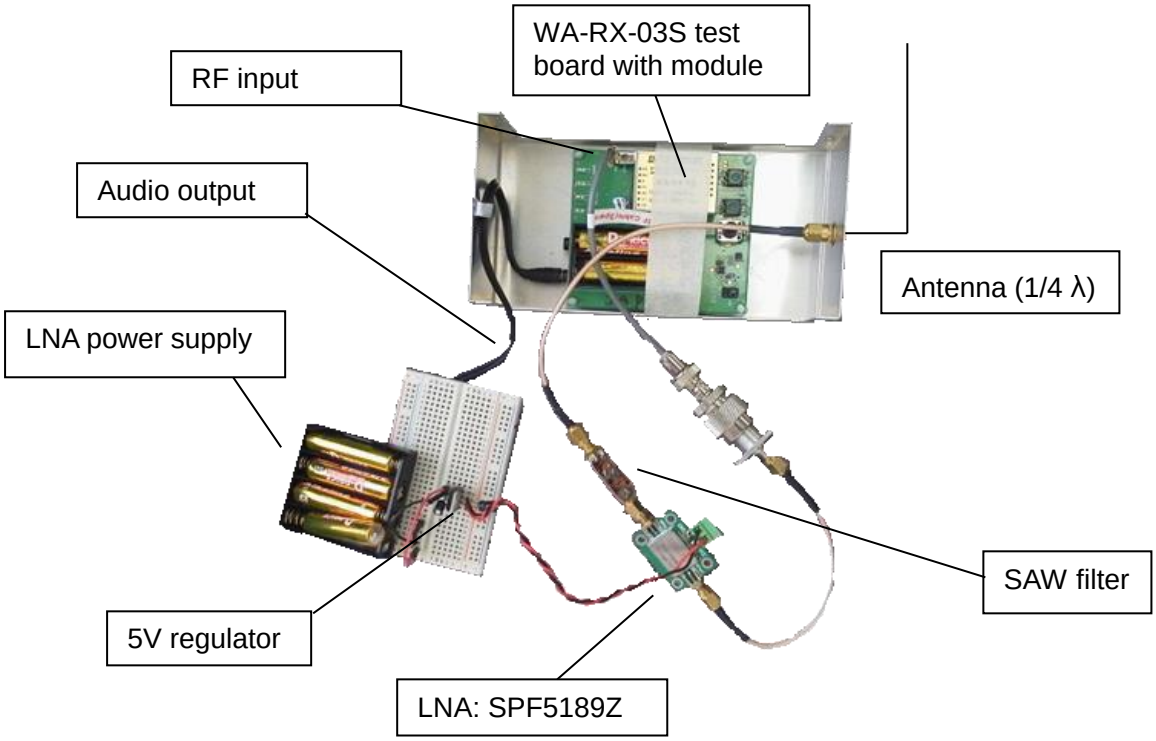
Testing - setup for transmitter and receiver

A range test was performed by Circuit Design in Japan to see how range and also reception stability was improved with the LNA and SAW filter combination.

1. Transmitter

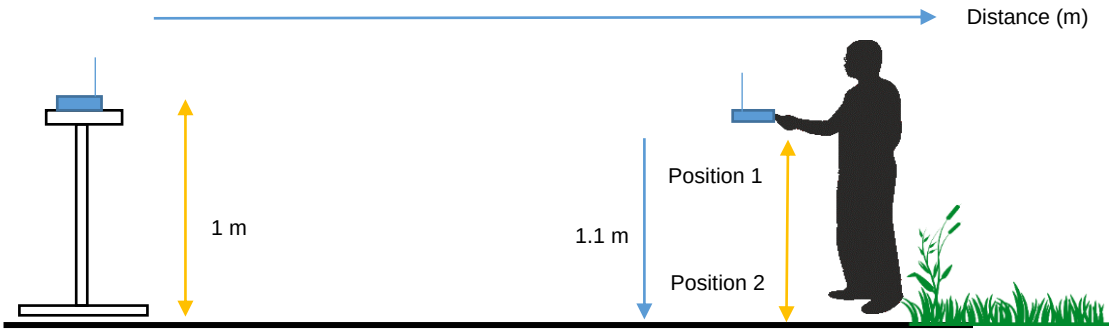


2. Receiver



Testing reception stability

To see how receiver position affected reception, measurements were taken - first when the receiver was placed at 1.1 m (position 1) and then 0 m (position 2) above the ground.



Results

Audio signal quality (%)

0	50	100

Distance (m)	No LNA + SAW				LNA + SAW		
	Pos.1		Pos.2		Pos.1		Pos.2
10		→				→	
40		→				→	
80		→				→	
100		→				→	
144		→				→	
170		→				→	
200		→				→	
215		→				→	
230		→				→	
250		→				→	
260		→				→	
308		→				→	
327		→				→	
370		→				→	
390		→				→	
400		→				→	
415		→				→	
480		→				→	
490		→				→	
495		→				→	
510		→				→	
520		→				→	
530		→				→	
540		→				→	

Conclusion:

Signal quality was judged by using ear so there were only 3 levels that could be used to realistically measure it. Expressed as a percentage, these are 0% - no signal, 50% - both signal and noise audible and 100% - perfect audio.

With the LNA and SAW filter in place, the reception stability is improved at higher distances. Here the range achieved by both setups is about the same but it is speculated that at higher distances, the difference would have been more evident.

Even though the range is normally quoted as being 50m for Circuit Design audio modules, good line of sight with minimal signal interference in this instance allowed distances in excess of 500m to be reached.

Notes:

Noise figure is the amount of noise introduced from the device's own internal electronics to the RF signal. All devices produce a small amount of internal noise.
For a LNA, it is important that it amplifies all the incoming signals without adding any noise by itself which is why it is purposely designed to have a low noise figure.

This is important as the overall noise figure of a receiver is largely dependent on the noise figure of the first amplifying stage. Therefore it is required to keep the noise figure of the external amplifier as low as possible.