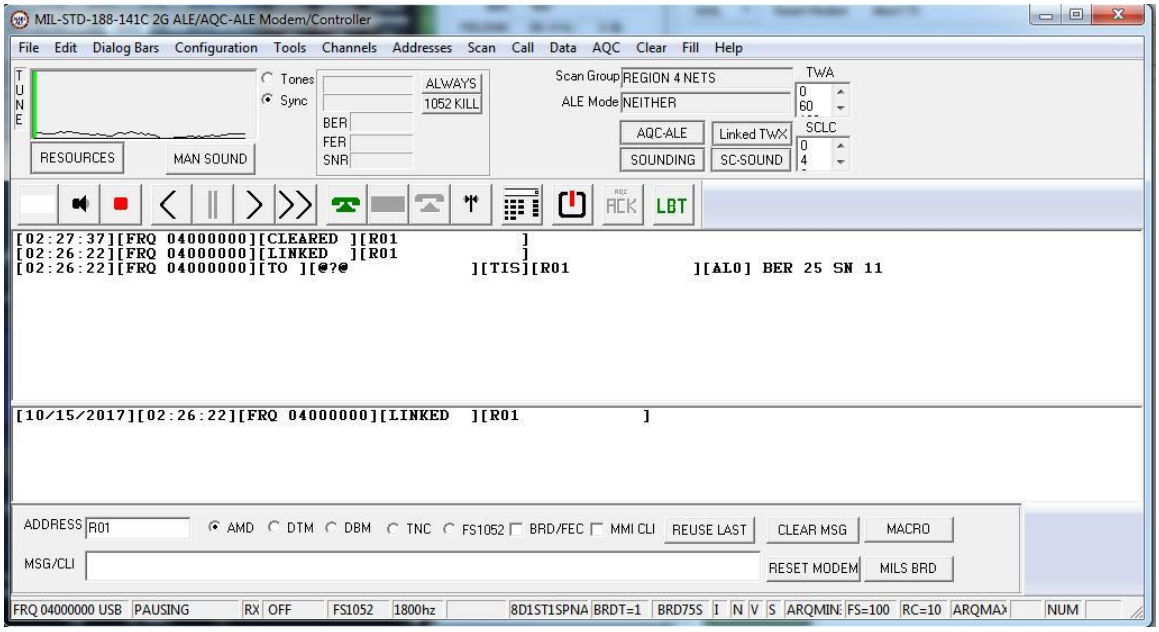
# DRAFT 0.1

# MARS-ALE based HF-ALE Guard Receiver for MIL-STD Data Modem based Broadcast Intercept

**Support forums:**

http://groups.yahoo.com/group/MARS-ALE/

https://groups.io/g/MARS-RSP2pro



**HF- ALE Guard Receiver**
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## OVERVIEW

In order for MARS to have a true 24/7 HF-ALE based network for alerting the membership via ALE follow-on MIL-STD data modem broadcasts we must have a large number of members, if not all members ALE active 24/7. However the prospect of leaving expensive radio equipment operational and unattended during most of that 24/7 period and subject to damage is a potentially expensive issue. The HF-ALE Guard Receiver (HAGR) approach addresses 24/7 monitoring with less expensive but yet capable radio equipment when the station is unattended.

By my definition an HAGR is any suitable remote controllable HF SSB communications receiver used with a 2G ALE modem/controller where the purpose is to monitor for a 2G ALE "Global All Call" linking call and once ALE linked, intercept follow-on data transmission(s). Once the ALE inlink state been established follow-on data transmission(s) are currently via MIL-STD-188-110A PSK Data Modem. When the data modem transmissions are completed, the ALE inlink state is cleared via remote ALE signaling or the TWA timeout setting of MARS-ALE with a return to ALE scanning.

In support of the HAGR premise, I prefer utilize a less expensive HF SSB communications receiver in lieu of a more expensive receiver or two-way HF SSB transceiver. The driving factor being to safe guard the expensive radio from damage that may be brought about from lightening, power failure or unknown events when the station is not attended.

In addition, the HAGR HF SSB receiver can be used to free the normal two-way radio for other communications uses given suitable additional antenna and required antenna isolation or HF combiner being in place for use of the same antenna exists. It is often challenging to bring about co-hosted HF-ALE systems when one or more is transmitting. This too is true of just one HF-ALE system that is transmitting and one or more non-HF-ALE radios in use. However for HAGR application we are only taking HF-ALE in RX operation.

The use of the HAGR approach will increase the probability of broadcast intercept over that of monitoring only during attended operational hours. The importance of this is that we are currently heading toward the bottom of the current 11 year Solar Cycle, where the year 2020 is the estimated Solar Minimum event. At the start of the next Solar Cycle in 2020 it is not known how long we shall remain at the Solar Minimum levels until we start to ascent toward the Solar Maximum predicted for 2025.

The ideal HF communications receiver for HAGR use would be one that is truly inexpensive and thus easily replaceable if damaged. The author has made use of an older TCI/BR 8174 1U rackmount receiver as the HAGR unit which has been used for various ALE intercept tasks for over 10 years now. However it was not an inexpensive when acquired used and it is not easily replaced even though less expensive now. It is also an aging piece equipment with some limitations and lacking features of newer, inexpensive SDR receivers.

MARS-ALE has supported a variety of HF SSB communications receivers from the beginning that many MARS members already apply to the HAGR approach. However many have asked me for recommendations as to what inexpensive current make/model receivers to purchase for such application, but until recently I have not had a good answer. However an HF-ALE Guard Receiver (HAGR) based on an SDRplay RSP2pro for use with MARS-ALE is an inexpensive (under $200USD shipped by HRO) and functional solution that has been tested and proven by the author during the last 8 months now.

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## SDRplay RSP2pro

The SDRplay RSP2 series of receivers are very capable 12-bit ADC based SDR Radio Spectrum Processors (RSP) introduced in late 2016 as a further evolution of the popular RSP1 receiver. Interfaced and powered over the USB 2.0 bus, the RSP2 series are compact and light weight units. The RSP2pro with its metal case for extra shielding and stability due the ensuring weight is also just the thing to take along when on TDY for use with a laptop or tablet PC and length of wire on the Hi-Z port.


The RSP2 series, in particular the RSP2pro is preferred as it provides many new and improved features over that of the RSP1 and the RPS2pro provides the best shielding. Specifications for the RSP2 series are:

- Continuous frequency coverage from 1 kHz to 2 GHz.
- 10Mhz bandwidth slice of spectrum processing capability.
- Up to 16 individual receive channels in any 10MHz slice.
- Highly stable 0.5PPM TCXO, field calibration to 0.01PPM.
- Better sensitivity and even lower Noise Floor.
- 2 x 50 Ω SMA antenna ports and 1 x High Impedance port for long wire antennas, all software selectable.
- 10 high-selectivity, built in front-end preselection filters.
- 24MHz reference clock input/output MCX connections to daisy-chain RSP2 receivers together in a master/slave configuration so that they can all be synchronized to a single clock source for extended bandwidth.

The only difference between the RSP2 and RSP2pro is that the later has a full metal enclosure and the RSP2 as with the RSP1 is enclosed within a plastic. However unlike the RSP1, the RSP2 plastic case is metalized painted on the inside of the case.

**NOTE: As this paper was being readied for its initial DRAFT release the new SDRplay RSP1A debuted. With respect to HAGR application, taking into account many of the features from the RSP2 now is available in the $100USD RSP1A, it too would appear to be a good choice. However it is their new entry class receiver, now replacing the RSP1. The RSP2 at $179 and RSP2pro at $192 are a lot more receiver.**


The added shielding of the RSP2pro and its extra weight provide added stability both which are well worth the additional cost in my opinion. This is especially true if the siting for HAGR application while in use shall include nearby HF RF transmissions.

The RSP2pro is a well designed and built unit with no frills packaging where even the required USB cable for operation is not provided to keep the costs down. It is assumed that most users will already have a spare USB cable, RF adapters or cables for use with the receiver as I certainly do.


Both units real world interface consists of three selectable antenna ports on one end, where one is a Hi-Z (high impedance) for direct use with random antenna. The two 50 ohm antenna ports use standard female SMA connectors where dust covers are provided. The other end of the unit features the USB connector and MCX Clock-in and Clock-out ports.



High Z port Characteristics:

- 1 kHz – 30 MHz operation
- 18 dB RF gain control
- 1kΩ input impedance (balanced)

- CTB9208/3 removable screw connector (one CTB9208/3 plug supplied)

For additional plugs I can recommend MCM electronics which is a good source of parts in any quantity: http://www.mcmelectronics.com/product/CAMDEN-BOSS-CTB9208-3-/26-5415


Port A Characteristics:

- SMA Female connector
- 1.5 MHz – 2 GHz operation
- 40 dB RF gain control
- 50 Ω input impedance

Port B Characteristics:

- SMA Female connector
- 1.5 MHz – 2 GHz operation
- 40 dB RF gain control
- 50 Ω input impedance
- Selectable 4.7V DC out (see Bias T)

Here in the U.S. the only source is Ham Radio Outlet (http://www.hamradio.com/detail.cfm?pid=H0-015447) at $192.95USD delivered currently.

REVIEWS:

The ARRL has reviewed the RSP2/RSP2pro recently in the September 2017 QST.

http://www.sdrplay.com/.../uploads/2017/09/QSTRSP2review.pdf

SDRplay new RSP1 debut:

http://www.sdrplay.com/announcing-the-new-rsp1a-wideband-full-featured-14-bit-sdr/

The ARRL review of the RSP1 in the February 2017 QST.

http://www.sdrplay.com/wp-content/uploads/2017/01/SDR-PlayQSTReview.pdf

However the RSGB in the April 2017 Radcomm has a review of the RSP2:

http://www.sdrplay.com/wp-content/uploads/2017/04/RadComRSP2review4.pdf

UXDF has a review of the RSP2 where they also compare it to the RSP1:

http://www.udxf.nl/SDRPlay_RSP2_SDR.pdf

RX comparison to an IC-7851 that bespeaks as to the RSP2 receivers ability.

https://www.youtube.com/watch?v=vri3-5xZhlE

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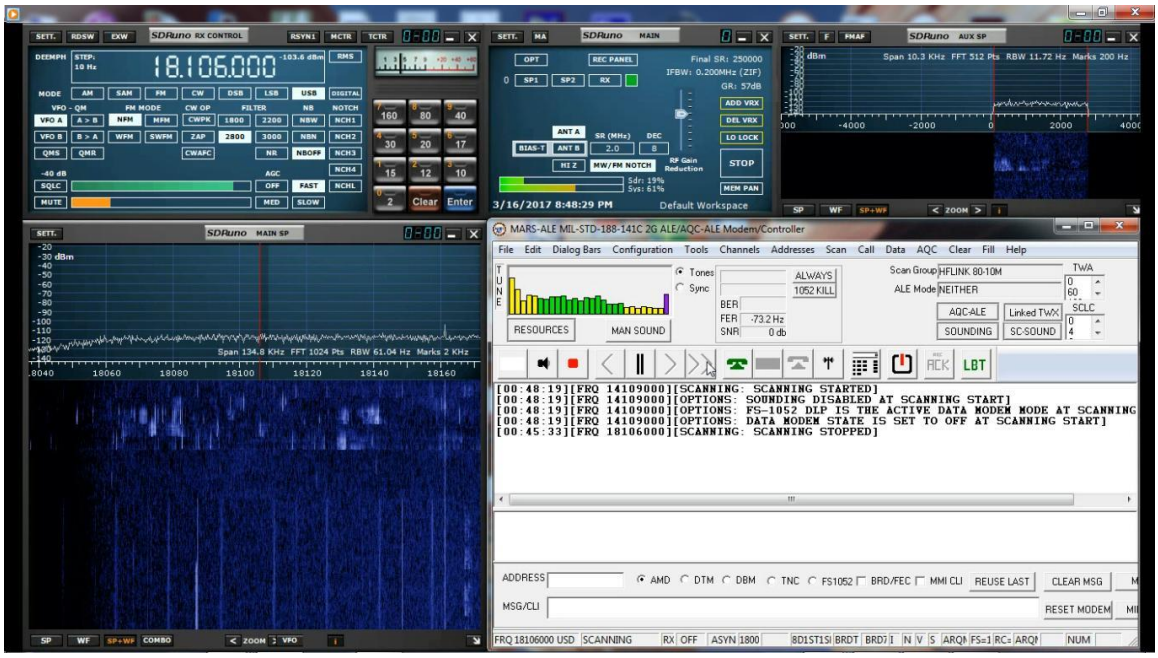
## SDRuno SOFTWARE

The RSP2pro and its companion software, SDRuno, is an easy to install, setup and use full featured combination for MARS HF communications requirements. The RSP2pro/SDRuno is so easy to configure and use that I had mine installed and working within a few minutes to include interfacing with MARS-ALE for CAT control of the RSP2pro for ALE scanning.

However there are a number of caveats involved in best configuration where certain details are not found in the current SDRuno documentation. This too is true of using SDRuno to create IQ .wav files which I have detailed in a separate document.




However having anything but MARS-ALE and the main SDRuno panel active after configuration is just overhead that is not required for our needs. In addition the SDRuno bandwidth should be reduced down to a minimum as the full 10Mhz results in too much CPU loading for our needs.

Herein the minimum amount of information regarding SDRuno as it pertains to use with MARS-ALE and or MS-DMT shall be detailed. For additional information the SDRuno User Manual (http://www.sdrplay.com/docs/SDRplay_SDRuno_User_Manual.pdf) and Release Notes (http://www.sdrplay.com/docs/SDRplay_SDRuno_Release_Notes.pdf) should read.

In addition I highly recommend reading the SDRuno Cookbook (http://www.nn4f.com/SDRuno-cookbook.pdf).

Although other software can be used with the RSP2pro, herein we shall only focus on the use of SDRuno. It must be noted that the SDRuno software as well as drivers are often updated to address issues and to add new features. They are also continuously developing SDRuno, which for the last 6 months was v1.13, where I had started with v1.12 and just recently v1.2 debuted, however the focus of this document at present is v1.13 until I have time to learn the differences with the new release.

As a matter of fact I have requested a number of new CAT control features so that I can pre-configure SDRuno at MARS-ALE start for our needs. Until such time those additional CAT commands are implemented manual configuration of SDRuno shall be required.

## TXCO CALIBRATION

The 0.5ppm TCXO provides for a very accurate and stable unit and I would leave it alone until an issue comes about.

However you can adjust it down to 0.01ppm via the SDRUno v1.1 and later software using the auto calibrate feature when tuned to WWV or another accurate time source signal.

The process requires the use of SAM mode and then going to “RX CONTROL” and selecting “SETT.” And then “CAL” and hitting “Auto CAL”. This will then calibrate the RSP2 series receiver.

## CAT CONTROL

Similar to the MARS-ALE REM Port support, SDRuno emulates the KENWOOD CAT commands for RS-232 remote control. This will require use of a Virtual Serial Port (VSP) pair between MARS-ALE and SDRuno for radio control. At present for HAGR application I have been using the SDR1000 selection in MARS-ALE, however an RSP2pro HAGR specific selection shall be added.

In SDRuno as seen in the image below, click the “SETT” button upper left of the “RX CONTROL” panel and select “CAT” which provides access to the “RECEIVCER/TRANSCEIVER EMLATION” dialog. Then select the “COM DEVICE” com port (one side of a VSP pair such as VSPmgr etc.) that will be entered into MARS-ALE as the radio com port. Then next select the “BAUD RATE”. Then click the check boxe’s “ENABLE & CONNECT” and “RX MODE CTRL”.

Also in SDRuno on the “RX CONTROL” panel select “USB” as the mode, 3000hz filter (which we shall tweak) and “NBOFF”.

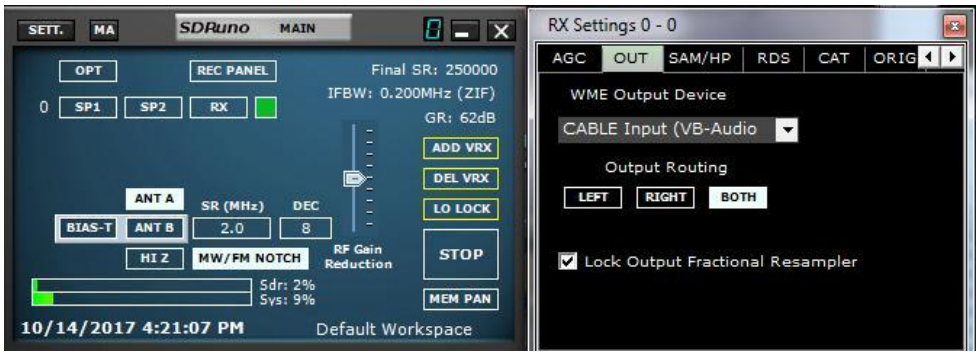

In MARS-ALE select ‘FLEX3000” as the radio type for now and enter the other VSP pair as the “Radio 1 Com Port”.

## AUDIO CONFIGURATION

SDRuno as with any SDR software requires the use of a Virtual Audio Cable driver to pipe the audio to another application such as MARS-ALE.

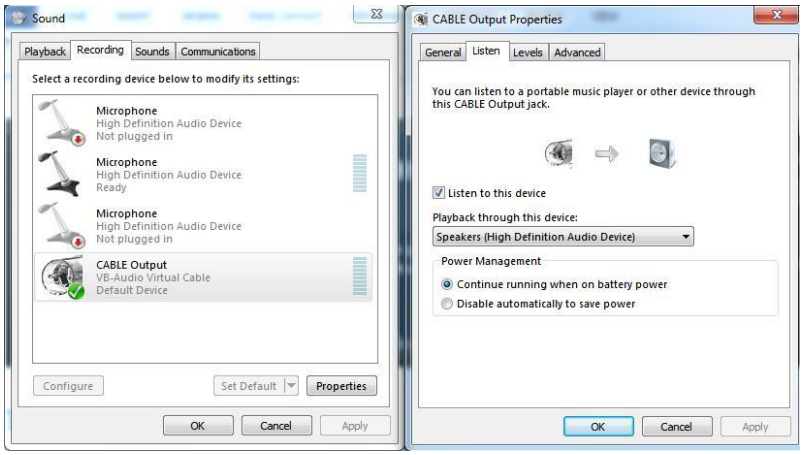
I have found VB Audio Virtual Cable (http://vb-audio.pagesperso-orange.fr/Cable/index.htm) which I already used for my modem development and testing needs to work very well with SDRuno in feeding MARS-ALE and MS-DMT.

In SDRuno from the "MAIN" window click "RX' to open the "RX CONTROL" and then click "SETT," and then click "OUT". Then for the "WME Output Device" select your choice in VAC, here I have selected VB-Audio Cable. Although not required for communications use where "LEFT" would suffice as that's all we currently use since are not supporting ISB. However I select "BOTH" for the "Output Routing" for when I want to use head phones in particular, it also sounds better for the computers speakers which I will explain soon. Lastly on this dialog select the check box for "Lock Output Fractional Resampler".




In MARS-ALE and MS-DMT you need to select your VAC output, in my case the VB-"Audio Cable Output" as the PCSDM input. You could also make the VAC the system default sound device as we are only talking RX with the RSP2pro receiver. There are some advantages in do this as some software used for audio recording just do not support other than the default sound device.

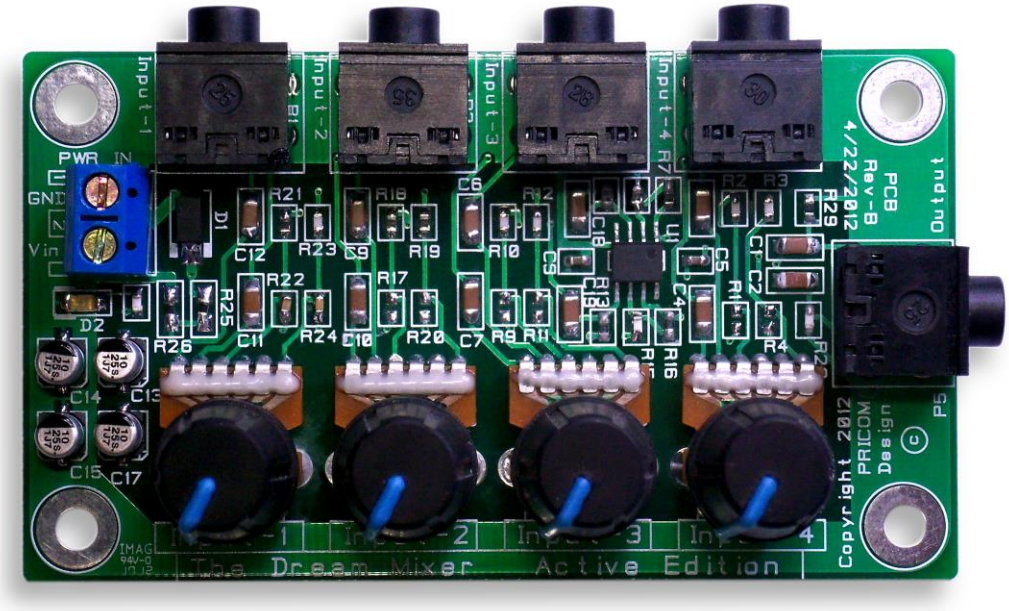
When it comes speakers and headsets you need to select "Listen to this device" for your VAC output on the Windows Sound Control panel following the path "Recording" to "Advanced Properties" as seen below.



However, unlike most users, I also have the need for analog audio to feed external hardware modems and other devices in my development efforts. Should anyone else have such needs I replace use of the VAC with a high quality PC sound device in a loopback configuration where either a passive or active audio mixer is used to breakout the audio.

The Pricom Dream Mixer passive (http://www.pricom.com/Trains/PassiveMixer.shtml)


and active (http://www.pricom.com/Trains/ActiveMixer.shtml) models are inexpensive and provide excellent results. In working with SDRuno I have only found the need of the passive mixer board.



## COMMUNICATIONS CONFIGURATION

The SDRplay RSP2 series can display a lot of RF Spectrum if your computer is up to dealing with the bandwidth being provided. However we are interested in Communications Receiver use of the RSP2pro with the best receiver characteristics.

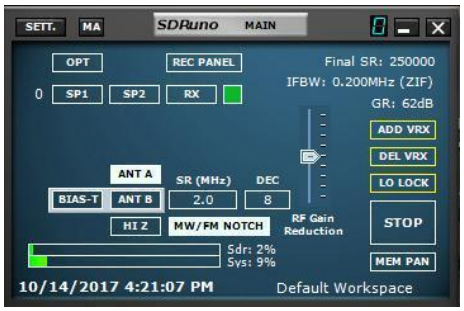
**NOTE: The more bandwidth configured and being displayed in SP1 the more system loading. Thus the minimum sample rate and maximum decimation should be used. In addition the SP1 display should be reduced to the minimum bandwidth display using the 2Mhz Sample Rate and decimation of 8 to minimize system loading if an issue on the computer being used. The System (Sys) resources as displayed on the "Main" SDRuno window must be kept low. It system resources rise to high the color range will go into the RED around 90% and SDR performance will become poor. After SDRuno setup if system loading is an issue, closing the SDRuno "Main SP1" window will reduce loading.**

As such we want to reduce the bandwidth on the "MAIN" panel by selecting and "SR" or 2.0 and "DEC" of 8.

**NOTE: The use of a 2Mhz Sample Rate will result in the smallest .WAV file being created given the same length of time spent recording when creating IQ .wav recordings. A full one hour recording at 2Mhz sample rate will only result in one .WAV file at just over 3GB in size. Whereas just 30 seconds at 10Mhz results in a 1GB plus file.**

**NOTE: When already using a higher sample rates it is best to select a Decimation (DEC) value of 1 prior to moving to lower a sample rate, especially if making a big change. If this is not done the selection of a lower sample rate will fail if the decimation value selected is larger than the lower sample rate supports.**

The Decimation (DEC) selection serves the purpose to reduce the active RF bandwidth by taking the data collected at an oversampled rate and then systematically reduces the sampling rate down to a lower bandwidth which improves the instantaneous dynamic range. This process of increasing the dynamic range is called "processing gain".

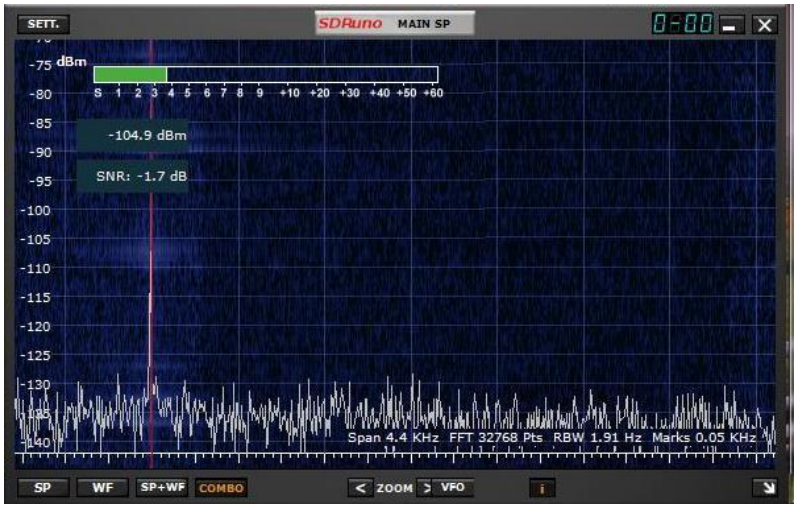



When DEC is at 1 as viewed on the "Main SP" (SP1) window when SP1 zoom is at its minimum affect the bandwidth span displayed will be at its maximum for the selected Sample Rate (SR) if the SP1 window is opened wide enough. The DEC selection of 2 will cut the SR selection bandwidth displayed on SP1 in half. Each successive DEC selection presented for the given SR selection will likewise act as a divisor in determining the provided RF bandwidth. The higher the SR the more DEC selection options.

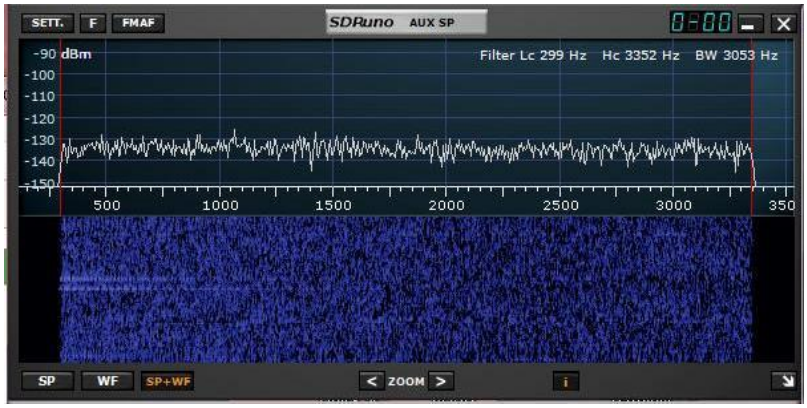
It is also best to always have "MW/FM NOTCH" enabled. The factory gain settings I have found to work the best, so return to them with a reset if you have changed them.

**NOTE: As an FYI, any time the use of "Reset Default Settings" is made, it will reset all settings of the currently active SDRuno version and any other installed version. This includes all saved Work Spaces.**

You want to open "SP1" and "SP2" and on SP1 click the "Zoom" greater arrow located between the word Zoom and the VFO until you can't click it anymore. In the image below this has resulted in a front end span of 4.4kHz.




Then on "SP2" we select our desired IF BW where the best results for MS110A is the full range of 300-3300hz. We do this by clicking the "Zoom Greater Arrow" at least once, twice provides a better view. Then click on the lower passband skirt, a vertical RED line to the far left, and drag it to the right until the "Filter LC" is just about 300hz, in the image below it is set to 299hz, as close as I could get. Then click the upper passband skirt and drag it to the right until "BW" reads at least 3000hz, I like 3050hz myself as we are talking IF DSP filtering here. In the image below BW is set to 3053hz as nailing the exact number desired is not always possible.




When intercepting an MS110A transmission the "SP2" window is the best to view as to the transmitting stations signal quality if in attended monitoring. We are looking to see the sending station with a bandwidth of at least 2.8kHz and no more than 3.0kHz displayed in our passband. As seen in the image below the sending station was making the grade at just about 2.8kHz on a channel with Multipath/Fading that was easily handled by MS-DMT resulting in perfect copy.

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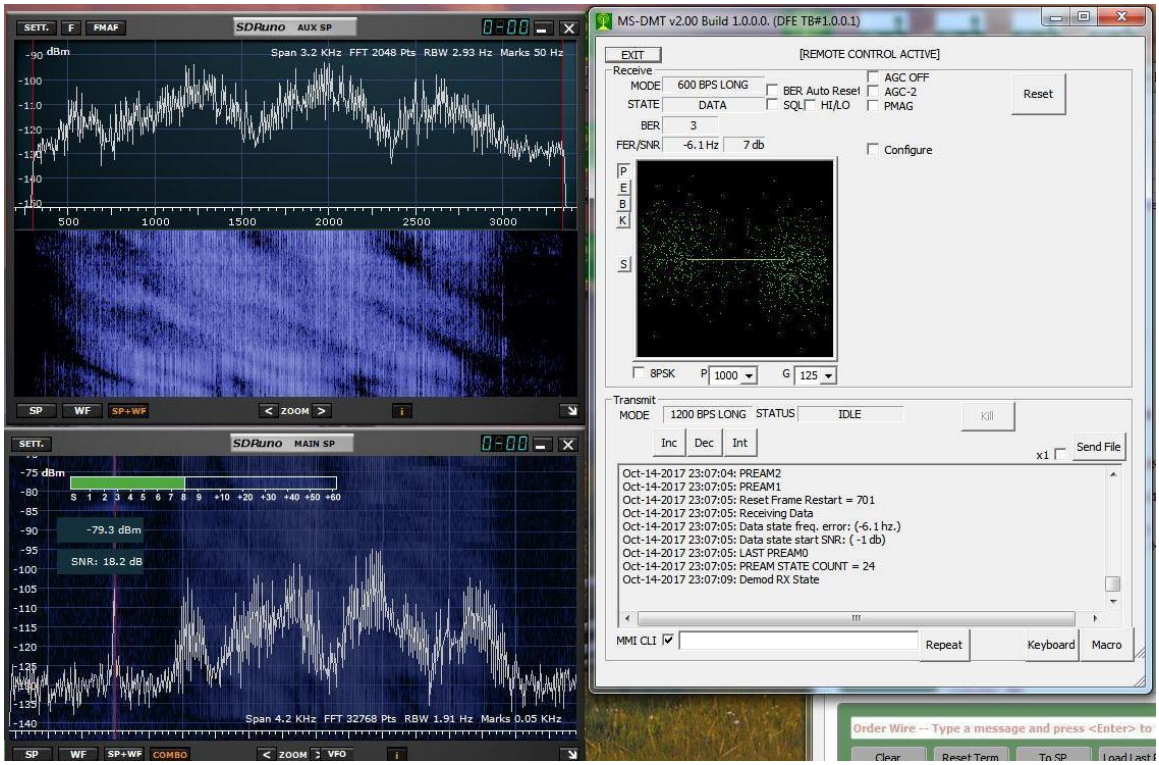


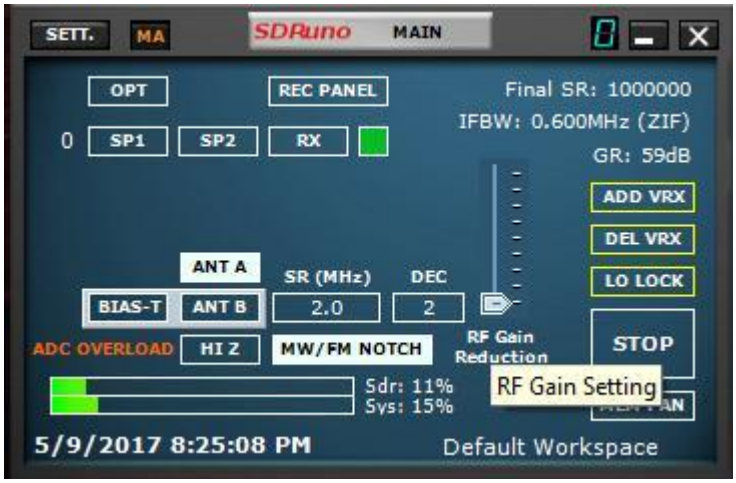
## FRONT END OVERLOAD

The RSP2 series are capable of a goodly amount of RF Gain and the better the antenna used the more possibility there is of receiver Front End Overload. Then too the higher the Sample Rate selected and thus resulting bandwidth streaming the more possibility of overload on a broadband antenna.

There is an "ADC OVERLOAD" indicator that is displayed in RED next to the [HI Z] antenna selection if you are overloading the ADC.

The gain can be reduced as one option to address ADC Overload if the AGC is set to automatic.

Other options are to increase Decimation (DEC) or reduce Sample Rate (SR) if either possible with respect to their current settings. It is best to increase DEC before reducing SR as if the DEC with a larger SR is set higher than DEC values exist at the lower SR no change may take place. Thus the SOP should always be to set DEC to 1 before decreasing SR, especially if making a large change where for example an SR of 10 changed to SR of 2 is the largest change.




The factory gain settings are a good starting point that I have found to work well out of the box. A return to them and all factory parameters can be had with a system reset at any time, however everything is reset.

The approach that I have taken is to setup the RSP2pro RX to match the RX performance of my newest transceiver with both setup to 14Mhz using my Shakespheare 393 Marine Whip antenna which I use the most for monitoring all of MF/HF and these days mostly as my two-way comms antenna as well.

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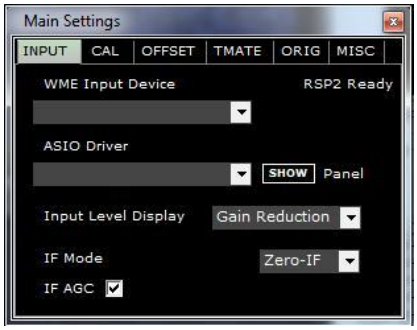


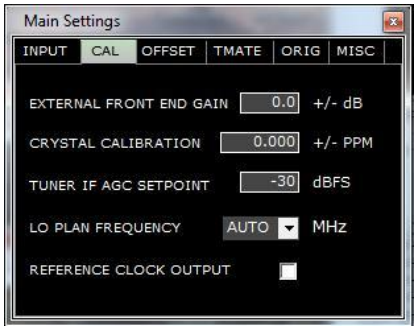


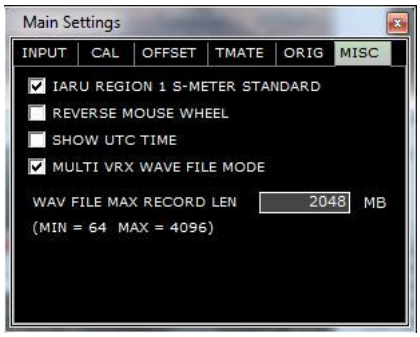

MULTIPLE VRX

We only want to have one “VRX” active as we are only focused on scanning one ALE network.

However if you have enough PC resources and configure all the required VAC’s and VSP’s and can handle multiple instances of MARS-ALE and or MS-DMT, you may be able to monitoring multiple ALE or single channel traffic nets, but it is not recommended.

## ADDITIONAL RSP2pro APPLICATIONS

In additional to being a dedicated HAGR receiver, the RSP2pro can be configured to provide a conventional HF SSB transceiver with an SDR based Panadapter display capability and still be used for MS110A decoding when desired.

In addition, the RSP2pro can be mated with a HF SSB transceiver for T/R operation in a split Receiver/Transceiver configuration to make use of HF transceivers which are challenged by PA Spectral Purity filter relays during ALE scanning. In both cases the RSP2pro with its metal case is the better choice over the RSP2 in T/R operation.

### Panadapter Operation:

For Panadapter operation with a conventional HF SSB transceiver some make/models of transceivers make Panadapter operation easy by bringing out an IF port on the radios rear panel. However most make/models of radios will require the end user to apply the Do-It-Yourself (DIY) approach in such interfacing. When taking the DIY approach some radios may require the addition of a buffer amplifier. The use of a short length of double shielded cable is highly recommended.

The use of the RSP2pro as a Panadapter requires interface configuration with the software chosen to track the transceivers operating frequency for proper pan display. Anyone interested in Panadapter use of their RSP2 should research what others may have already documented on the subject via the Internet. SDRuno version 1.13 which adds the much requested 'IF Out' facility for Panadapter use.

### T/R Operation:

The prospect of T/R operation with the RSP2pro married to an HF transceiver is something that I plan to explore in MARS-ALE as it would address the issue of PA spectral filter relays for radios with such where no QS/S hardware modification exists. Then too using it as an optional selection in MARS-ALE would eliminate the need of using the QS/S Split VFO approach with radios that support such and its overhead and timing challenges.

For T/R operation in a split Receiver/Transceiver configuration MARS-ALE will need to be modified to support the RSP2pro as the receiver and the end users choice of HF transceiver as the transmitter. The use of SDRuno is an obvious approach, however it may also be possible to add direct RSP2pro support via the SDRplay RSP Application Program Interface (API), however I do not know when I will be able to make time for that pursuit.

In either case, but starting with use of SDRuno first, on the TX side I envision providing a selection to enable use of the RSP2pro support with existing transceiver support selections. This operation will be similar to the existing ICOM/ICOM selection in operation. I also plan to support the RSP2pro via the MMI Radio and coming DDL-RADIO interface to permit end user support of any transceiver with an RSP2pro receiver pairing.

The use of a T/R switch rated to 150 watts which can be hard wired keyed is also required. The least expensive such COTS unit that I located in kit form was the “Easy TR Switch” which was recently reviewed in the February 2017 edition of QST. The unit can be purchased from:

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http://www.qrpkits.com/ezseries.html#eztrsw

Documentation for the unit complete with schematic can be found at:

http://www.qrpkits.com/files/EasyTRSW20170325.pdf

The spare set of contacts should be wired so as to short the RSP2pro antenna port close ground through a 10 to 100 ohm resistor when the unit transitions from RX to TX.


A suitable shielded enclosure for the TR Switch is required if not mounted inside the transceiver, which few would likely do. The least expensive selection of suitable enclosures that I found are those available from:

https://www.specialtybottle.com/metal-tin-containers/hinged/thn4?gclid=EAIaIQobChMIk_flqp_B1wIVVT2BCh22OAgoEAQYASABEgISNfD_BwE

The through hole approach with the Teflon coax cables vs. chassis connectors would the best approach.