

Prototype EMWIN Receiver Station Design And DLL User's Manual

This document describe NOAA's "prototype" software based receiver, designed to support the DFSK modulation employed in the existing EMWIN-I broadcasts as well as the new BPSK modulation that will be employed in the next generation EMWIN-N broadcasts. The document consists of three sections, 1. Prototype EMWIN Receiver System Description, 2. Configuration Parameters for the NOAA provided executable software modules, and 3. Prototype Receiver Setup. This document provides design information that may be useful for developing relatively low cost EMWIN receiver stations, especially those that can employ the NOAA provided executable software or Data Link Libraries (DLL's). This document may also serve as a basis for a users guide for receivers that incorporate these DLL's .

Subsequent versions of this draft document will be provided based on user and vendor feedback.

1. Prototype EMWIN Receiver System Description

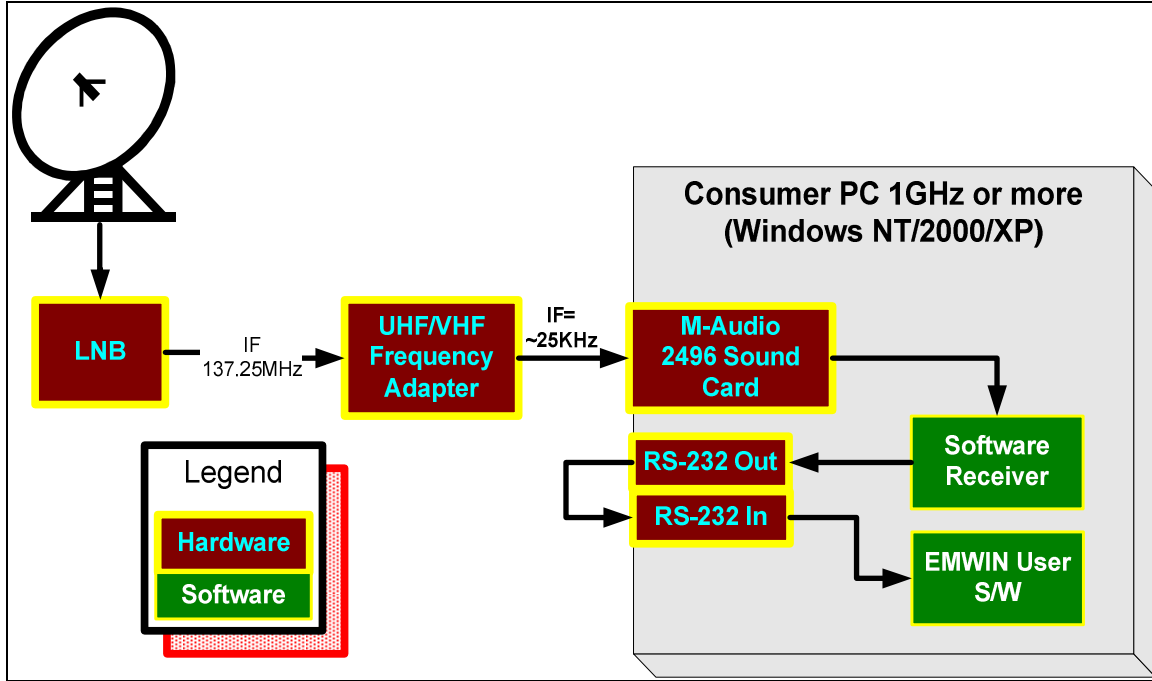


Figure 1 EMWIN Receive Station Overview

EMWIN Prototype Receiver Station Specifications

The EMWIN Receive Station described herein was developed as a prototype dual purpose station to satisfy both existing (i.e., GOES I-M) and future (i.e., GOES N-P) broadcast requirements and is designed to facilitate transition from EMWIN-I to EMWIN-N. The user data format, content and basic capacity will not change appreciably between the existing and new broadcasts. The major EMWIN receiver characteristics for the existing and new systems (i.e. EMWIN-I and EMWIN-N) are summarized in the Table 1.

Table 1, Major EMWIN Receiver Characteristics

Characteristic	EMWIN I-M	EMWIN N-P	Comment
Receive Frequency	1690.725 MHz	1692.700 MHz	Dual frequency capability will facilitate operational cutover during the transition phase
G/T	-0.3 dB	-0.3 dB	Since this characteristic has not changed, the existing antenna, and perhaps the LNA, should be reusable
Modulation	DFSK	BPSK	Dual modulation capability will facilitate operational cutover during the transition phase
Coding	None	R-S, ½ Rate Convolutional	Conforms to CCSDS

As is shown in Figure 1, the prototype receiver employs two additional receiver hardware components which are not typically part of currently deployed EMWIN solutions. The first component is the UHF/VHF frequency adapter, which is necessary to translate the signal into an appropriate interface for the second component, an analogue to digital (A/D) converter. The prototype system has a 137.25 MHz interface on the front end of the UHF/VHF frequency adapter, and an M-Audio 2496 professional grade sound card to perform the A/D conversion. The UHF/VHF frequency adapter currently has no commercial equivalent source.

The EMWIN receiver will perform the typical RF and IF functions as well as the demodulation and data recovery functions required for reception and display of the satellite broadcast data. The prototype software based receiver employs software to perform the demodulation and data recovery (i.e. decoding) function. The software or Data Link Libraries (DLL's) are executables designed to run on a conventional PC running Windows NT/2000/XP (e.g., Pentium IV) leaving sufficient capacity to run additional EMWIN display and data management software. The DLL's should also run under Windows 95/98/Me in a debug or console mode. The G/T of the antenna should be at least -0.3 dB which is the same requirement for both EMWIN-I and EMWIN-N. The low noise amplifier (LNA) has a noise figure of less than 2 dB. The LNA RF output down converts the RF frequency to an IF frequency of 137.25 MHz. The VHF EMWIN IF converter amplifies the IF signal sufficiently to interface with the Analog to Digital (A/D) converter which was designed to have nominal output signal of -10 dBm. All of the down conversion parts employ oscillators which have a frequency stability of at least 5 ppm. The A/D converter

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converts the analog IF data to a digital format. This converter has a pass band of > 40 KHz, a sampling rate greater than 96 kilo-symbols per second (KSPS) and a bits/sample rate of 16.

The prototype system uses a 1.2 Meter Andersen dish with a Quorum down converter to 137 MHz. The output of the Quorum down converter feeds into a UHF/VHF frequency adapter designed to amplify, filter, and frequency translate the signal to be compatible with a commercially available sound card. The sound card is an M-Audio 2496 sound card which is capable of sampling at 96 KSPS and has an analog bandwidth of approximately 48 KHz. It is important that the sound card have a frequency response near 48 KHz, since the new BPSK signal will occupy a bandwidth of over 22 KHz. The additional frequency allowances are necessary to accommodate frequency tolerances within the down converter signal chain. Many sound cards advertising a 96 KSPS sample rate may not have a frequency response covering the full 48 KHz, and must be verified if a different sound card is to be used instead of the one specified here.

Data Link Library (DLL) Input Summary

A/D Converter (e.g., sound card)

Sample rate of > 96 Ksps

16 bits per sample

TCP/IP socket output

48 KHz bandwidth

Data Link Library (DLL) Output Summary

FSK:

Output Data (demodulated FSK bitstream)

TCP/IP Socket (data only, no start/stop bits)

RS-232 Serial Output (V.35, 9600 baud, 8, N, 1)

Effective Data Rate: 7680 bps

BPSK:

Output Data (demodulated, CCSDS processed bitstream)

CCSDS Error Detection and Correction

CCSDS CADU, VCDU, BPDU Wrapper removed

TCP/IP Socket (data only, no encapsulation)

RS-232 Serial Output (V.35, 19200 baud, 8, N, 1, gaps inserted)

Effective Data Rate: 9537 bps

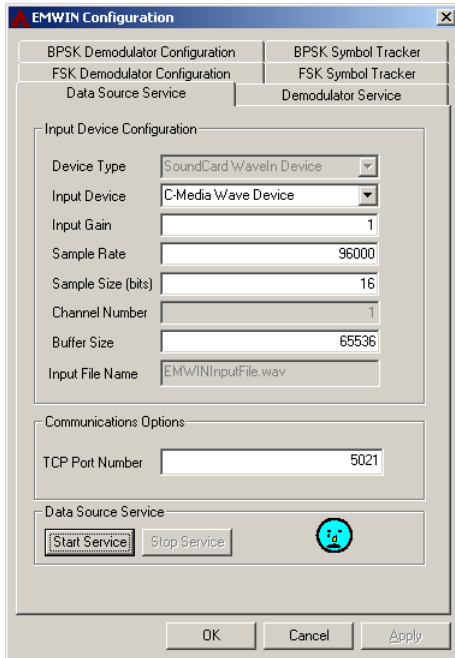
EMWIN-N Coding and Data Format

The Convolution Code follows the CCSDS recommendation and has been selected to be the same as the LRIT broadcast. The code parameters are: Rate = $\frac{1}{2}$, Constraint Length = 7, no G2 Symbol Inversion. The Interleave Depth follows the CCSDS recommendation and has been selected to be the same as the LRIT broadcast. The Interleave is depth is 4. The Reed-Solomon Code Descriptors and Symbol Size Code follow the CCSDS recommendation and have been selected to be the same as the LRIT broadcast. The CCSDS Reed-Solomon (255, 223) corrects 16 symbol errors per interleave. There are 255 total Bytes per interleave (prior to virtual fill), 223 input Bytes (prior to coding) per interleave, and 32 Reed-Solomon check symbols per interleave. The CADU contains 8192 bits (including 32 bits ASM and 1024 Reed-Solomon check symbols); 4 interleaves with 892 data and 128 check symbols.

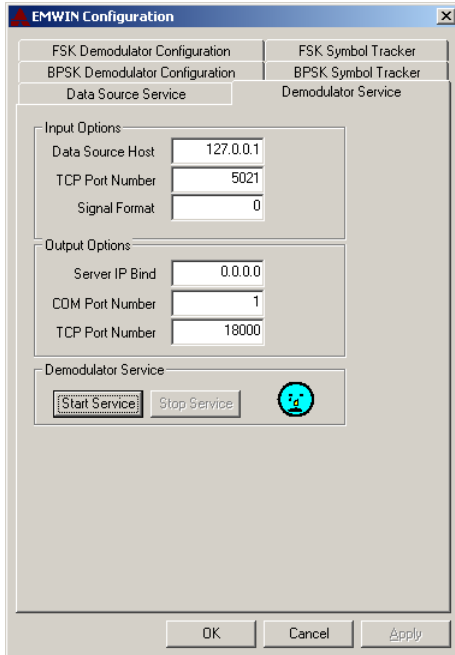
2. Configuration Parameters

Common Parameters:

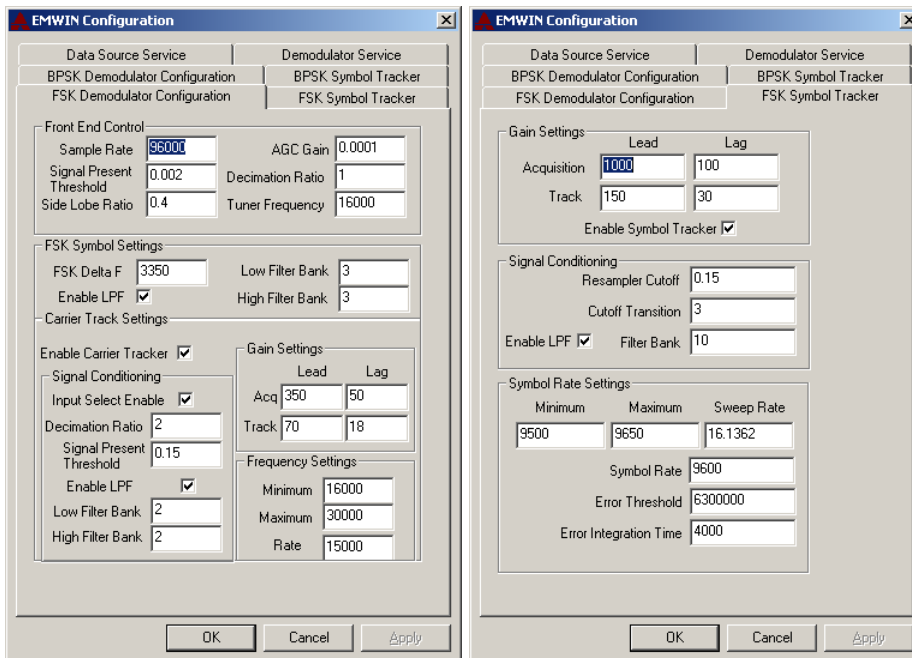
The following property sheets show the available options for both EMWIN-I and EMWIN-N services. The data source service controls the service which controls the input from the A/D converter, and pipes the data across a sockets interface. The Data Source normally will run as a service in the background of windows and will automatically start up when windows is booted. The only items to note is the status of the data source service as indicated by the icon on the control panel, which in the included picture shows that the service is not running but is installed. The only item which will normally be configured on this screen is the TCP port number, which will be initially set to 5021.



The next screen shows the demodulator service settings, which controls the included demodulator service. After installation, this screen will show the status of the demodulator service, which when operating normally will show a smiley face. The normal user configurable items will be the IP address of the data source server, and the IP port number (which needs to match the port number for the data source server), the signal format (either 0-FSK or 1-BPSK), and the serial port number. The serial port number is used to output the decoded bits in a format compatible with current generations of EMWIN software. Alternatively an output to a TCP connection is also possible, which is specified by the outbound IP address.



FSK Control Settings



Sample Rate

The front end sample rate needs to be set to the nominal A/D sample rate. Under normal circumstances, the A/D sample rate will be 96 KHz for a sound card solution. If the parameter is different, then it needs to be set accordingly. It is stressed that the minimum

sample rate needs to be high enough to capture the entire bandwidth of the full signal. For normal circumstances, the minimum A/D needs to be set at 96 KHz or higher. The units of this parameter are in hertz.

Signal Present Threshold

This setting determines the threshold which is used to indicate whether a valid signal is being presented to the demodulator. The parameter is specified in terms of full scale voltage. The default setting is 0.002 or 0.2 % of full scale (voltage), or -54 dB from full scale.

Side Lobe Ratio

The side lobe ratio setting is used to determine whether or not the demodulator appears to be tuned to a modulation side-lobe instead of the real signal. The side lobe detector compares the RMS voltage presented at the front end of the receiver, to the RMS voltage at the backend of the low and high side “tuners” (essentially matched filters for the 0 and 1 symbols if everything is ok). If the observed ratio is not at least as high as the value set by this parameter, then it will be assumed that the signal is not locked onto the correct frequency, and the receiver will be forced into acquisition mode. This parameter is expressed as a linear ratio in the voltage domain.

AGC Gain

The AGC gain is the gain bandwidth setting. The value listed corresponds to about a 10 Hz bandwidth at the given input sample rate, which is near the minimum. If for some reason a users terminal experiences faster fading (which is not expected for stationary installations), then this parameter can be adjusted to a larger bandwidth setting to improve the response of the receiver if required.

Decimation Ratio

The decimation ratio is used to decimate the input to be compatible with the bandwidth of the signal. For sound card solutions, it is set to one. The implementation of the decimation filter is not without computational burden, and as a result, it is currently disabled in the version 1.0 release. If required to decimate the front end samples, it can be enabled for users wishing to sample at a higher frequency.

Tuner Frequency

This parameter specifies the initial tuner frequency, and represents the frequency as seen by the A/D converter. The nominal center frequency has been designed for approximately 25 KHz, which is in the center of the pass band of the software receiver using the illustrated sound card. This parameter normally should be set to a value which is near the observed frequency to speed signal acquisition time. It is also used as the tuner frequency set point if one disables the automatic carrier tracker function.

FSK Symbol Settings

FSK Delta F

This setting determines the FSK symbol frequency spacing in Hertz. In the example, the FSK symbols are spaced approximately ± 3500 Hz for the 9600 baud EMWIN downlink.

Low Filter Bank

The low filter bank controls the low frequency filter bank setting for the low frequency symbol. Valid numbers range from 0 to 19, which correspond to approximate bandwidths of {4800, 6240, 7200, 8160, 9600, 12000, 14400, 16800, 19200, 21600, 24000, 26400, 28800, 31200, 33600, 36000, 38400, 40800, 45600}.

High Filter Bank

The high filter bank settings are identical to the low filter bank settings, except they apply to the high side symbol.

Enable LPF

This enables or disables the filtering function for the low and high side filter banks. This setting needs to be enabled for normal operations, and should only be used for debugging purposes.

Carrier Track Settings

Enable Carrier Tracker

This enables or disables the carrier track loop.

Decimation Ratio

This reduces the number of samples processed by the carrier tracker loop.

Signal Present threshold

This value used to determine whether a signal is present in the mark and space signals relative to the input level.

Enable Low Pass Filter

This enables a low pass filter to eliminate unwanted noise into the carrier tracker.

Low Pass Filter Bank

This sets the bandwidth of the low pass filter.

Acquisition Lead and Lag Gain Settings

This determines the effective carrier tracker bandwidth during acquisition. Higher numbers increase the carrier tracker bandwidth, and represent parameters in a lead-lag 2nd order loop. Normally, the ratio between the two should be kept near constant.

Track Lead and Lag Gain Settings

This is similar to the previous setting, except these are used when the receiver determines that the signal is in a tracking state.

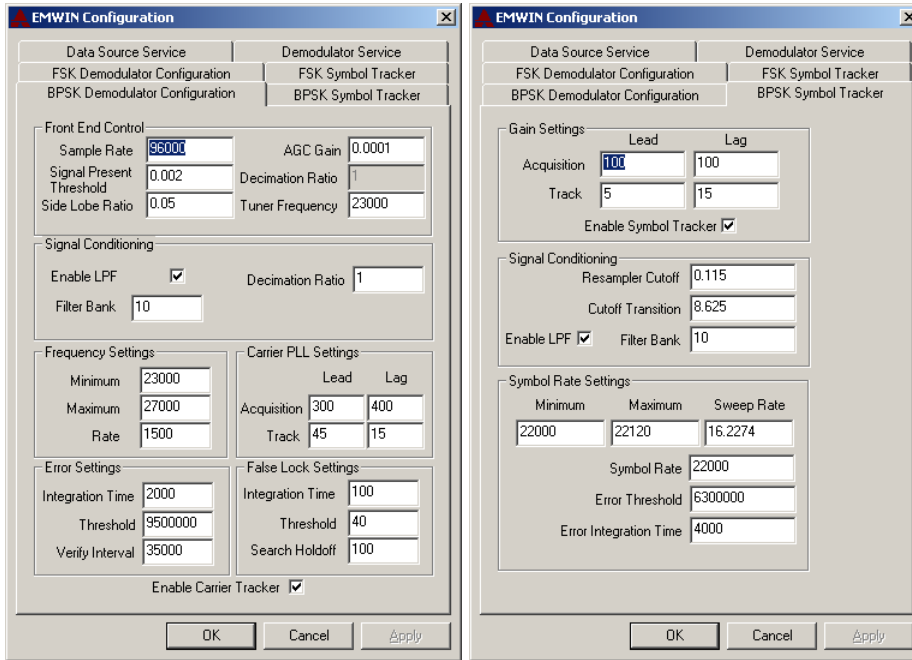
Frequency Minimum and Maximum Settings

This sets the minimum and maximum frequency (in A/D space) which the receiver will search for the signal.

Frequency Sweep Settings

This determines how fast the signal will sweep across the pass band frequency when in acquisition mode.

BPSK Control Settings



The following icons are used to display the status of both the Data Source and Demodulator service status. The meanings are as follows: service running normally, service either starting up or shutting down, service not running and service not installed.



3. Prototype Receiver System Setup

1. Connect the signal from the 137 MHz downconverter into the input of the VHF frequency converter box.

2. Connect the output of the UHF frequency converter box into the line input of the M-Audio sound card.
3. Verify that the sound card has a valid signal. Since the signal will be ingested by the sound card, first determine that the signal is present by looking at the signal at the soundcard input. For the M-Audio 2496 installations, the control panel applet which comes with the sound card displays the current input line level, which is where the signal will appear. If there is a signal present, then the display can be used as a signal strength meter to help with setting up the antenna. A more capable program <http://audacity.sourceforge.net/windows.php> is able to record and display the “spectrum” of the input signal, which will verify that the signal appears to be centered in frequency.
4. The demonstration system used required 2 serial ports to ingest the signal, as well as a RS-232 loop back cable. Connect the loop back cable from serial port 1 to serial port 2 using a DB9 to DB9 connector. The reason that this was required was to enable the software which was written with serial port support to be able to work without upgrades or modifications.
5. The default settings for the software demodulator are contained in the EMWINSettings.reg file distributed as part of the installation package. Double click on this file (must have administrator privileges) to reinstall the default settings into the registry. Normally, only the serial port number will need to be reconfigured. The application is configured through the supplied control panel applet.
6. Restart the machine or alternatively restart the two services making up the demodulator.
7. The next step is to be certain that the parameters are setup correctly. Use the control panel applet and this document as a guide. These settings contained here will be set as the defaults for initial installs.