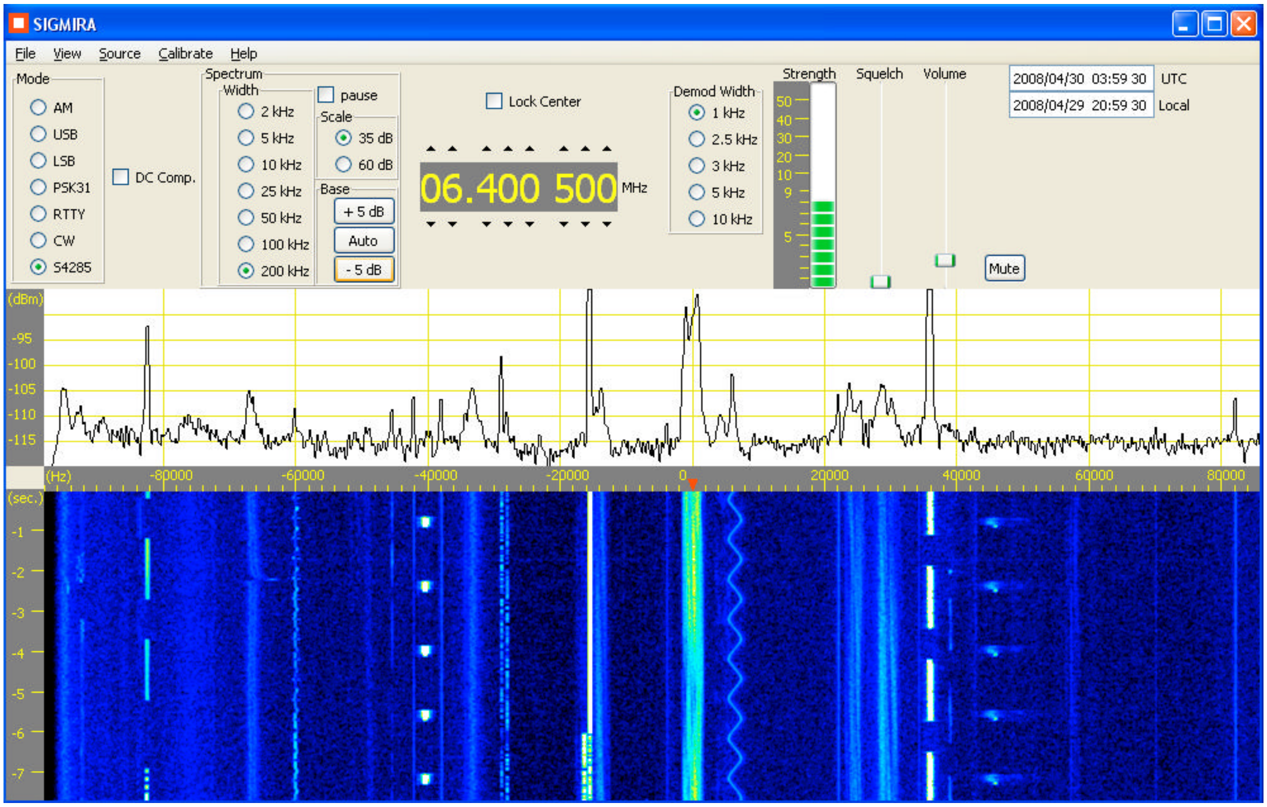
Sigmira 1r5

Operations Manual



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1 Introduction

Sigmira™ is a Software Defined Radio (SDR) application program that runs on Windows. It operates with the RFSpace SDR-IQ™ and SDR-14™ receivers or with an external conventional receiver. Sigmira offers wideband spectrograph and waterfall displays. It also demodulates various "Ham" radio and military signals.

Its features include:

- "Waterfall" and spectrograph displays of up to 200 kHz width with the SDR-IQ™ and SDR-14™.
- Demodulation of PSK31, FSK, SITOR-B, CW, and NFM modes.
- Demodulation of NATO STANAG 4285.
- Demodulation of the "Japanese Navy Slot Machine" to QPSK symbols.
- Point and click signal selection/tuning.
- Signal database with automated tuning and logging.
- Playback of saved .wav files.
- Phase plane display.
- 16 bit sampling. Typical sampling rate: 48 ksps.
- Signal strength meter.
- Adjustable squelch.
- Clock display with UTC and local time.

The distribution package includes examples of PSK31, RTTY, SITOR-B, CW, NFM, JSM and STANAG 4285 signals in .wav files.

http://www.saharlow.com/technology/sigmira

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2 Program Installation

If you already have Spectravue installed and working then the necessary drivers are already in place for the SDR-IQ™ and SDR-14™.

If you are about to start the SDR-IQ/14 for the first time, install Sigtools first. That way the necessary drivers will be available when Windows asks for them.

Sigmira is distributed in the executable self-installer 'sigtools_1r8_installer.exe'. To install Sigmira simply run the installer.

(On some machines a pop-up window will appear asking if a .bat script should be allowed to run. If that happens click 'Allow' and see section 8 - Program Installation Details.)

Connect the SDR-IQ™ to your PC with the USB cable. If Windows asks for a driver for the device tell it to find the drivers in the <sigtools install root>/drivers. (The drivers are from Future Technology Devices International, Ltd. [FTDI] and are also available from their web site. http://www.ftdichip.com/Drivers/VCP.htm)

The nicer features of Sigmira are available when it is used with the SDR-IQ™.

Instructions on connecting a conventional radio receiver are given in section 6. Connecting a receiver is not necessary in order to use Sigmira with .wav files. See section 7.

3 Controls and Displays

3.1 Waterfall Display

The waterfall display displays a time history of the signal spectrum. It is also used to select which signal to demodulate.

The waterfall display is the bottom third of the window. Higher frequency components are displayed to the right. The strengths of the frequency components are represented by brightness/color. The display shifts down with time so that the most recent signal content is displayed upper most. The display has a frequency scale along the top and a time scale along the left edge.

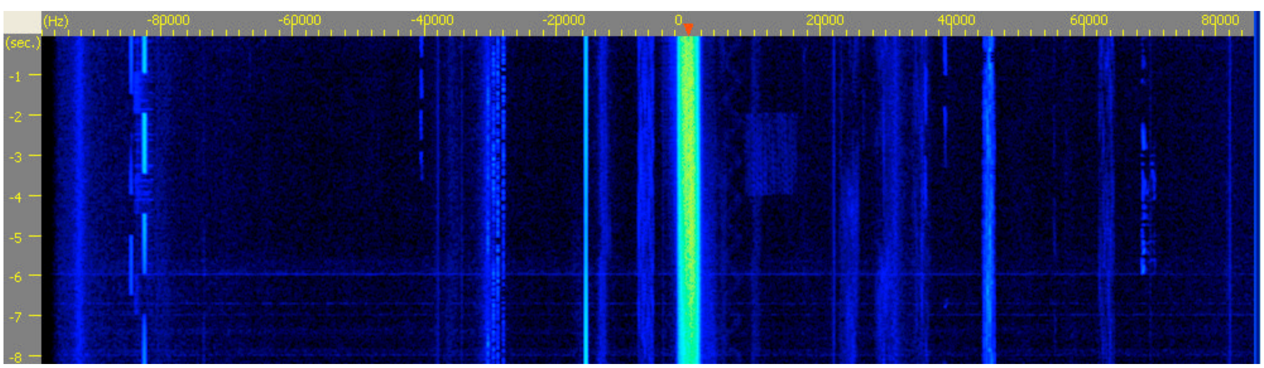

Figure 1 - Waterfall Display

The frequency scale is in Hz and is relative to the center tuning frequency. The frequency span of the waterfall display is adjustable with the "Spectrum" "Width" controls. There are also controls to pause the waterfall and to adjust the scaling of the display intensity level.

The scroll rate is adjustable. Move the cursor into the time scale on the left and roll the mouse wheel.

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The waterfall display is also used to select which signal to demodulate. RTTY, PSK31, and CW are all narrow band transmissions. They show as bright vertical bands in the waterfall display. PSK31 and CW transmissions show as single vertical bands. A RTTY transmission shows as a pair of vertical bands. Multiple transmissions may be present on the input and in the waterfall display at one time.

Select the particular transmission to be demodulated by right-clicking on it in the waterfall display.

A little red triangular pointer in the frequency scale indicates the frequency selected for demodulation of the signal. When the 'Lock Center' option is off the select frequency is shifted to the center of the display. When the 'Lock Center' option is on the display center frequency does not change and the red triangle moves to the selected frequency.

When in PSK31 or CW mode right-click directly on the signal. When in RTTY mode two triangles are shown on the frequency scale. The triangle to the right is red and corresponds with the 'Mark' frequency. Right-click on the higher frequency column of the desired signal, i.e. the mark frequency. (It is easier to click on a signal when the displayed spectrum width is narrower.)

With the sound card or wave file selected as the source the maximum waterfall width is 10 kHz.

3.2 Spectrum Display

The spectrum display displays a plot of signal level vs. frequency.

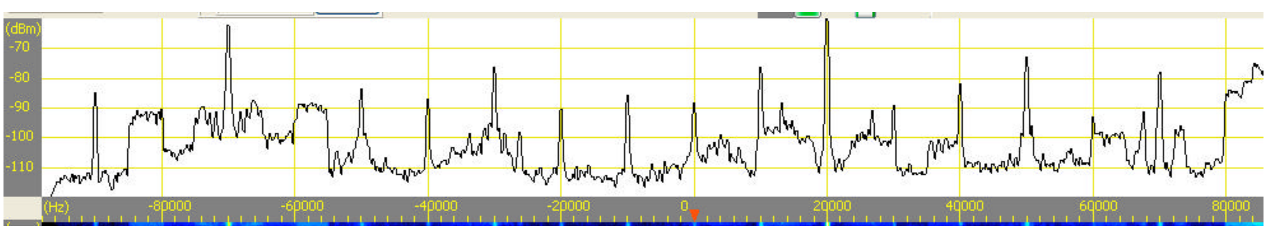

Figure 2 - Spectrum Display

There is a signal power scale at the left of the display. When SDR-IQ is selected as the source the scale is in dBm at the antenna input. When the source is the sound card or a wave file the scale is in dB relative to the full scale internal sample representation.

Tuning/frequency selection can be accomplished by right-clicking on the spectrum display just as on the waterfall display.

The base level of the display can be adjusted with the Spectrum Base controls described in section 3.7.2. The base level can also be adjusted by rolling the mouse wheel while the cursor is in the spectrum display.

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3.3 Rx Text Display

The received text display pops up whenever one of the RTTY, PSK31, CW, or S4285 mode buttons is clicked.

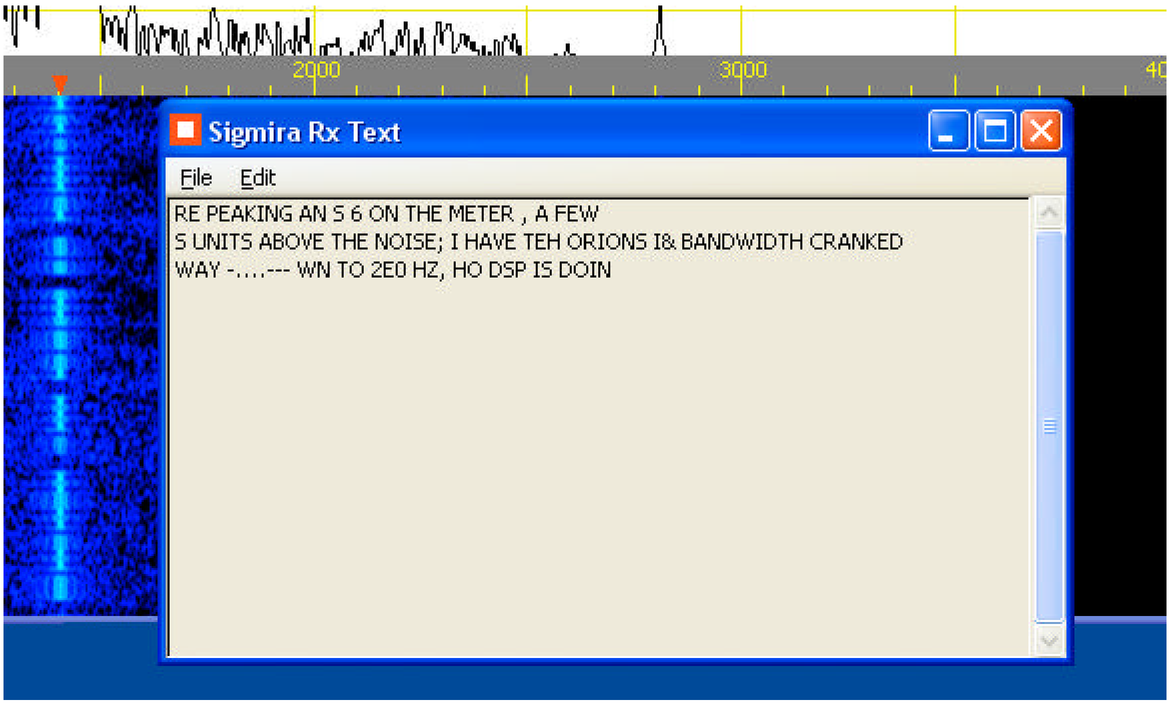

Figure 3 - Rx Text Window

The demodulated text of the selected transmission appears here. (RTTY, PSK31, and CW transmissions all originate as text type messages.)

Received text can be saved by following the File=>Save or File=>Save As menu dialogs.

The text display can be cleared by selecting the Edit=>Clear Text menu item.

Whenever the demodulation mode is changed or the frequency is changed by 100 Hz or more a note is displayed in the Rx Text window.

3.3.1 File->Save/Save As

Selecting Save or Save As brings up a dialog window that can be used to save the received demodulated text to a windows text file. The entire text from the Rx Text window is saved to the file. The default name of the destination text file at start-up is 'untitled'. The name can be changed with the 'Save As' selection. Sigmira remembers any such change to the destination file name. Subsequent 'Save' selections will write to the remembered destination file name. Any save to a file overwrites the previous contents if any.

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3.3.2 Edit Menu

The Sigmira Rx Text window Edit menu has one entry, 'Clear text'. Selecting 'Clear text' clears the received text display.

3.4 Phase Plane Display

The Phase Plane display can be brought up by selecting View->Phase Plane from the main window menu bar.

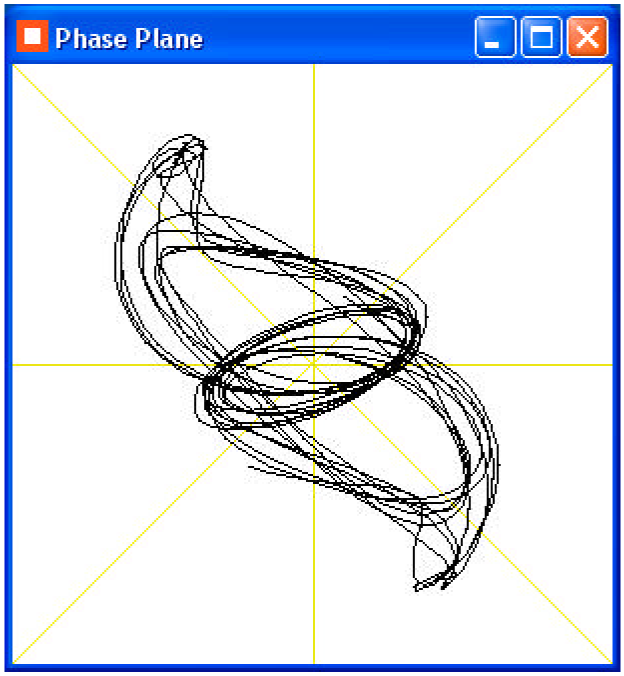

Figure 4 - Phase Plane Window

The phase plane displays the time varying phase and amplitude of the signal. The phase is relative to the tuning VFO. At any instant in time the phase and amplitude of the signal are represented by a point in the display. The amplitude is represented by the distance of the point from the center of the display. The phase is represented by the angle of the point around the center. Positive angle is counter-clockwise. To the right is 0 degrees, up is 90 degrees, left is 180 degrees, and down is 270 or -90 degrees. If a constant amplitude pure carrier of the same frequency and phase of the VFO were being received it would be displayed as a dot to the right of the center. If the carrier were 1 Hz higher in frequency than the VFO the dot would revolve around the center counter-clockwise making one revolution per second.

A Binary Phase-Shift Keying (BPSK) High Frequency Data Link (HFDL) signal is shown in the figure above. In the absence of noise and distortion a BPSK signal would appear as two dots 180 degrees opposite each other with a line between them. Distortion in the radio wave propagation causes the wiggling seen above.

The phase plane display is appropriate for viewing phase modulated signals such as PSK31, STANAG 4285, HFDL, etc. Certainly it is also of interest out of general curiosity. And it is also useful as a tuning and calibration indicator.

An AM signal will generally appear as a line segment radiating from the center of the display. If Sigmira is tuned exactly to the carrier frequency the line will be stationary and not revolve around the center. As mentioned above, if the signal is 1 Hz higher in frequency the line will revolve around the center counter-clockwise at 1 Hz. This makes the phase plane a sensitive tuning indicator. This is useful in calibrating the SDR-IQ. See section 3.16.1.

The phase plane display is functional in all of Sigmira's demodulation modes.

In the AM, USB, and LSB modes the Demod Width setting is effective. In those modes the signal content on both sides of the tuning frequency are processed into the phase plane display (i.e. USB and LSB modes do not cut off the sidebands in the phase plane display.) It is appropriate and advantageous to set the Demod Width to a minimum which includes the signal of interest and excludes outside noise. The Demod Width is the one-sided width. So, if one is viewing a phase modulated signal with a two-sided (total) width of 2 kHz, the Demod Width should be set to 1 kHz.

In the PSK31 mode the Demod Width setting is not important. In addition, the demodulator locks phase with the signal and that is reflected in the phase plane display. With a good signal the displayed phase will bounce between approximately 0 degrees and 180 degrees.

In the RTTY mode the phase plane display is used to instead to approximate the old style RTTY tuning indicators. The 'mark' filter drives the horizontal axis and the 'space' filter drives the vertical axis. The implementation is crude and of limited usefulness in RTTY mode.

3.5 Modes

The Mode refers to the type of signal, AM, USB, LSB, RTTY, PSK31, CW, or STANAG 4285. The mode setting selects which type of signal the program demodulates. The currently active mode is selected by clicking on the particular Mode 'radio button' in the 'Mode' group in the upper left corner of the program window.

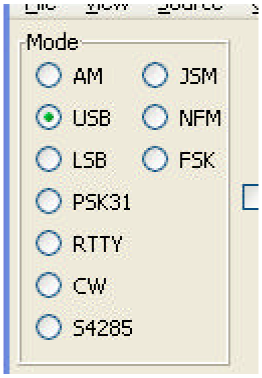

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Figure 5 - Mode

3.5.1 AM

The AM is the usual Amplitude Modulation that everyone is familiar with. AM is typically used to send audio signals. The "AM broadcast band" (also know as MW or "medium wave") ranges from 520 to 1610 (1710 in the US) kHz. International short-wave broadcasters operate on several bands in the 3 to 30 MHz range. AM can also be described as double sideband (DSB) with carrier. AM signals can have various widths, 10 kHz and 20 kHz being common.

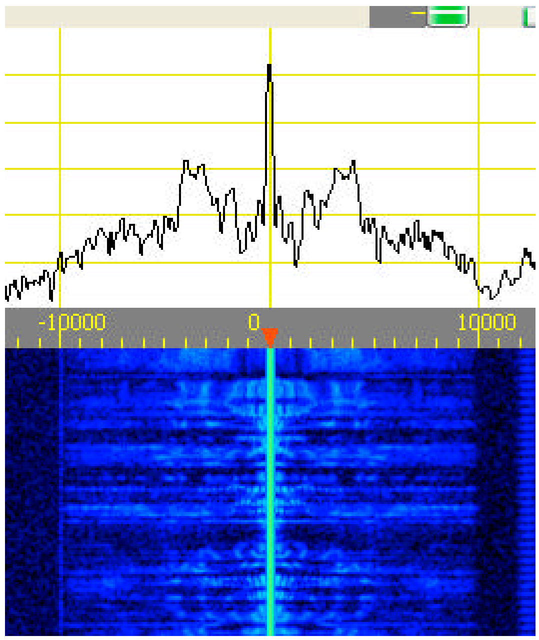

Figure 6 - Typical AM Signal

To tune in an AM transmission click on the AM radio button in the Mode group in the upper left corner of the Sigmira window. Then select the particular transmission to demodulate by right-clicking on it in the waterfall display.

For the optimum signal to noise ratio the demodulation width should be adjust to match the signal. See section 3.8 "Demodulation Width". For the signal in the above figure a demodulation width of 10 kHz would be appropriate.

AM broadcast signals have modulation bandwidths of 5 or 10 kHz, typically.

The squelch control can be used to reduce response to noise. See section 3.11, Squelch Control.

3.5.2 USB

USB stands for Upper Sideband. It is one of the two single sideband (SSB) modes. SSB is normally used to send audio signals. Normal amplitude modulation produces two sidebands, one on each side of the carrier. The audio information is in the sidebands and the sidebands are mirror images of each other. SSB was developed to be more efficient than AM. Only one sideband is transmitted, thus SSB signals are narrower. There are two advantages to that. 1. More signals can be packed into the same bandwidth and 2. the reduced receiver bandwidth allows less noise in with the signal. Typically the carrier is suppressed too which is an additional power savings at the transmitter. The down side to SSB is that demodulating the signal is more complex. The receiver must either reinsert a locally generated approximation of the carrier or use a complex signal and the Hilbert transform. And tuning is critical. If the receiver is tuned to high or low in frequency the resulting audio is shifted up or down giving what is described as a Donald Duck sound.

Since an AM signal has two sidebands there are two choices as to which sideband to transmit for SSB. Thus Upper Sideband (USB) and Lower Sideband (LSB). Hams make extensive use of SSB. By convention they use LSB below 10 MHz and USB above 10 MHz.

The USB or LSB receive modes can sometimes be used for improved reception of a regular AM signal. If there is an interfering signal that affects one sideband of an AM signal more than the other one can use the appropriate SSB mode to demodulate the sideband suffering the least interference. Another case where SSB receive mode can be used to advantage on an AM signal is when the AM signal is experiencing severe frequency selective fading. In instances where the carrier specifically is faded out the sound can be particularly distorted using the normal AM demodulation mode. Switching to SSB significantly reduces the distortion because SSB demodulation does not use the carrier.

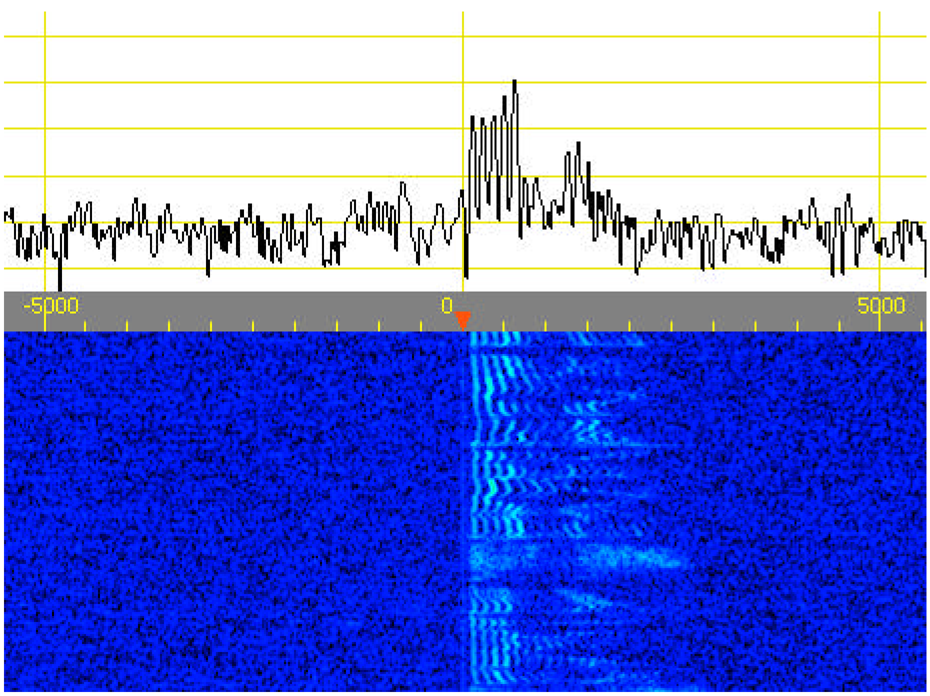

Figure 7 - Upper Sideband (USB)

3.5.3 LSB

LSB stands for Lower Sideband. It is the flip side of Upper Sideband, USB. See USB above.

3.5.4 PSK31

PSK31 is a narrow-band character-based modulation mode used by hams for interactive long distance communication in the HF bands. PSK31 employs Binary Phase Shift Keying (BPSK), Huffman coding, and a low baud rate. Those features are particularly suited to the HF bands which offer over-the-horizon and world wide propagation with the challenges of ionospheric fading and limited frequency resources.

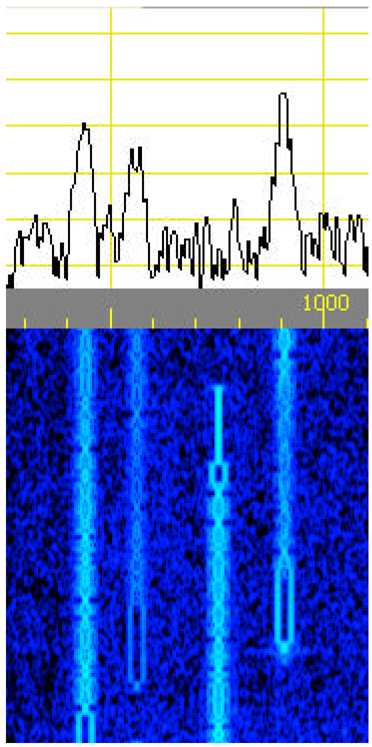

Figure 8 - PSK31 Signals

PSK31 signals can regularly be found at 7070 kHz and 14070 kHz. The lower frequency, 7070 kHz, is more active evenings and the higher frequency is more active middays. A PSK31 signal appears as a bright column in Sigmira's waterfall display. Figure 8, above, is an example of the appearance of PSK31 signals. That example is from a particularly active period but it is common that there are many signals visible at one time. The narrowband nature of PSK31 signals allows many signals to be placed close together, even within the passband of a short-wave communications receiver, and thus be visible at the same time at one receiver frequency setting.

To demodulate a PSK31 transmission click on the PSK31 radio button in the Mode group in the upper left corner of the Sigmira window. Then select the particular transmission to demodulate by right-clicking on it in the waterfall display. The demodulated text will appear in the Rx Text window.

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Sigmira uses a narrow filter to separate the selected transmission from the rest of the input. The signal strength indicator indicates the strength of the filtered signal. The waterfall display continues to display the entire input.

The SDR-IQ has something of a "0 Hz birdie". Samples from the SDR-IQ have a DC offset that shows as a peak or faint line at the center of the spectrum/waterfall. It can interfere with PSK31 demodulation (when 'Lock Center' is off). The offset can be minimized with the 'DC Comp.' feature described below. However in some cases it may still be advantageous to tune slightly off from the PSK31 signal (so that it is not at the center of the spectrum), turn 'Lock Center' on, and then tune directly on the PSK31 signal.

The squelch control can be used to reduce response to noise. See section 3.11, Squelch Control.

3.5.5 RTTY

RTTY (Radio Teletype) is a narrow-band character-based modulation mode used by hams for interactive long distance communication in the HF bands. RTTY employs Frequency Shift Keying (FSK) modulation, "Baudot" coding, and a low baud rate. Those features are suited to the HF bands which offer over-the-horizon and world wide propagation with the challenges of ionospheric fading and limited frequency resources. RTTY is one of the earliest forms of digital modulation having originated probably before the 1940s. As such it doesn't include the more modern features of Huffman coding and phase shift keying that PSK31 does. . (Note that the Sigmira RTTY mode is specifically oriented to the ham FSK signal. For the general FSK demodulation mode see the FSK mode section, below.)

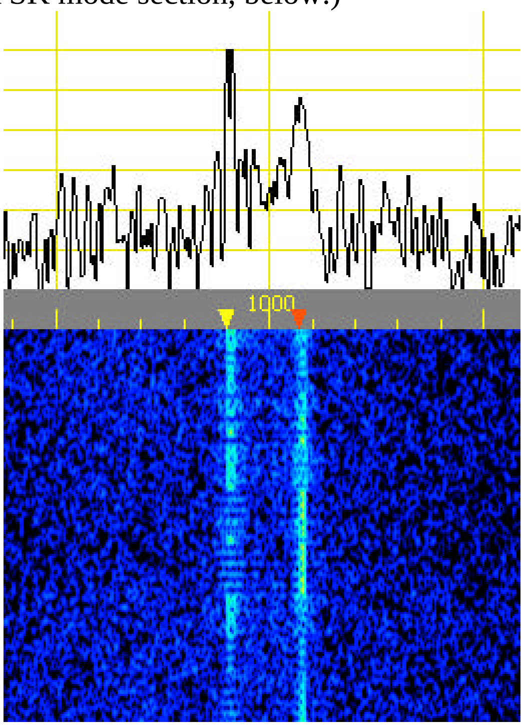


Figure 9 - RTTY Signal

RTTY signals can generally be found from 7080 kHz to 7100 kHz and 14080 kHz to 14100 kHz. The lower frequency range is more active evenings and the higher frequency range is more active middays. (When using an external receiver connected to the sound card input set the receiver to USB mode.)

The frequency shift for RTTY signals is 170 Hz. The higher frequency is the "mark" frequency and the lower frequency is the "space" frequency. The baud rate is 45.45. A RTTY signal appears as a pair of bright column in Sigmira's waterfall display. Figure 9, above, is an example of the appearance of a RTTY signal.

To demodulate a RTTY signal click on the RTTY radio button in the Mode group in the upper left corner of the Sigmira window. When in RTTY mode two triangles are shown on the frequency scale. The triangle to the right is red and corresponds with the 'Mark' frequency. Right-click on the higher frequency column of the desired signal, i.e. the mark frequency. (It is easier to click on a signal when the displayed spectrum width is narrower.) The demodulated text will appear in the Rx Text window. (When using a conventional receiver with Sigmira for RTTY demodulation make sure the receiver is in USB mode.)

Sigmira uses a narrow filters to separate the selected transmission from the rest of the input. The signal strength indicator indicates the strength of the filtered signal. The waterfall display continues to display the entire input.

The squelch control can be used to reduce response to noise. See section 3.11, Squelch Control.

3.5.6 FSK

FSK (Frequency Shift Keying) is a mature, uncomplicated "digital" mode. It is generally used for character-based communication. It originated before the 1940s and is still used by military, government, and private maritime entities for long-haul, over-the-horizon communication on the HF bands. Hams also use FSK. Sigmira has a separate RTTY mode that is specifically oriented to the ham FSK mode.

Sigmira's FSK mode can also be used to demodulate SITOR-B signals.

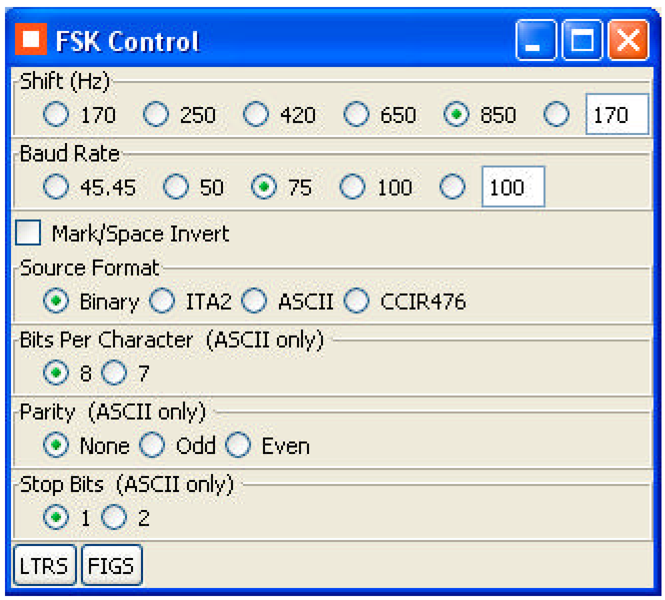
There are over a dozen entries for FSK signals in the Sigmira signal database. There are currently four entries for SITOR-B signals. There are many FSK signals that run almost constantly. They are most commonly 850 shift and 50 or 75 baud. They are also typically encrypted. Some of the stronger signals received in southern California are 5345, 7593, 9085, and 14436.3 kHz (center).

At least two of the SITOR-B signals heard in southern California are from NMC. They consist of maritime weather information (unencrypted). They are at 8416.5 and 12579 kHz (center).

To demodulate an FSK signal click on the FSK radio button in the Mode group in the upper left corner of the Sigmira window. When in FSK mode two triangles are shown on the frequency scale. The triangle to the right is red and corresponds with the 'Mark' frequency. Right-click on the higher frequency column of the desired signal, i.e. the mark frequency. (It is easier to click on a signal when the displayed spectrum width is narrower.) The demodulated text will appear in the Rx Text window. (When using a conventional receiver with Sigmira for FSK demodulation make sure the receiver is in USB mode.)

Sigmira's FSK mode offers user selectable shift, baud rate, mark/space inversion, and source format.

The FSK Control window is displayed whenever the FSK mode is selected (from the mode buttons in the upper left corner of the main window) or when called up via the View menu, View=>FSK Control, also in the upper left corner of the main window. The FSK Control window appears as below:



The Shift radio buttons allow the demodulator to be set to match the frequency shift of the received signal. The shift of the received signal is most easily observed when the displayed spectrum width is set at lower values, i.e. 25 kHz or less. When in the FSK mode two triangles are shown on the frequency scale. They correspond to the 'mark' and 'space' frequencies. (Typically the higher frequency is the mark frequency.) Select the shift so that the separation of the triangles matches the separation of the displayed columns of the received signal. Then right-clicking on the mark column in the waterfall display tunes the demodulator so that the red triangle is over the mark frequency and the yellow triangle is over the space frequency. Most signals are either 170 or 850 shift. The FSK Control window offers preset buttons for several known shift values. In addition the far right shift button allows the selection of a shift value that can be entered by the user.

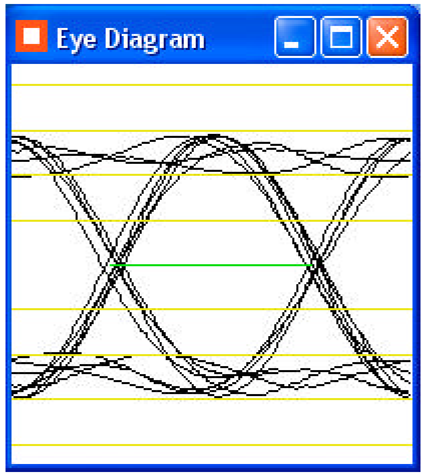
The Baud Rate radio buttons allow the demodulator to be set to match the baud rate of the received signal. Most 850 shift signals are either 50 or 75 baud. Amateur RTTY signals are 45.45 baud (170 shift). SITOR-B signals are 100 baud (170 shift). Selection of the correct baud rate can be verified in the eye diagram described below. The FSK Control window offers preset buttons for the common baud rates. In addition the far right baud rate button allows the selection of a rate that can be entered by the user.

The Mark/Space Invert checkbox allows the swapping of which frequency is interpreted as mark and which as space. Normally the higher transmitted frequency is mark. A few stations transmit mark as the lower frequency. In addition, when using a conventional receiver it is common for the receiver to switch to lower sideband mode below 10 MHz. That swaps the mark and space frequencies. The Mark/Space Invert checkbox can be used to adapt the demodulation to an inverted sender or to a lower sideband swap.

The Source Format radio buttons allow one to select the final interpretation of the data for display in the Rx Text window. The 'Binary' mode is basically no interpretation. The individual bits are displayed. The binary mode is appropriate for encrypted transmissions because the encryption conceals the original source format. The binary mode is also useful in assessing unknown signals and looking for patterns that indicate the actual format. The regular pattern of start and stop bits is usually apparent when viewing ITA2 data in binary mode. The 'ITA2' mode prints data formatted at the source in the 5-bit start stop serial ITA2 alphabet. (ITA2 is sometimes referred to as "Baudot".) The 'ASCII' mode prints data formatted at the source in the common 7 or 8-bit start stop serial format. The control window also includes options for the number of bits, parity bits, and stop bits. Those settings are only effective in the ASCII mode. The 'CCIR476' format is used by SITOR-B and NAVTEX. (In CCIR476 characters are seven bit long with exactly four '1' bits per character. Each character is sent twice with the repeated characters being interleaved and delayed by five characters.)

The LTRS and FIGS button allow the LTRS/FIGS state of the demodulator to be manually changed. Both ITA2 and CCIR476 use a LTRS/FIGS state to extend the range of characters that may be sent. The five bits of an ITA2 character and the seven bits of a CCIR476 character basically only allow for about 32 different characters. "LTRS" and "FIGS" control characters are used to tell the demodulator to switch back and forth between two tables of meanings for the transmitted character. When in the LTRS state '10000' (ITA2) means 'T' and when in the FIGS state '10000' means '5'. The demodulator must track the LTRS/FIGS state. Noise, interference, and fading can cause the demodulator to miss or receive false LTRS and FIGS control characters and thus lose track. In that case a string of inappropriate letters or figures will be observed in the received text display. If the demodulator is erroneously in the FIGS state clicking the LTRS button forces the demodulator back to the LTRS state. Likewise the FIGS button forces the demodulator to the FIGS state. The LTRS and FIGS buttons in the FSK Control window are also effective when Sigmira is in RTTY mode.

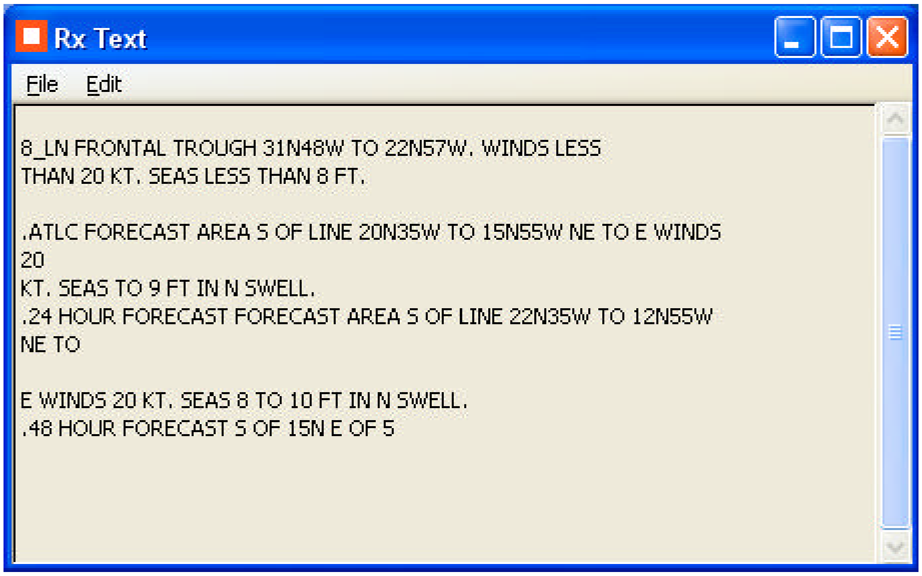
The eye diagram display is shown below.



The eye diagram allows the signal quality and the demodulated bit timing to be observed. With a good quality signal and the correct baud rate selected the diagram appears as above. There is one complete "eye" that is centered and "open". The signal zero-crossing points are at the ends of the green line. Note that ITA2 and ASCII signals can have irregular bit timing. The functioning of the eye diagram is adjusted to compensate for that when the ITA2 or ASCII source format is selected.

The Phase Plane display displays the output of the mark and space filters rather than phase while in FSK mode. The mark filter output is displayed in the horizontal direction and the space filter output is displayed in the vertical direction.

Two recorded examples of FSK signals are included in the Sigmira package. They can be found at <sigtools_install_root>/examples/fsk_8r432_090418_1236_ksm.wav and <sigtools_install_root>/examples/sitorb_8r432_090418_1504_ksm.wav. The FSK example is 1000 Hz center, 170 shift, 45.45 baud, ITA2. The SITOR-B example is 1000 Hz center, 170 shift, 100 baud, CCIR476. To demodulate the SITOR-B example open the .wav file using the "File" menu in the main Sigmira window. (Refer to section 7 of this document for more details on opening .wav files.) Set the tuning frequency to 1000 Hz in the frequency control of the main window. (Section 3.8 can be referred to for more details on frequency setting.) Select "FSK" in the "Mode" menu in Sigmira's main window. Then in the "FSK Control" window select the 170 Hz shift. Select the 100 baud rate. The Mark/Space Invert box should be unchecked. Set the "Source Format" option to "CCIR476". The decoded text should appear in the Rx Text window as shown below.



The squelch control is usable in the FSK mode.

3.5.7 CW

CW is old fashioned Morse code over radio. "CW" stands for "continuous wave", which is a historic term arising from the fact that the very first transmitters of a hundred years ago could not always produce the long 'dash' sound.

CW is "low tech". It requires the least hardware. All one needs to transmit a CW signal is a radio frequency generator with an on-off switch. That simplicity plus a nostalgia factor account for the longevity CW. CW does place greater demands on the receiver software, which has traditionally been implemented in a human being.

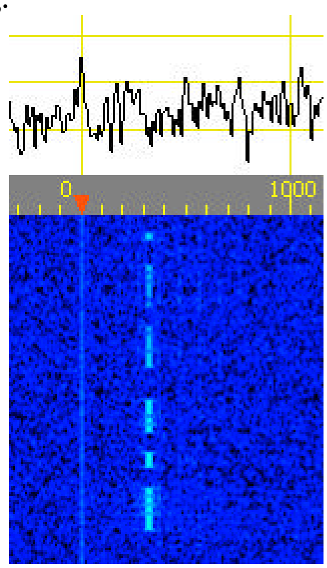


Figure 10 - A CW Signal

Interestingly, Morse code incorporates a basic concept that has been most recognized in the more modern Huffman coding. Huffman codes were invented some one hundred and twenty years later. In both codes the most common characters are mapped to the shortest transmit sequences.

CW signals can generally be found from 7000 kHz to 7070 kHz and 14000 kHz to 14070 kHz. The lower frequency range is more active evenings and the higher frequency range is more active middays.

A CW signal appears as a bright column in Sigmira's waterfall display. To demodulate a CW signal click on the CW radio button in the Mode group in the upper left corner of the Sigmira window. Then select the particular transmission to demodulate by right-clicking on the signal in the waterfall display. Initially Sigmira has to adapt to the rate at which the code is being sent. CW can be sent at a rate anywhere from 3 words per minute to 60 words per minute. While adapting Sigmira will typically print a number of 'E's in the Rx Text window. With a decent signal Sigmira will adapt to the correct speed within 10 seconds

Sigmira uses a very narrow filter to select the CW transmission out of the total input. The signal strength indicator indicates the strength of the filtered signal. The waterfall display continues to display the entire input.

(The CW filter is fixed at 50 Hz and is perhaps too narrow for some uses. If the automatic to-text deciphering is not need then CW can be listened to in the USB mode. A selectable range of CW filters will be added to a future version of Sigmira.)

The SDR-IQ has something of a "0 Hz birdie". Samples from the SDR-IQ have a DC offset that shows as a peak or faint line at the center of the spectrum/waterfall. It can interfere with CW demodulation (when 'Lock Center' is off). The offset can be minimized with the 'DC Comp.' feature described below. However in some cases it may still be advantageous to tune slightly off from the CW signal (so that it is not at the center of the spectrum), turn 'Lock Center' on, and then tune directly on the CW signal.

In CW mode the 'Squelch' control can optionally be used to set the signal level that is considered as "key down". When the signal level is above the squelch level it is considered a "key down" period, i.e. part of a 'dit' or a 'dah'. When the signal level is below the squelch level it is consider to be a "key up" interval, i.e. between a 'dit' or 'dah'. But it is not necessary that the best setting for this control be selected manually. If the squelch level is set at 0, at the bottom, the program automatically adjusts to what it calculates is the best level.
Also see section 3.11, Squelch Control.

3.5.8 STANAG 4285

STANAG 4285 is a digital modulation mode designed by NATO for HF radio communications. It appears to be used mostly for long haul broadcast communication by various navies/maritime organizations. STANAG 4285 is a 2400 baud, 8-PSK signal.

The symbol rate is always 2400 symbols per second but various modulation options result in data rates from 75 to 3600 bps. The 2400 sps rate and PSK modulation result in a bandwidth of about 2400 Hz. Thus STANAG 4285 is wider than many HF data signals but still fits in the bandwidth of a typical voice signal. The signal has a 256 symbol frame structure which includes an 80 symbol synchronization pattern and three 16 symbol reference patterns. The sync and reference patterns along with 8-ary symbol scrambling facilitate adaptive channel equalization. Channel equalization is advantageous for a high data rate signal in the HF band considering the associated ionospheric fading. The sync pattern also facilitates Doppler adaptation as well as frame synchronization and symbol rate adaptation.

STANAG 4285 provides for forward error correction (FEC). FEC adds redundancy to the data such that the receiver can detect and generally correct errors in the received data. In STANAG 4285 FEC is implemented in a rate 1/2, constraint length 7 convolutional code and interleaver. The convolutional code effectively adds as many "parity" bits as there are data bits, thus the source data rate is 1/2 the coded data rate. Decoders for convolutional codes are less effective against bursts of errors. Bursts of errors are common in radio channels so an interleaver is typically employed along with a convolutional code. The interleaver shuffles the order of the data bits. A deinterleaver in the receiver reverses the interleaving. The errors of a bursts of errors caused by the radio channel are spaced out by the deinterleaver in the receiver.

The length of the interleaver in STANAG 4285 is a selectable option. Two nominal values are available, "short" and "long". The longer interleave is more resistant to channel noise bursts and fades. The length of the interleaver also corresponds with a real time delay in the data becoming available at the output of the demodulator. The "short" interleave corresponds with a delay of about 1 second. The "long" interleave corresponds with a delay of about 10 seconds. So if the "long" interleave option is selected any disturbance or change in the received signal won't be evident until 10 seconds later.

The STANAG 4285 specification includes an optional "message mode". The message mode is something of a digital squelch. The message mode specifies a "start of message" bit pattern (SOM) and an "end of message" bit pattern (EOM). When the message mode is selected the receiver is only to output data after a SOM is detected and before the next EOM is detected. In this observer's opinion the message mode is something of a misfeature. There are other less error prone methods of achieving the same result and no known actual users of STANAG 4285 use the message mode.

Sigmira employs an adaptive decision feedback equalizer (DFE) for channel equalization and a Viterbi decoder for the convolutional code.

STANAG 4285 transmitters have typically used a modem that produces an audio signal which is then the input to an USB transmitter. The carrier or center of the audio band STANAG 4285 signal is specified as 1800 Hz. The commonly quoted frequency for a STANAG 4285 radio signal is the tuning of the USB transmitter. So the actual center of the STANAG 4285 RF signal is 1800 Hz higher than the quoted frequency. Sigmira tuning is oriented to the center of the signal. When using Sigmira with the SDR-IQ the frequency setting should be the commonly

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quoted frequency plus 1800 Hz. When using Sigmira with a conventional receiver tune the receiver to the commonly quoted frequency, USB mode, and set Sigmira to 1800 Hz.

Monitoring from southern California STANAG 4285 signals are often found around 6500 kHz and 8500 kHz. They are more common and stronger at night. A couple common signals are at 6400.5, 8490, and 8554.4 kHz (center). All observed signals have data rates of either 300 or 600 bits per second. A slight majority operate at 300 bits per second. All of them operate with the long interleave option.

Most of the observed signals appear to be encrypted. (The bit autocorrelation is flat and the run length statistics are the same as a Bernoulli process.) But there are signals transmitted in the clear. The French navy has been broadcasting several test signals in the clear for some time now. Examples are 8480.3, 8626.8, and 8647.8 kHz (center). The 8626.8 signal is at 600 bps. The others are 300 bps. All use the long interleave. They use the ITA2 alphabet.

The spectrogram of a STANAG 4285 signal is given in Figure 11, below. This is not a particularly strong signal. Significant fading is also evident. Even so, good copy was obtained from this signal.

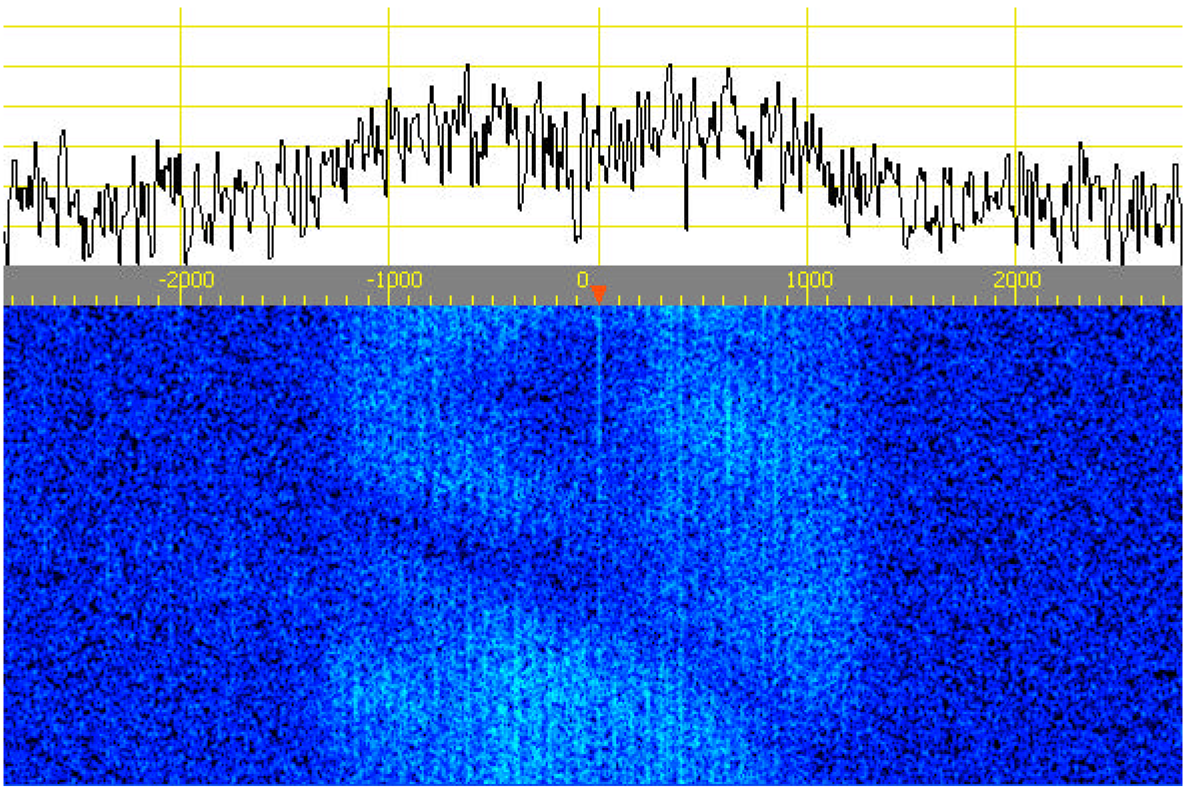

Figure 11 - STANAG 4285 Signal Spectrogram

To demodulate a STANAG 4285 transmission click on the S4285 radio button in the Mode group in the upper left corner of the Sigmira window. The Rx Text window and STANAG 4285 Control window should appear.

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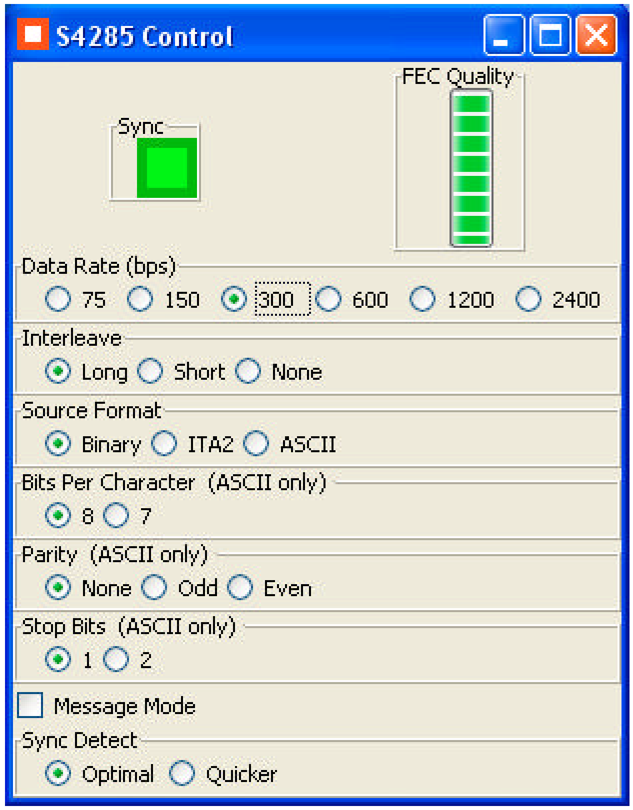


Figure 12 - STANAG 4285 Control Window

In the upper part of the control window are two indicators, the Sync indicator and the FEC Quality indicator. The Sync indicator illuminates green when Sigmira locks on to the synchronization of a STANAG 4285 signal. (Since the signal energy from 80 out of every 256 symbols contributes to sync detection it is possible detect sync even from signals which are too poor to yield good payload data.) The FEC Quality indicator is a thermometer type graph that indicates the quality of the demodulated data before the Viterbi decoder. If the indicator is above the 70% level the Viterbi decoder is able to correct virtually all errors. Good copy can still be obtained in the 50 to 60% range. (Note that the FEC Quality indicator is after the deinterleaver. If the interleave setting is changed to 'Long' or if the tuning is changed there will be a 10 second delay before the FEC Quality indicator gives a true indication.)

The Data Rate radio buttons in the control window allow the selection of the signal's expected data rate. It appears that virtually all real signals are either 300 or 600 bits per second. For an unknown signal one can determine the data rate by switching between the two rates and observing the FEC Quality indicator. The FEC Quality indicator will be near zero for the incorrect rate. (Setting the data rate to a value above 600 bps also affects the deinterleaver. After changing the data rate to a value above 600 or back again one must wait the interleaver delay, 10 seconds for the 'Long' interleave, before the FEC Quality indication catches up.)

The Interleave radio buttons in the control window allow the selection of the signal's expected interleave. It appears that virtually all real signals use the long interleave. The interleave results in a real time delay through the demodulator. The short interleave results in a delay of about 1 second. The long interleave results in about 10 seconds. Changing the interleave setting resets the deinterleaver and the interleave delay must pass before good data works its way through the deinterleaver again. The interleaver is also reset if the data rate is changed to or from any value above 600.

The Source Format radio buttons allow one to select the final interpretation of the data for display in the Rx Text window. The 'Binary' mode is basically no interpretation. The individual bits are displayed. The binary mode is appropriate for encrypted transmissions because the encryption conceals the original source format. Most signals appear to be encrypted. The binary mode is also useful in assessing unknown signals and looking for patterns that indicate the actual format. The regular pattern of start and stop bits is quite apparent when viewing ITA2 data in binary mode. The 'ITA2' mode prints data formatted at the source in the 5-bit start stop serial ITA2 alphabet. (ITA2 is sometimes referred to as "Baudot".) Several real broadcast test signals have been observed using ITA2. The 'ASCII' mode prints data formatted at the source in the common 7 or 8-bit start stop serial format. The control window also includes options for the number of bits, parity bits, and stop bits. Those settings are only effective in the ASCII mode.

The Message Mode check box controls the STANAG 4285 specified optional "message mode". When in the message mode the printing of demodulated data begins when the specified "start of message" bit pattern is detected and ends when the specified "end of message" bit pattern is detected. When not in message mode all data are printed. Message mode filtering is never applied when the 'Binary' Source Format is selected.

The Sync Detect radio buttons allow one to choose between two signal synchronization detector settings. With the 'Optimal' setting the sync detector is optimized for stable synchronization and minimal errors for both good and marginal signals per the STANAG 4285 specification. The 'Quicker' setting modifies the sync detector to synchronize instantly when given a good quality signal. Instant synchronization is not part of the mission of STANAG 4285. Generally the Sync Detect option should remain set to Optimal.

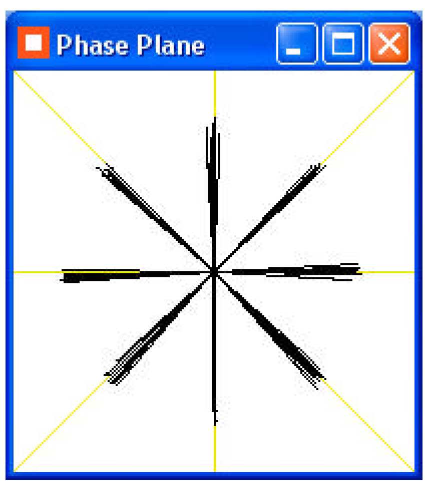


Figure 13 - Phase Plane Display for STANAG 4285 Signal

Figure 13 above illustrates the phase plane display when a high quality STANAG 4285 signal is being received. The end points of the radials correspond to the received symbols. The 8-PSK nature of the signal is quite clear. Note that at the lower data rates, including 300 and 600 bps, good copy is possible even with signals so noisy and distorted that an 8-PSK constellation is hardly recognizable in the phase plane. (The constellation in the phase plane is distinctly eight-pointed only when the signal is greater than the noise floor by 15 dB or more.)

A recorded example of a STANAG 4285 signal is included in the Sigmira package. To demonstrate Sigmira's STANAG 4285 operation begin by opening the example STANAG 4285 .wav file. The example is in the "examples" directory and is named "s4285_081020_2200_8r6268_600lita2_fnav_fum.wav". Wave files are opened using the "File" menu in the main Sigmira window. (Refer to section 7 of this document for more details on opening .wav files.) Set the tuning frequency to 1800 Hz in the frequency control of the main window. (Section 3.8 can be referred to for more details on frequency setting.) Select "S4285" in the "Mode" menu in Sigmira's main window. Then in the "S4285 Control" window select the "600" bps data rate. The "Interleave" option should also be set to "Long" (which is the default). Set the "Source Format" option to "ITA2". The "Message Mode" check box should be unchecked (which is the default). The signal will then be demodulated and wend its way through the deinterleaver and Viterbi decoder. After about 10 seconds text as shown below in Figure 14 will appear in the Rx Text window.

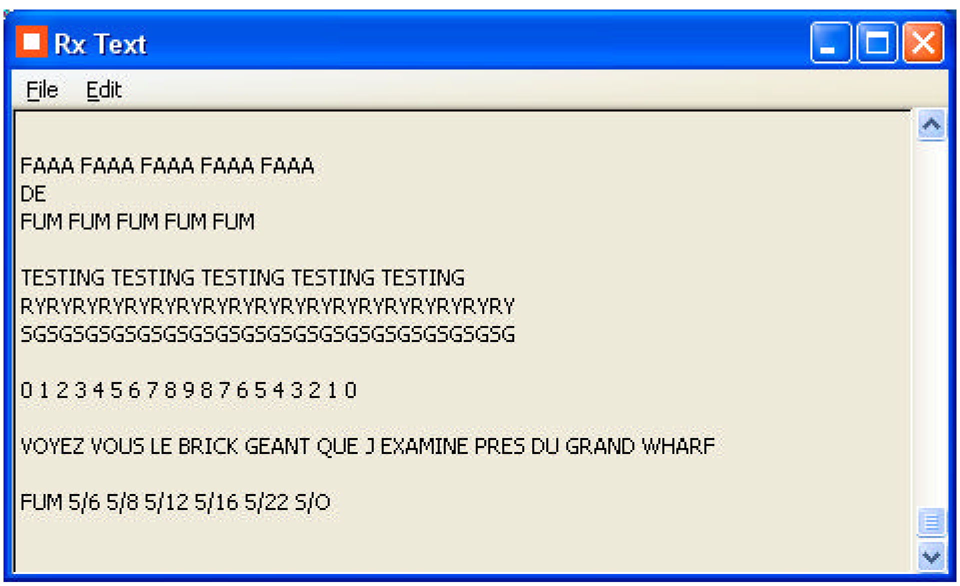


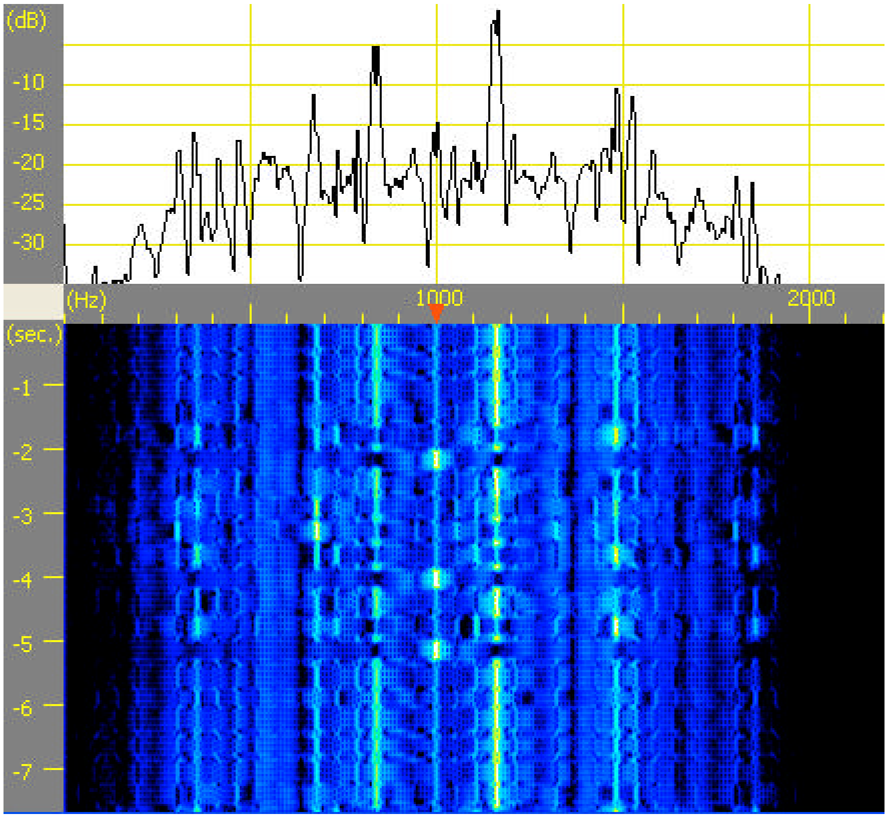
Figure 14 - Text of the French Navy FUM STANAG 4285 Test Signal

3.5.9 JSM (Japanese Navy "Slot Machine")

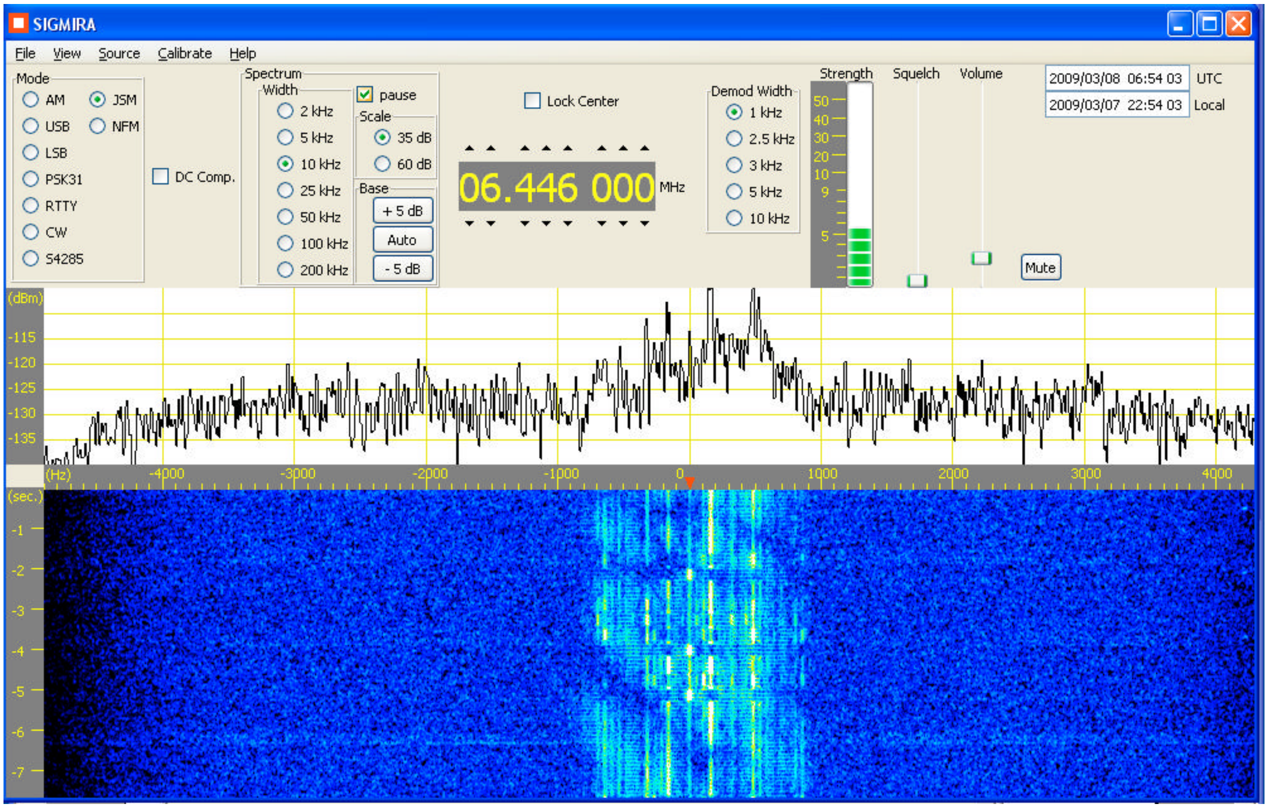
JSM refers to a rather strange signal. The consensus is that it is transmitted by the Japanese navy. When one listens to it in USB mode it normally sounds like a continuous repetitive melody. Some have likened the sound to that of a Las Vegas slot machine. Thus the name, JSM, Japanese Slot Machine.

In California it is commonly best received after 22:00 (local) and up to the hour after sunrise (local) on 6.446 and 8.589 MHz (center). It has also been heard on 4.154, 4.2325, 4.291, 6.251, 6.418, 8.314, 8.7045 MHz (center).

A recorded .wav file example of the signal is include in the Sigmira distribution package. It can be found at <sigtools_install_root>/examples/jsm_080904_0651_8r5888_example.wav. Sigmira displays the example as shown below:



A recent live capture is shown below.

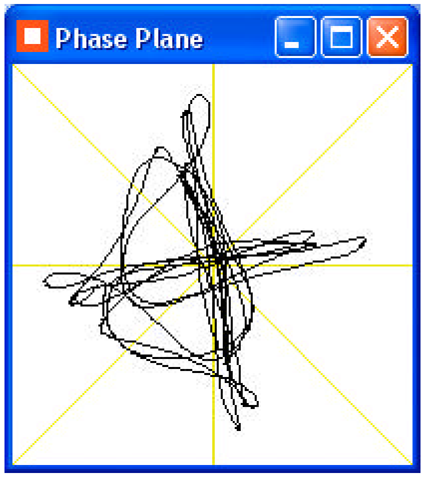


Most of the time the signal is an exactly repeating melody. It also includes an 11.4 Hz ticking sound. The melody repeats every 5.6 seconds. This is odd. Information theory tells us that the more predictable a signal is the less information it contains. This repeating signal contains basically no more than three pieces of information: a frequency, a phase, and a station ID. Occasionally the signal changes to become more chaotic and noise-like. That is the information payload. The melody intervals of the signal are called the "idle" time here.

The observed characteristics of the signal are consistent with a fixed (land based) broadcast to multiple, likely mobile, receivers over the horizon. The signals run continuously without interruption. The content of the signal on each of the various transmit frequencies appears identical. There is never anything like a "reply".

The actual frequency of the nominal 8.589 MHz signal has been measured at 8.588997 MHz +/- 0.5 Hz. So the signal is not a top stratum frequency reference (such as NIST WWV).

A snapshot of the signal in the phase plane is shown in the image below. (The "Demod Width" was set to 1 kHz.)



Clearly it is a QPSK signal.

With some investigation the symbol rate was determined to be 1500.00 baud. The regular ticking sound was found to be an exactly repeating sequence of symbols. Clearly that serves as a channel probe and frame synchronization pattern. One tick sound period is here defined as a "frame". Frames were found to consist of 140 QPSK symbols. So the frame rate is 10.71428 Hz. The probe/sync pattern is 28 symbols which is one fifth the number of symbols per frame. It is found that, during the repetitive melody idle time, the remaining symbols of a frame consist of four repetitions of another 28 symbol pattern. So a frame appears to consist of five "blocks" of 28 symbols.

During idle time there is a finite set of symbol patterns that appear in the blocks. The patterns are designated here: ps, p0, p1, p2, p3, p4, p5, p6, p7, p8, p9, p10, and p11. The "ps" pattern is the probe/sync pattern. The rest are numbered roughly in the order of their frequency of occurrence. The "p0" pattern is most common.

The melodic idle time consists of an exactly repeating sequence of 64 frames. A 64 frame sequence is called a "super frame" here. The duration of a super frame is 5.973333 seconds. The frame/block pattern of the idle super frame is presented in the following table.

Idle Super Frame Structure

Frame Number	Block 0 Pattern	Block 1 Pattern	Block 2 Pattern	Block 3 Pattern	Block 4 Pattern
0	ps	p10	p10	p10	p10
1	ps	p10	p10	p10	p10
2	ps	p10	p10	p10	p10
3	ps	p0	p0	p0	p0
4	ps	p8	p8	p8	p8
5	ps	p8	p8	p8	p8
6	ps	p8	p8	p8	p8

7	ps	p0	p0	p0	p0
8	ps	p9	p9	p9	p9
9	ps	p9	p9	p9	p9
10	ps	p9	p9	p9	p9
11	ps	p1	p1	p1	p1
12	ps	p11	p11	p11	p11
13	ps	p11	p11	p11	p11
14	ps	p11	p11	p11	p11
15	ps	p0	p0	p0	p0
16	ps	p6	p6	p6	p6
17	ps	p6	p6	p6	p6
18	ps	p6	p6	p6	p6
19	ps	p0	p0	p0	p0
20	ps	p5	p5	p5	p5
21	ps	p5	p5	p5	p5
22	ps	p5	p5	p5	p5
23	ps	p0	p0	p0	p0
24	ps	p4	p4	p4	p4
25	ps	p4	p4	p4	p4
26	ps	p4	p4	p4	p4
27	ps	p1	p1	p1	p1
28	ps	p3	p3	p3	p3
29	ps	p3	p3	p3	p3
30	ps	p3	p3	p3	p3
31	ps	p1	p1	p1	p1
32	ps	p11	p11	p11	p11
33	ps	p11	p11	p11	p11
34	ps	p11	p11	p11	p11
35	ps	p0	p0	p0	p0
36	ps	p7	p7	p7	p7
37	ps	p7	p7	p7	p7

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38	ps	p7	p7	p7	p7
39	ps	p1	p1	p1	p1
40	ps	p3	p3	p3	p3
41	ps	p3	p3	p3	p3
42	ps	p3	p3	p3	p3
43	ps	p0	p0	p0	p0
44	ps	p0	p0	p0	p0
45	ps	p0	p0	p0	p0
46	ps	p0	p0	p0	p0
47	ps	p1	p1	p1	p1
48	ps	p0	p0	p0	p0
49	ps	p0	p0	p0	p0
50	ps	p0	p0	p0	p0
51	ps	p1	p1	p1	p1
52	ps	p0	p0	p0	p0
53	ps	p0	p0	p0	p0
54	ps	p0	p0	p0	p0
55	ps	p0	p0	p0	p0
56	ps	p1	p1	p1	p1
57	ps	p1	p1	p1	p1
58	ps	p1	p1	p1	p1
59	ps	p0	p0	p0	p0
60	ps	p0	p0	p0	p0
61	ps	p0	p0	p0	p0
62	ps	p0	p0	p0	p0
63	ps	p1	p1	p1	p1

The choice of which frame in the super frame should be designated as frame 0 was somewhat arbitrary. The numbering in the above table is used as the convention in this document.

The melody arises from the regular repeated simple patterns of symbols/phases. The p10 pattern is all one phase. So it produces a single tone. The p11 pattern is also all one phase but 180 degrees from p10. The other patterns are somewhat more complex and result in different and multiple apparent tones.

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There are times that the signal departs from the idle pattern and sounds more "noisy". That is no doubt the data payload. There are typically from 4 to 20 such data intervals per hour. There seems to be no pattern to the minute of the hour at which data intervals begin. The length of each data interval is an exact multiple of super frames. At the end of a data interval the idle pattern resumes exactly in step and alignment as if there had been no interruption. So there appears to be an underlying continuous 64-frame super frame structure to the signal.

It appears that each data interval begins at frame 31 or frame 32 in the super frame (by the frame numbering convention here). Likewise the signal returns to idle at frame 31 or 32. There appear to be several formats for data intervals. They can roughly be characterized by the number of frames consisting of the fixed 'p' patterns (described above) that are mixed in with frames containing the data. The data interval super frames generally consist of a repeating pattern of four frames, some of which are random (data) symbols with the rest being the fixed patterns. The number of data frames in those four frame groups can vary from one to four. Data super frames in which less than all four frames of the four frame groups are data could be called "partial" data super frames. Data super frames in which every frame contains data could be called "full" data super frames. The full data super frames are often preceded and followed by partial data super frames.

The suspected data symbols have been extracted and analyzed via autocorrelation. The symbols were also converted to bits according to an expected Gray code. The autocorrelations have been flat indicating that the symbols are further coded and/or encrypted.

The abrupt boundaries of the data super frames could expose evidence of convolutional coding or interleaving if used. Such evidence has not been obvious in the observed signals.

Sigmira uses the 'ps' block of the signal frames to accomplish carrier recovery, symbol synchronization, frame synchronization, and channel equalization. The carrier reference phase was somewhat arbitrarily chosen such that the 'p10' pattern symbols are at 90 degrees. (0 degrees is to the right in the Sigmira phase plane display. 90 degrees is up.)

Sigmira displays the demodulation results in the "Rx Text" window. An example is given in the figure below.

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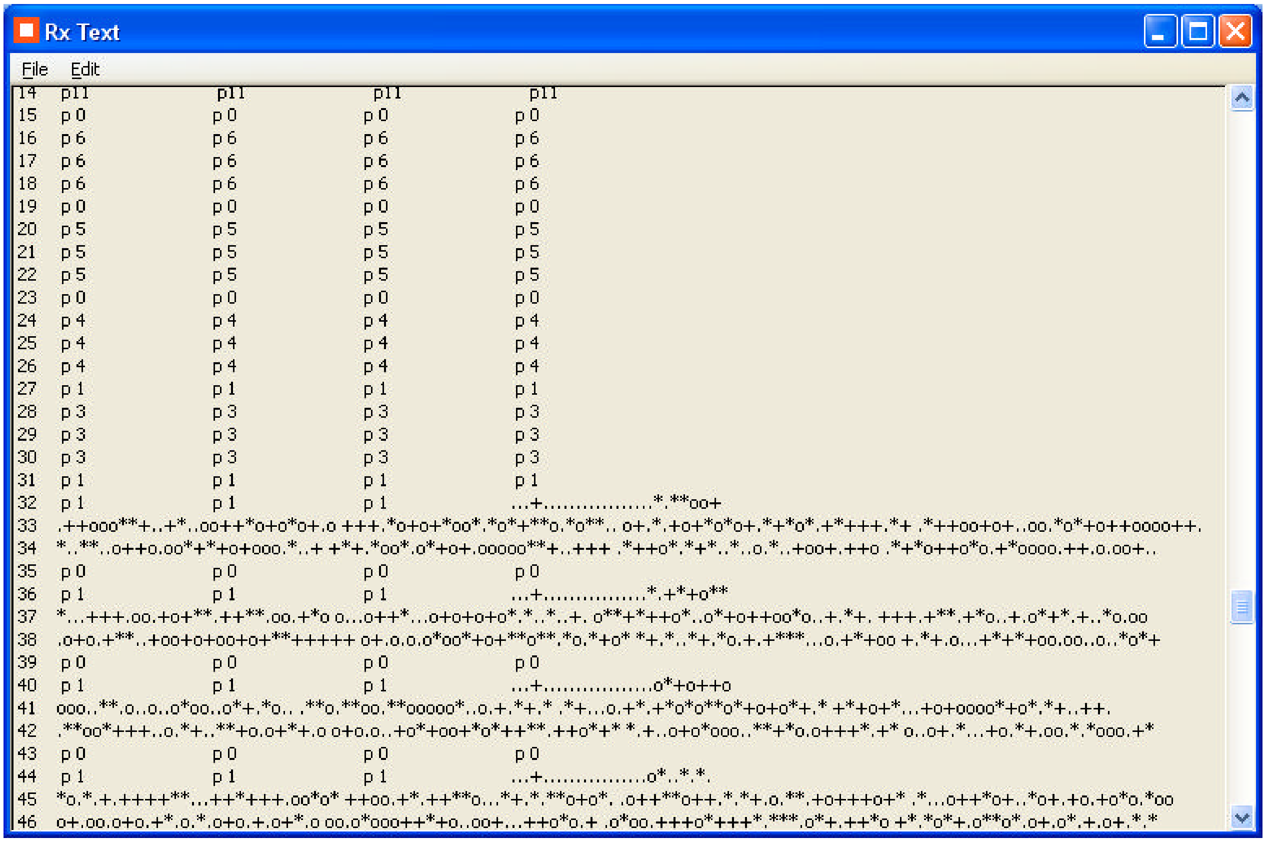


The above display resulted from demodulating the included example file: <sigtools_install_root>/examples/jsm_080904_0651_8r5888_example.wav. (Set the tuning frequency to the center of the signal, which is 1000 Hz for the example file.) The above display shows a transition from an idle interval to a "partial" data interval.

The display consists of one frame per line.

The first number in each line is the number of the frame in the super frame. Note that Sigmira must first detect the idle super frame pattern in order to synchronize the frame numbers. Before that occurs the frame numbers are displayed as "-1".

The rest of each displayed line/frame consists of either the recognized fixed group patterns or the raw QPSK symbols. Each received 28 symbol group is compared to the fixed patterns. If the group exactly matches a pattern, e.g. p0, p1, p2, etc., then the pattern number is displayed. Otherwise the 28 raw QPSK symbols are displayed. The four possible QPSK symbols are translated to printable characters for display. The translation is given in the following table.

QPSK Symbol Phase (degrees)	Printed Character
0	'.'
90	'+'

180	'o'
270	'*'

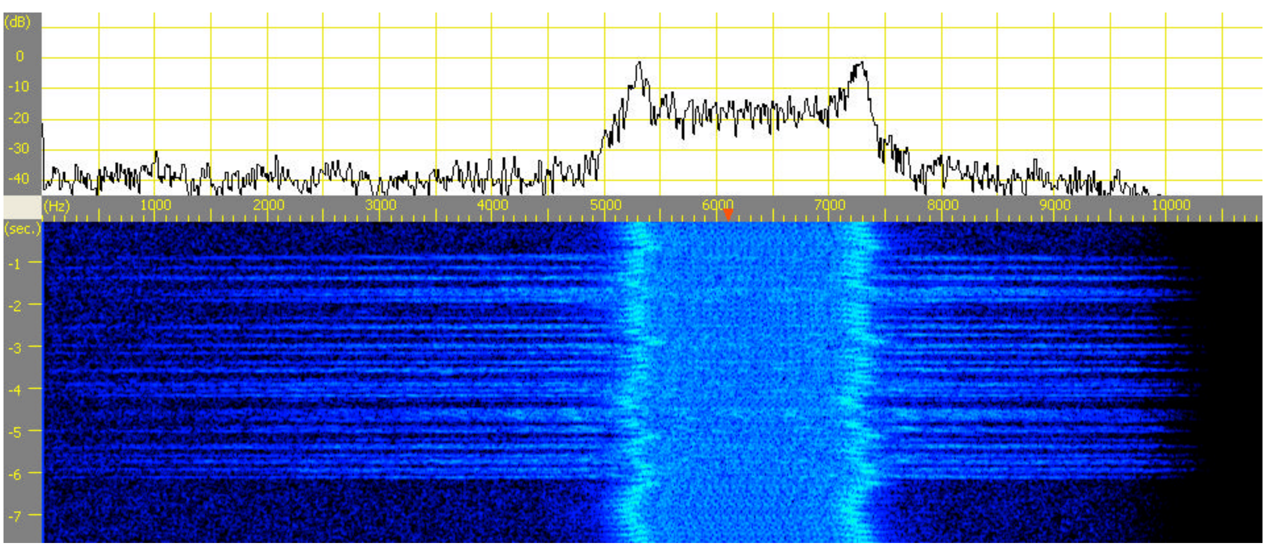
It is likely that two bits are encoded in each QPSK symbol using a Gray code. An arbitrary alignment could have been chosen and the resulting bits displayed in the Rx Text window. Any misalignment of the code would have been manifest in every bit or every other bit being inverted from the correct sense. Patterns in the data bits might be evident despite the inversions, but autocorrelations of the data so far have revealed no patterns. It was decided to simply display the QPSK symbols in order to reduce the volume of characters sent to the display.

3.5.10 NFM

The NFM is narrowband frequency modulation. NFM is similar but significantly narrower than broadcast radio FM signals and television sound signals. NFM is used, albeit rarely, on HF. Typically only narrowband FM is used on HF because of the limited total HF bandwidth available and also because the main advantage of HF (i.e. over the horizon ionospheric propagation) is not kind to wide signals. NFM is also used on VHF/UHF for public service (police, ambulance, fire, etc.) communications. The public services have traditionally used NFM because typically only voice quality communication has been required. Commercial broadcasters are also known to use FM on HF for "studio links".

NFM can occasionally be heard in the 10m ham band around 29.6 MHz. On rare occasions studio links originating in Texas can be heard in southern California around 25.99 MHz and 26.19 MHz. NFM public service communications can be heard around 856 MHz, 860 MHz, and various other frequencies.

An example of the appearance of an NFM signal in Sigmira's spectrum and waterfall displays is given in the figure immediately below.



NFM Signal

The above display is from the included recorded example. It can be found at
<sigtools_install_root>/examples/fm_090130_0012_864r052.wav
The recording is of police and ambulance calls at 864.052 MHz. Looking at the spectrum, the central plateau with the "ears" on each end is no doubt from a Continuous Tone-Coded Squelch System (CTCSS). The voice information is in the sidebands that extend further out from the center.

Radio amateurs use a "deviation" of 5 kHz. The deviation is the frequency difference of the carrier from the nominal central frequency at the maximum DC modulation input to the transmitter. The bandwidth of the modulating signal is limited to 3 kHz for amateurs. According to Carson's rule the bandwidth of the transmitted signal is twice the sum of the deviation and modulation bandwidth, or 16 kHz in this case.

Generally the Sigmira's Demod Width should be set to 10 kHz for NFM signals. (The Demod Width is the nominal one sided IF width, so a setting of 10 kHz admits a double sided IF width of 20 kHz.)

(Note that the included example file was recorded at a sample rate too low to capture the full width of the signal. Part of the upper sideband is cut off. It is still usable as a demonstration.)

Sigmira uses the North American 75 µs de-emphasis.

Set Sigmira's tuning frequency to the center of the signal. It is not critical that the tuning be at the exact center.

The squelch control is also functional in NFM mode. (See section 3.11, Squelch Control.)

3.6 DC Comp.

The DC Comp. feature adapts to the DC offset in the samples from the SDR-IQ™.

Figure 15 - DC Comp. Button

Samples from the SDR-IQ™ have a DC offset that shows as a peak or faint line at the center of the spectrum/waterfall. It can interfere with the demodulation of CW and phase modulated signals. The offset varies with time and tuning.

In normal operation Sigmira subtracts an offset from each sample. That offset is a saved value that is fixed when the 'DC Comp' feature is off. When the 'DC Comp' feature is turned on Sigmira monitors the input samples and adapts the saved offset value to the current sample stream.

Normal usage would be to leave the DC Comp feature off so that is not disturbed by actual signals. If the DC offset becomes annoying tune to a quiet area of spectrum in the neighborhood of the signals of interest. Turn the DC Comp on. The adaptation takes 5 or 10 seconds. The results are observable in the spectrum/waterfall particularly at the narrow width settings. When the central ridge is minimized turn DC Comp off.

3.7 Spectrum Controls

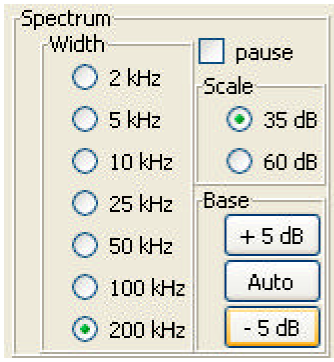


Figure 16 - Spectrum Controls

3.7.1 Spectrum Width

The Width buttons control the width of spectrum displayed in the spectrum and waterfall displays. When the selected source is the SDR-IQ the full range of widths, 2 kHz to 200 kHz is available. When the selected source is the sound card or a wave file the maximum width available is 10 kHz.

3.7.2 Spectrum Base

There are three buttons, "Auto", "+5 dB", and "-5 dB" that control the base level displayed in the spectrum and waterfall displays. Level here refers to how bright the noise floor appears in the waterfall display or how high or low the curve is drawn in the spectrum display. Adjusting the display level is necessary because background noise levels vary considerably.

Pressing the Auto button causes Sigmira to examine the current signal and noise levels and adjust the display level such that the noise floor is near dark in the waterfall display and near the bottom of the spectrum display. Pressing the +5 dB button causes the display levels to shift up the equivalent of 5 dB. The -5 dB button causes the levels to shift down. Note that the signal level scale in the spectrum display tracks the shifts so that the indicated levels remain calibrated.

The spectrum base can also be adjusted by rolling the mouse wheel while the cursor is in the spectrum display.

3.7.3 Spectrum Scale

There are two buttons, "35 dB", and "60 dB" that control the scale of the spectrum and waterfall displays. Scale here refers to how bright a signal appears in the waterfall display or how high above the noise floor it is drawn in the spectrum display. Adjusting the display scale is necessary because absolute signal levels vary considerably.

At the smaller scale value smaller signals will be more prominently displayed. Note that the signal level scale in the spectrum display tracks the scale adjustments so that the indicated levels remain calibrated.

3.7.4 Spectrum Pause

The Pause button causes the spectrum and waterfall display to pause. Demodulation, audio output, and all other functions continue.

3.8 Frequency

The Frequency indicator displays and controls the tuning frequency when operating with the SDR-IQ.

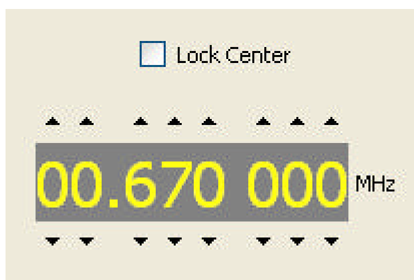


Figure 17 - Frequency Control

The displayed frequency is the frequency pointed to by the red triangle in the waterfall frequency scale. Positioning the PC mouse cursor over a digit and spinning the mouse wheel causes the frequency to roll up or down in that digit position. Clicking on a digit in the frequency display causes the tuning frequency to be rounded in that digit place. (i.e. clicking on the 5 in a display of 10.500000 causes the frequency to change to 11.000000.) Clicking on the triangle above a digit causes the frequency to increment in that digit. Similarly, clicking on the triangle below a digit causes a decrement.

As described in the section on the waterfall display, right-clicking in the waterfall display (or the frequency scale, or the spectrum display) causes the tuning frequency to change to the frequency of the point clicked. If the Lock Center box is not checked then the center of the displayed spectrum range changes to that frequency. Consequently the red triangle will always be at the center of the display.

If the Lock Center box is checked then the center frequency of the displayed spectrum is fixed. When the tuning frequency is changed the red triangle will move to the corresponding location in the frequency scale. This is useful when the center frequency has been set to be within a group of signals of interest. The tuning can be changed from signal to signal and the red triangle will follow while the signals maintain their positions in the spectrum display.

3.9 Demodulation Width

The demodulation width control adjusts the bandwidth used in demodulating the signal. Signals vary in width. It is advantageous to adjust the demodulation width to be wide enough to include the signal but no wider so that no extra noise is included.

Figure 18 - Demod Width

The demodulation width control is effective in the AM, USB, and LSB modes. AM and SSB signals have considerable variability in width. In the other modes (particularly PSK31 and RTTY) the signals have defined widths and the demodulators are tailored to those widths.

The selectable widths refer to the demodulated output. AM signals are double sideband. So the transmitted width of an AM radio signal is twice that of the modulation. The transmitted radio signal for AM with 5 kHz modulation will be 10 kHz wide as seen in the spectrum/waterfall display. For such a signal the 5 kHz demodulation width would be appropriate. For SSB signals the transmitted width is the same as the modulation width.

AM broadcast signals have modulation bandwidth of 5 or 10 kHz typically. Ham SSB signals are typically 2.5 to 3 kHz wide.

3.10 Strength Indicator

The Strength indicator is a thermometer-like display that indicates the strength of the demodulated signal.

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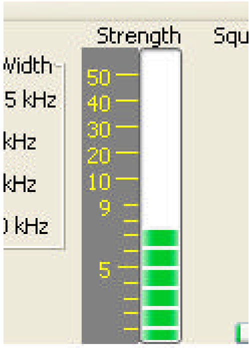

Figure 19 - S-Meter

If the SDR-IQ™ is selected as the source then the strength scale is similar to a traditional S-Meter. The tick marks are "S-Units" up to "S9" and then dB above S9 above that. (Only S5 and S9 are marked with digits to save clutter.) S9 is -73 dBm or 50 µVrms at the antenna input.

If the sound card or .wav file is selected as the source then the strength scale is relative. (It is not possible to accurately calibrate sound wave samples to radio signal strength. Recorded .wav files can have a wide range of recording levels. And an external receiver connected to the sound input typically has an AGC which results in a relatively constant audio level.) The strength scale is logarithmic. Full scale corresponds to the full strength representable by sound sample values.

Besides general curiosity, the Strength indicator is useful in adjusting the squelch (see section 3.11, Squelch Control) and setting up the optimum input level (see section 6, Conventional Receiver Connection).

3.11 Squelch Control

The squelch controls when the demodulation of the incoming signal is active. It sets a minimum strength level that the signal must reach in order to be demodulated. This is useful in preventing the background noise between transmissions from being interpreted as signal.

The squelch is a slider control that is controlled by clicking on it and sliding it up or down.

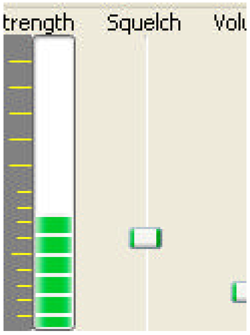

Figure 20

The squelch control is located next to the signal strength indicator and their levels correspond. If the indicated signal strength is higher than the squelch the demodulation will be active. If the squelch control is set to the bottom of its range the demodulation will always be active.

In CW mode the squelch control has a somewhat different function. In CW mode (Morse mode) the squelch control can optionally be used to set the signal level that is considered as "key down". When the signal level is above the squelch level it is considered a "key down" period, i.e. part of a 'dit' or a 'dah'. When the signal level is below the squelch level it is consider to be a "key up" interval, i.e. between a 'dit' or 'dah'. But it is not necessary that the best setting for this control be selected manually. If the squelch level is set at 0, at the bottom, the program automatically adjusts to what it calculates is the best level.

3.12 Mute

The Mute button controls whether the demodulated audio is played out to the PC sound output.

3.13 File Menu

The File menu is in the menu bar at the top of Sigmira's window. The File menu has two entries, Open and Quit.

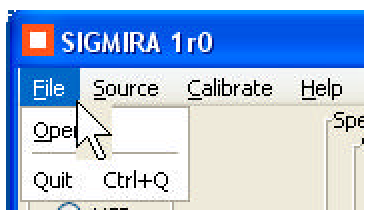

Figure 21 - File Menu

3.13.1 Open

Selecting Open brings up a dialog window that can be used to open an audio file. The file would typically be previously recorded undemodulated signal as from the short-wave receiver output. Once opened Sigmira will play and demodulate the signal just as if it were live input.

The file can be a .wav format file with any normal sample rate from 8000 to 48000 Samples/sec.

Several example .wav files are included with Sigmira. They are useful in demonstrating Sigmira's operation. See section 7, 'Wave File Input'.

3.14 Source Menu

Sigmira can operate with input from three different signal sources. The source is selected with the 'Source' menu at the top left of the main window.

Figure 22 - Source Menu

3.14.1 SDR-IQ™

If the SDR-IQ is connected operation will start immediately when selection is made.

3.14.2 Sound Card

Typically the sound card is used as the source when Sigmira is used with an external conventional receiver. The receiver's audio output is connected to the sound card input. See section 6 of this document.

When the sound card is selected as the source the maximum width of the spectrum and waterfall displays is 10 kHz. The Sigmira frequency controls do not control the tuning of the external receiver. (That is coming in a future version.)

3.14.3 Wave File

Playback begins when a .wav file is opened with the File->Open selection. (Opening a wave file with File->Open also automatically sets the Source selection to Wave File.)

When 'Wave File' is selected as the source the maximum width of the spectrum and waterfall displays is 10 kHz.

3.15 View Menu

Sigmira has several displayable sub-windows. They include the Signal Database, Phase Plane, S4285 Control, and Rx Text displays. They are described in sections 3.3 and 3.4. The View menu can be used to cause these sub-windows to be viewable.

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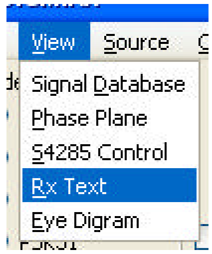


Figure 23 - View Menu

3.16 Calibrate Menu

Under the top level "Calibrate" menu there is a menu item that allows for calibration of the SDR-IQ crystal frequency.

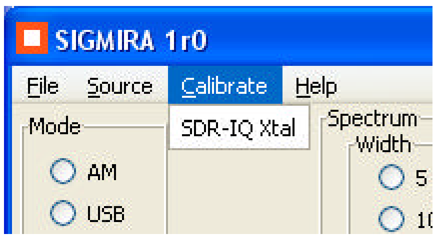


Figure 24 - Calibrate Menu

3.16.1 SDR-IQ™ Xtal

The SDR-IQ™ operates with a quartz crystal oscillator frequency standard. Crystal oscillators are highly accurate but have some small frequency offset. That offset is evident with current communications technology. Fortunately it is easy to compensate for the offset.

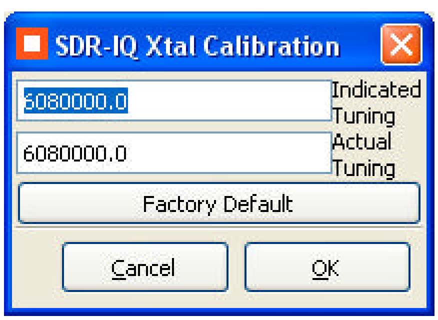


Figure 25 - SDR-IQ Crystal Frequency Calibration

The SDR-IQ Xtal Calibration window allows one to adjust Sigmira to cancel out the frequency offset. When the window comes up both the 'Indicated Tuning' and 'Actual Tuning' are set to the current indicated tuning. If either one is known to be incorrect the correct value can be entered.

When the 'OK' button is clicked Sigmira will adjust so that thereafter the indicated frequency will match the actual.

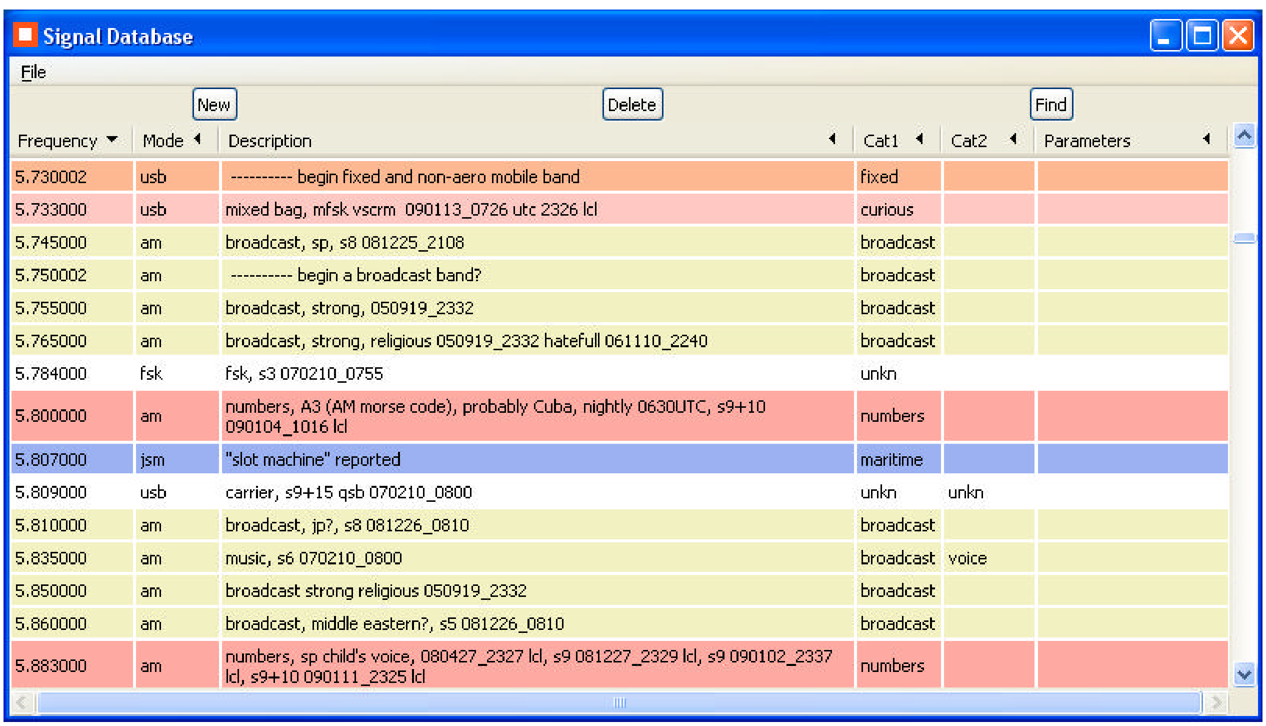
As an example of how this can be done: One would tune to a known frequency standard such as WWV. The higher the frequency the more accurate the calibration. Bring up the phase plane display. (See section 3.4.) The signal should appear as a dot or line segment radiating from the center of the display. If Sigmira is tuned exactly to the carrier frequency the dot/line will be stationary and not revolve around the center. If the signal is higher in frequency the dot/line will revolve around the center counter-clockwise. Adjust the tuning frequency so that the dot/line motion is the minimum possible. At this point the actual frequency will be most correct. Bring up the calibration window. Correct the displayed 'Actual Tuning' to be the known correct frequency of the reference signal and click 'OK'. (Note that the best practically achievable accuracy is about 0.5 Hz and that the crystal reference in the SDR-IQ can easily drift several Hz in an hour.)

The 'Factory Default' button allows the calibration to be reset to the original nominal value.

4 Signal Database

The Signal Database allows one to log, categorize, recall, and instantly tune to signals. The number of entries is unlimited. A database already containing over a thousand entries is included in the Sigmira package.

The Signal Database is brought up by clicking the menu View=>Signal Database in the Sigmira main window. The Signal Database will appear as shown in Figure 26, below.



Frequency	Mode	Description	Cat1	Cat2	Parameters
5.730002	usb	---------- begin fixed and non-aero mobile band	fixed		
5.733000	usb	mixed bag, mfsk vscrm 090113_0726 utc 2326 lcl	curious		
5.745000	am	broadcast, sp, s8 081225_2108	broadcast		
5.750002	am	---------- begin a broadcast band?	broadcast		
5.755000	am	broadcast, strong, 050919_2332	broadcast		
5.765000	am	broadcast, strong, religious 050919_2332 hatefull 061110_2240	broadcast		
5.784000	fsk	fsk, s3 070210_0755	unkn		
5.800000	am	numbers, A3 (AM morse code), probably Cuba, nightly 0630UTC, s9+10 090104_1016 lcl	numbers		
5.807000	jsm	"slot machine" reported	maritime		
5.809000	usb	carrier, s9+15 qsb 070210_0800	unkn	unkn	
5.810000	am	broadcast, jp?, s8 081226_0810	broadcast		
5.835000	am	music, s6 070210_0800	broadcast	voice	
5.850000	am	broadcast strong religious 050919_2332	broadcast		
5.860000	am	broadcast, middle eastern?, s5 081226_0810	broadcast		
5.883000	am	numbers, sp child's voice, 080427_2327 lcl, s9 081227_2329 lcl, s9 090102_2337 lcl, s9+10 090111_2325 lcl	numbers		

Figure 26 - Signal Database

Each signal entry in the database is one row. Right-clicking on a row tunes Sigmira to the frequency shown in Frequency field for the selected entry. The right-click also sets the demodulation mode according to the Mode field.

4.1 Sorting

Each entry has six fields: Frequency, Mode, Description, Cat1, Cat2, and Parameters. The six fields make up the six columns of the view. Left-clicking on the heading of a column causes the database view to be sorted based on that field. Clicking a column heading the first time causes an ascending sort. Clicking a second time causes a descending sort. If a signal entry is already selected when a sort is performed then that signal entry will be scrolled to the center of the view.

4.2 Editing

All of the fields of an entry are editable. Left-click on a field twice in order to edit it. Note that edits made are not saved to disk until Save or Save As is clicked in the Signal Database window File menu.

4.3 Fields

The Frequency field is in MHz. Whenever a new database entry is created Sigmira automatically enters the currently tuned frequency.

The Mode field corresponds with the demodulation modes in the upper left of the Sigmira main window. The Mode field is not case sensitive. "am", "AM", "aM", and "Am" are all equivalent. If the content of the Mode field doesn't correspond with one of Sigmira's recognized modes Sigmira defaults to USB. Whenever a new database entry is created Sigmira automatically enters the currently selected mode.

The Description field is available for any descriptive information the user would like to associate with the signal. Whenever a new database entry is created Sigmira automatically enters the string "new" plus the current date and time. This may of course be edited.

The Cat1 and Cat2 fields offers a means to place signals in user defined sortable categories. Clicking on the head of the Cat1 or Cat2 column will sort the database based on the contents of that field. So if all of the "numbers" station signal entries have the string "numbers" in the Cat1 field then sorting on the Cat1 column will display the numbers stations grouped together.

The contents of the Cat1 field are also interpreted to give a background tint to each entry. Ten predefined values for the Cat1 field are recognized. The values and the associated colors are given in the table below. The categories correspond roughly with the categories in the US Frequency Allocation Chart, http://www.ntia.doc.gov/osmhome/Chp04Chart.pdf.

Cat1 field value	Tint
av	light blue
broadcast	yellow
cb	light yellow
curious	pink
fixed	brown
ham	green
maritime	blue
misc	gray
numbers	red
ref	light gray

The Parameters field provides a means to associate additional demodulation parameters with a signal. The Parameters field will be fully implemented in a future version of Sigmira. The parameters can include things such as bit rate and interleave for STANAG 4285 signals or shift and baud rate for FSK signals, etc.

4.4 Buttons

Clicking the Find button in the upper right portion of the Signal Database window causes the entry in the database closest in frequency to the current main tuning to be scrolled to the center of the database window and highlighted.

Clicking the Delete button in the upper center portion of the Signal Database window causes the current selected entry to be deleted.

Clicking the New button in the upper left portion of the Signal Database window causes a new entry to be created. The Frequency field of the new entry is automatically filled in with the current tuning frequency as shown in the Sigmira's main window. The Mode field is automatically filled in with the current mode. The Description field is filled in with the string "new" plus the current date and time.

4.5 Signal Database File Menu

In the menu bar at the top of the Signal Database window is a File menu. The File menu has four entries, Open, Read, Save and Save As.

Selecting File=>Open brings up a dialog window that can be used to open a signal database file. At startup Sigmira automatically opens the signal database file "sigmira.sdb". Using the Open dialog a different file can be opened. The contents of the newly specified file become the operating signal database. The newly specified file name also becomes the default for the Save function.

Selecting File=>Read brings up a dialog window that can be used to read in an additional signal database content from a file. The contents of the file are added to the current operating signal database. The file name specified in the Read operation does not change the default file name for Open and Save operations.

The signal database can be saved to disk by following the File=>Save or File=>Save As menu dialogs in the Signal Database window. The Save operation saves the signal database to the default signal database file name. The default file name at start-up is "sigmira.sdb". With the Save As operation the database is saved to a newly specified file. The newly specified file name becomes the default file name. Subsequent 'Save' selections will write to the remembered destination file name. Any save to a file overwrites the previous contents if any.

On exit Sigmira backs up the current database contents to the file "sigmira_bu.sdb" regardless of other operations.

5 SDR-IQ™ Operation

Connect the SDR-IQ™ to the computer with the USB (Universal Serial Bus in this case) cable. Connect an antenna to the SDR-IQ™. Start Sigmira and select the SDR-IQ™ as the signal source via the 'Source' menu at the top left of the window.

6 Conventional Receiver Connection

Sigmira can operate with a conventional short-wave receiver. The receiver must have and must be operated in the Single Sideband (SSB) mode. Upper Sideband (USB) mode is preferable.

Connect the audio output of a short-wave receiver to the audio "Line In" audio input of the PC.

If you are fortunate your receiver will have an output that is before the volume control. In that case the PC receives a good constant level signal regardless of the receiver's volume control setting. On some receivers such an output is labeled AFSK Out. Otherwise you can tap the speaker output, set the volume for a moderate level, and avoid making changes to the level.

Adjust the gain and volume controls so that the signal isn't so strong that it becomes clipped or distorted. The controls on the receiver and also the PC's Recording Control window can be use to make adjustments. The PC sound controls can be accessed by clicking start=>run... and typing "sndvol32" or they can be accessed through the control panel by clicking start=>Control Panel=>Sound and Audio Devices=>Audio=>Volume. The resulting window will likely look like:

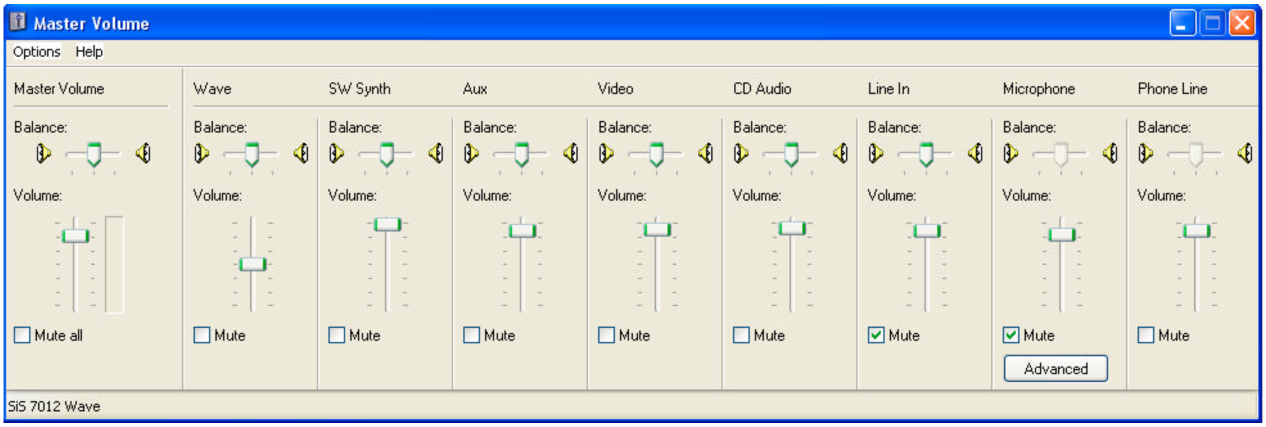


Figure 27

(It is a good idea to mute the "Line In" in the Master Volume window.)

Then the "Line In" input needs to be selected in the Recording Control.

To get to the Recording Control window select Options=>Properties=>Recording. You should get a window like:

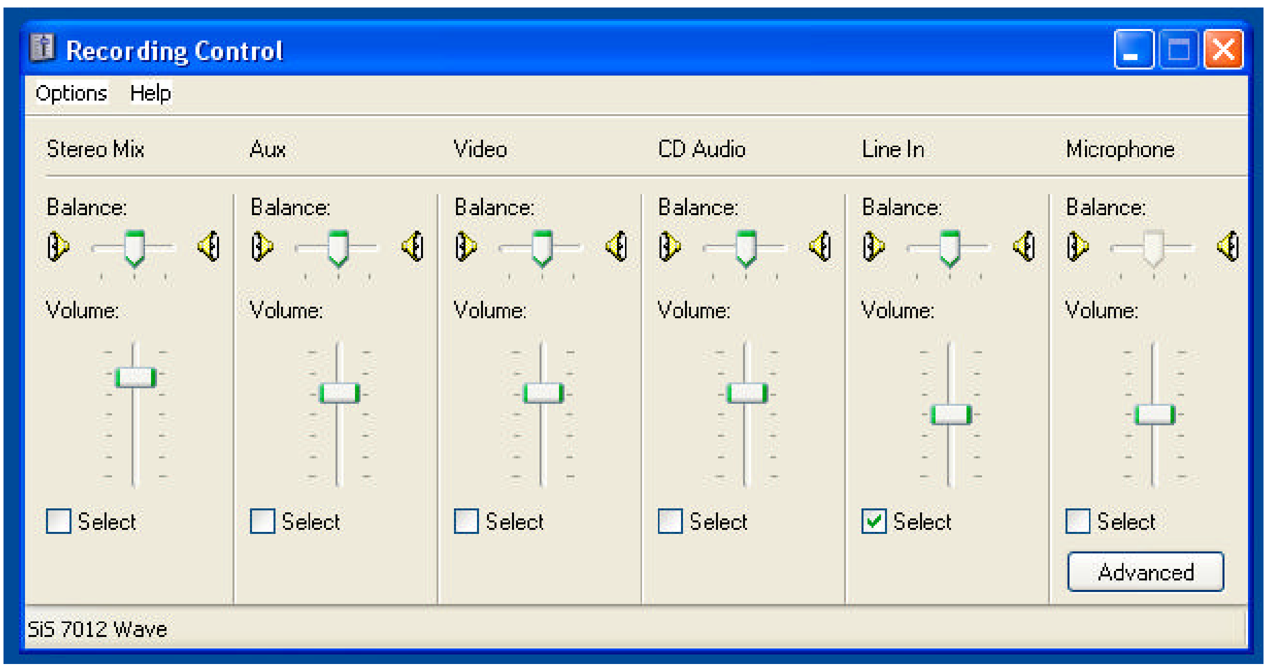


Figure 28

Click the Select box under Line In and then adjust the Volume slider.

The optimum volume level setting is obtained when even the strongest input does not "peg" Sigmira's Strength indicator. Start Sigmira, select "Sound Card" source, and select the AM mode. Tune in a strong signal (of any type) on the receiver. Observe the Sigmira Strength indicator and adjust the volume so that the strength indicator never goes to full scale.

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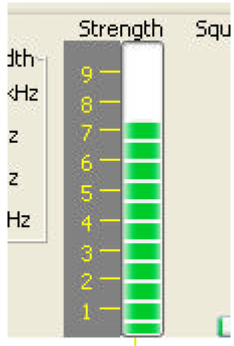

Figure 29

7 Wave file Input

Sigmira can operate on prerecorded .wav files without an external receiver connected. Start the program and from the top menus select: File => Open. To find the example files first click on the "Sigtools" button:

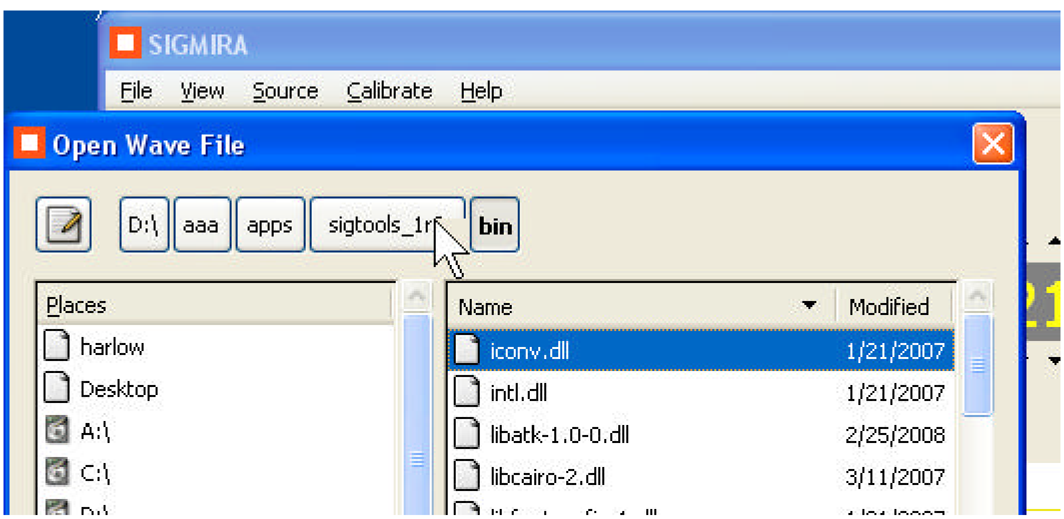

Figure 30

The "examples" directory will then appear. Double-click on it:

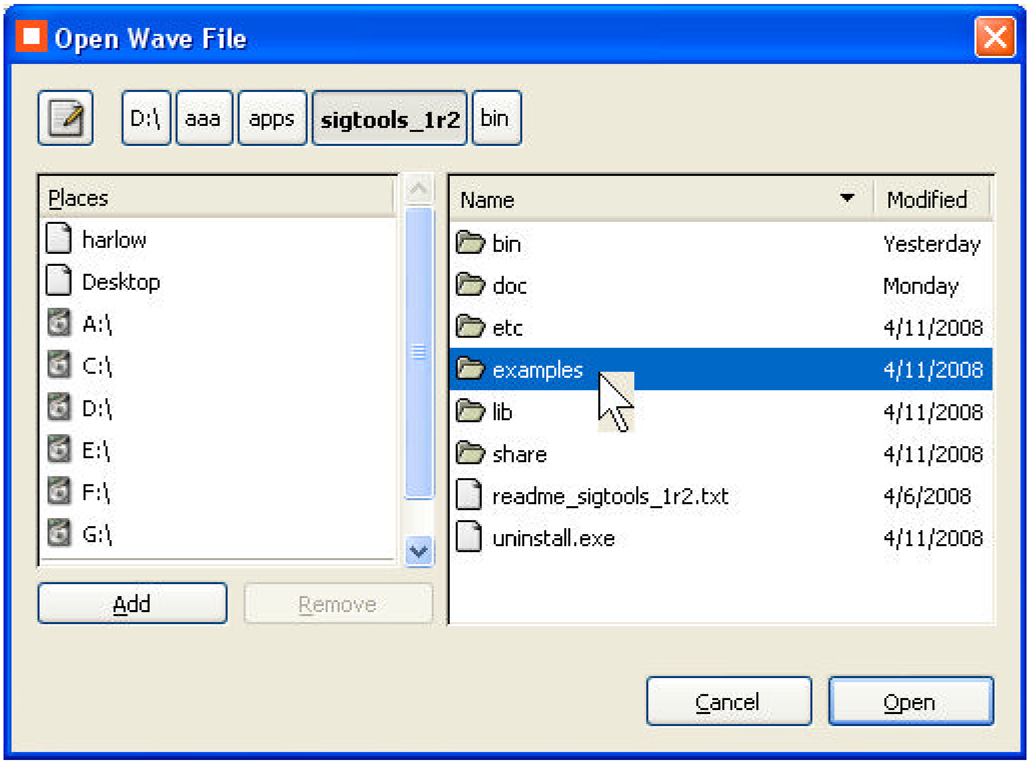

Figure 31

Then select the RTTY example file by double-clicking on it:

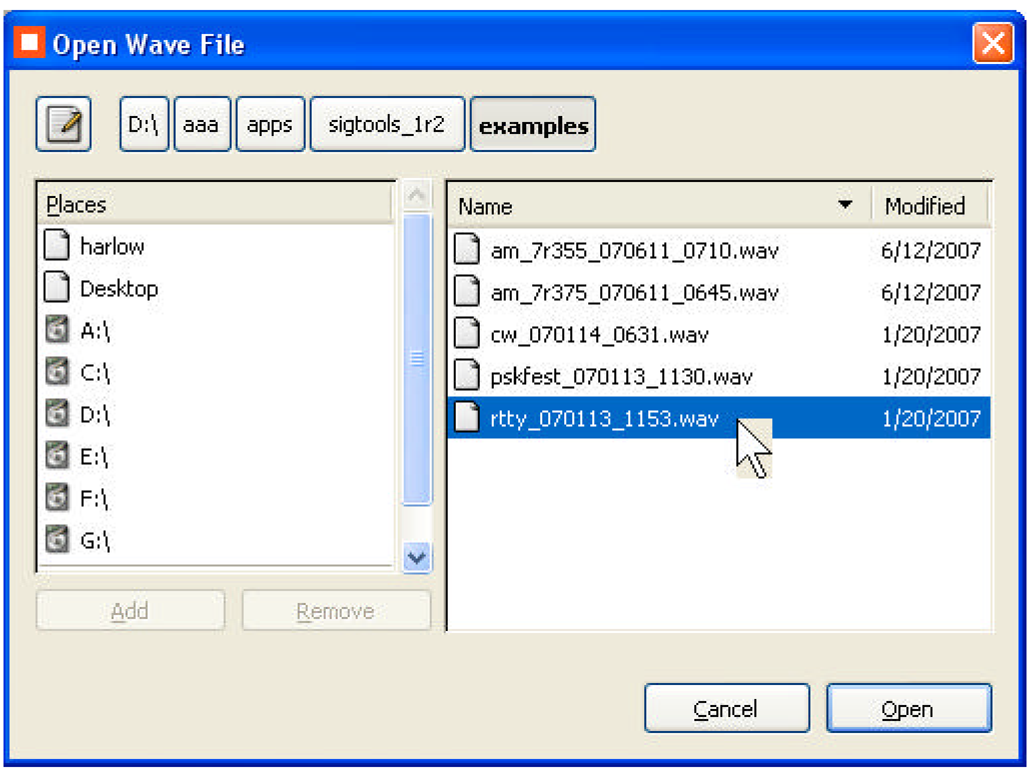

Figure 32

The example file will then start playing. Click on the "Lock Center" button. Click on the Spectrum Width 5 kHz button. Right-click on the 1070 mark on the waterfall frequency scale. The display will look something like:

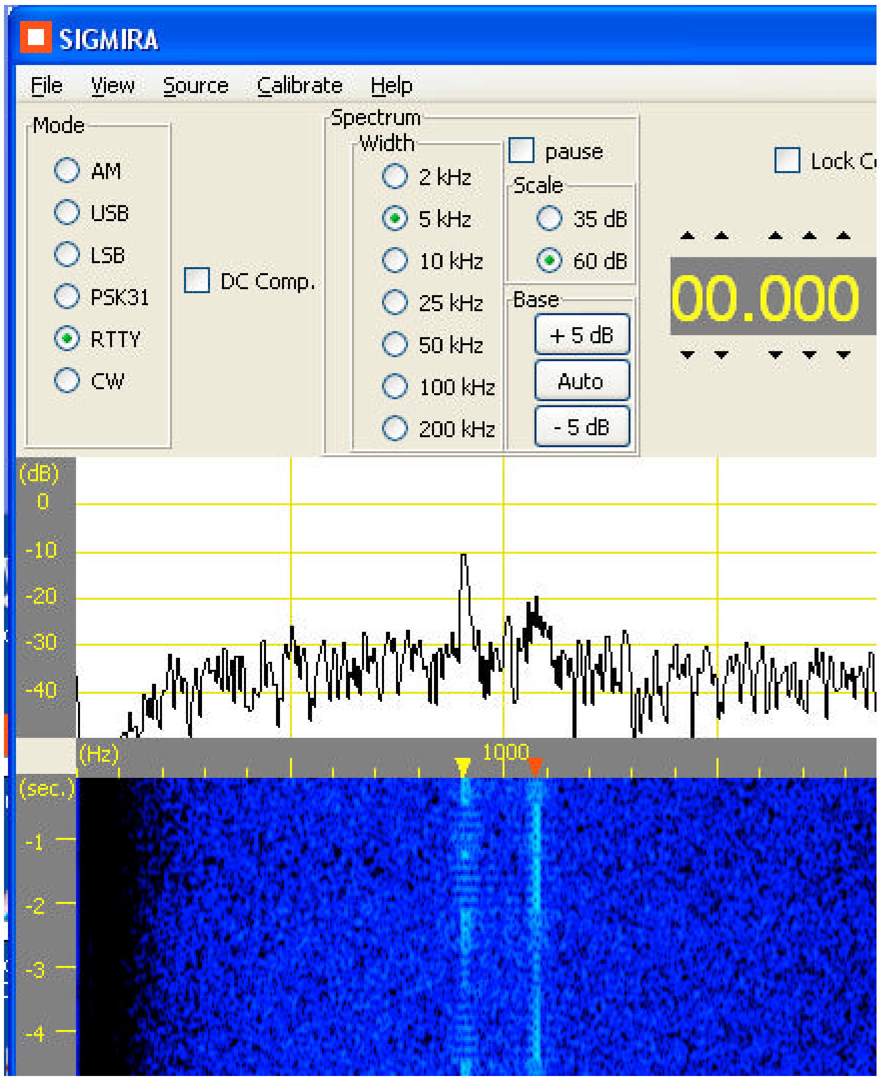

Figure 33

Click on the RTTY mode 'radio button':

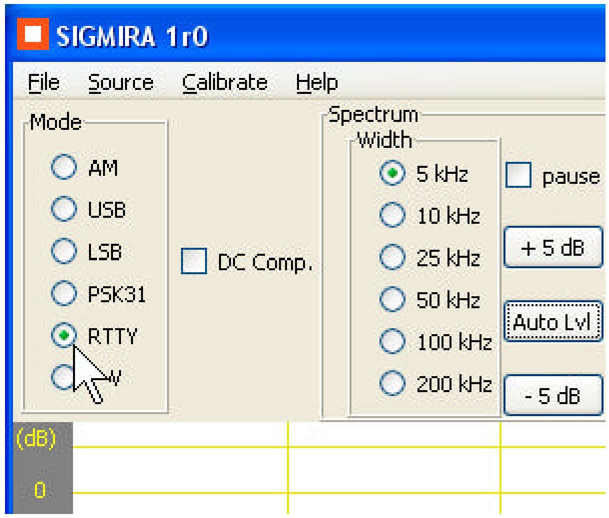

Figure 34

The demodulated message will then start to appear:

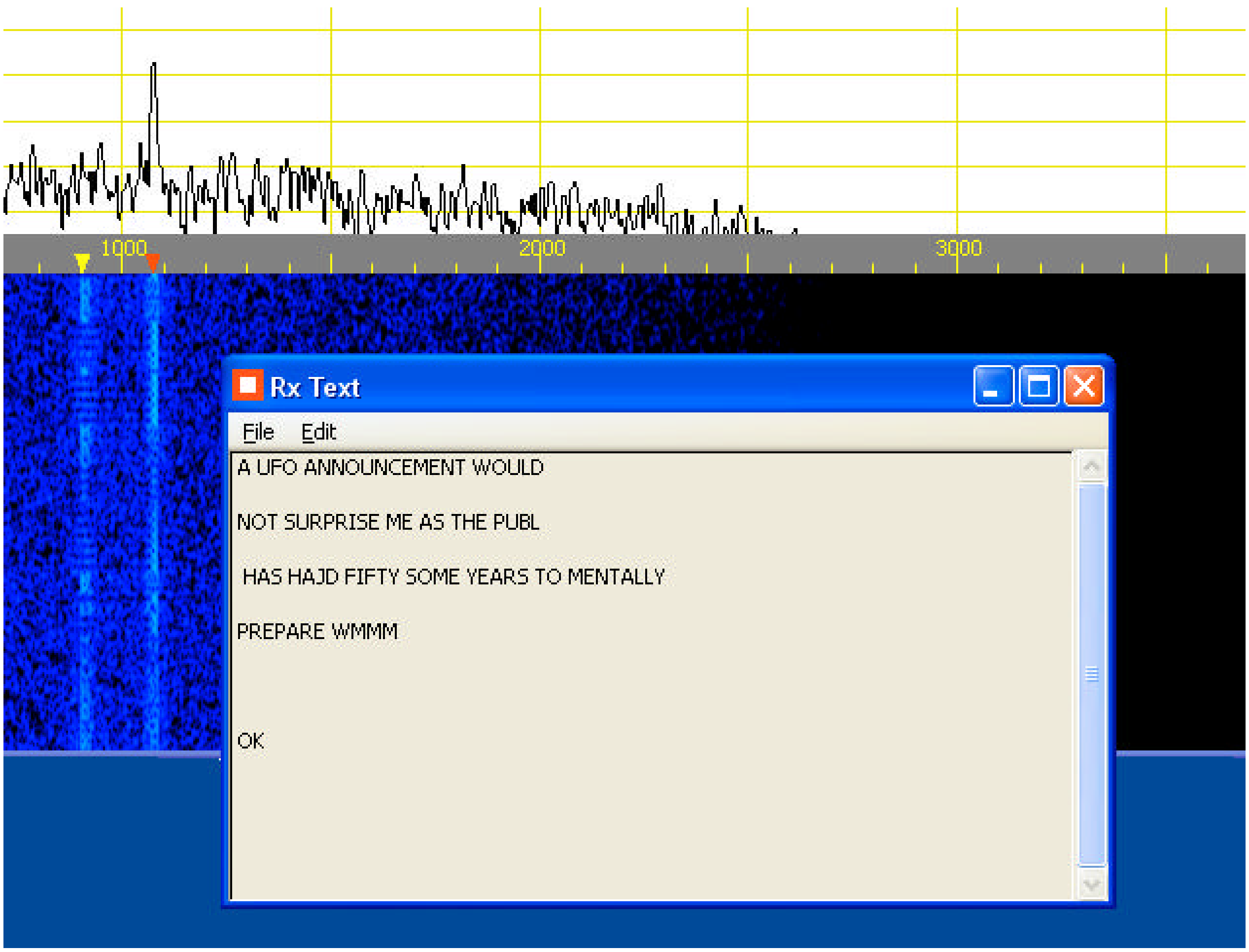

Figure - 35

8 Program Installation Details

On some machines Sigtools may not install correctly on the first install. In that case there are two visible symptoms. One is that at installation time a pop-up will appear asking if a .bat script should be allowed to run. The other is that when Sigmira is started after installation its lettering appears as squares rather than letters.

The cause is that the PC's particular security settings blocked a .bat script that the installer uses. It should be allowed to run. The script is necessary and it is not harmful. (The script remains under the installation directory and can be examined.)

Unfortunately allowing the script to run doesn't always work on the first install. It does work on the second install. The reliable solution if the problem occurs is to allow the script on the first install, uninstall, and then install again.

The following problem should be eliminated as of Sigmira 1r3:

> After first installation on some systems Sigmira complains that it can't find ftd2xx.dll. ftd2xx.dll is the USB driver dynamically linked library from Future Technology Devices International, Ltd. The easiest solution is to copy the file <sigtools install root>\drivers\i386\ftd2xx.dll (<sigtools install root>\drivers\amd64\ftd2xx64.dll if you are on a 64 bit machine) to the directory c:\WINDOWS\system32

9 Credits

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Sigmira™ is a trademark of Steven A. Harlow.

SDR-IQ™ and SDR-14™ are trademarks of RFSpace, Inc. http://www.rfspace.com/Home.html

Sigmira uses GTK, GDK, Pango, Cairo and OpenGL, which are licensed under the GNU Lesser General Public License (LGPL). http://www.gtk.org http://www.pango.org http://cairographics.org http://www.opengl.org

Sigmira uses USB drivers from Future Technology Devices International, Ltd. [FTDI]. http://www.ftdichip.com/Drivers/VCP.htm