# WSPRSONDE

A simultaneous eight-channel WSPR / FST4W beacon system

## User's Guide and Specifications

Document Version 1.0
March 25 2025

# Table of Contents

# Illustration Index

# IMPORTANT!

The WS-8 (WSPRSONDE) is an experimental Amateur Radio device, and has not been submitted for formal FCC certification. When operated under normal conditions the WS-8 should comply with U.S.A. FCC requirements for harmonic and other spurious content, but the responsibility for proper operation is assumed by the operator.

At least in some cases, the WS-8 USB port will not work when directly connected to a USB 3.0 port. However, it will work with an intermediate USB hub (even a USB3 hub.) In any case, I recommend using a USB hub with a fairly short cable to the WS-8. The USB connection is required for initial WS-8 configuration, but is not necessary after configuration.

For more information, contact us at https://turnislandsystems.com/

# Changes to This Document

V 0.1: First draft

V 0.2: Updates to firmware, new commands

# New Features (software version 2.3.2)

Two new features allow flexible control of the WS-8 operation:

## *Channel Modes:* `CHAN`

Each output channel can be configured in one of three modes:

- Beacon – This will be the globally-selected WSPR of FST4W-x modes.
- CW – The channel will transmit a “Tone-Zero” signal for the duration of the scheduled channel transmit frames.
- Fixed-frequency – The channel will transmit a continuous “Tone-Zero” signal.

See the CHAN command description in this document for details.

## *Flexible Scheduling:* `CRON`

This is a loose subset of the Linux “cron”, allowing any WS-8 command to be executed on a minute/hour schedule. This can be used to change any parameter option, including channel transmit schedules, frequencies, and modes.

See the CRON command description in this document for details.

# Introducing the *WSPRSONDE*

This document describes the WSPRSONDE Version 2, which has some changes from the initial Version 1 unit:

- Addition of a 250 mW transmitter output power option. This configurable option applies simultaneously to all eight outputs. The default output power is 1W.
- A smaller enclosure.

With the Version 2 release comes updated firmware, containing new features and options. This firmware is also compatible with the Version 1 unit.

## *What it Does*

- Simultaneously transmits WSPR, FST4W-120 or FST4W-300 signals on up to eight channels, on any frequency between 1 and 60 MHz (usually the 160 – 6 meter ham bands).
- Precise frequency accuracy and stability using external 10 MHz reference clock
- One Watt output power on each channel, 250 mW option.
- Flexible per-channel transmit scheduling, optional CW identification
- Can run with or without USB-connected computer

## *Dimensions*

The *WSPRSONDE* V2 is housed in a 1RU (Rack Unit) enclosure:

19” wide x 1.75” high x 4.9” deep

It weighs slightly under three pounds.

## *Connections*

All ports are on the WS-8 front panel. They are:

- Channels 1-8 Output - SMA jacks
- GPS Antenna – SMA jack
- GPS Auxiliary (antenna connection splitter output) – SMA jack
- Reference Clock Input (10 MHz) – SMA jack
- USB - type B
- T/R Switch control output – 1/8” mono/stereo jack
- Power - 5.5 x 2.1mm barrel jack

## Power

The *WSPRSONDE* requires a 9-16V DC power source, and uses a 5.5 x 2.1mm barrel jack power connector, positive pin and negative sleeve.

Typical Power Consumption, all ports transmitting at 10 MHz into 50 Ohm resistive load:

| 1 Watt Transmit Mode | | |
|---|---|---|
| Vin | $I_{DC}$ | Watts |
| 9 V | 2.12 A | 19.1 W |
| 12 V | 1.51 A | 18.1 W |
| 16 V | 1.13 A | 18.1 W |

| ¼ Watt Transmit Mode | | |
|---|---|---|
| Vin | $I_{DC}$ | Watts |
| 12 V | 0.48 A | 5.8 W |

A regular 9V or 12V “wall wart” DC power supply is usually adequate, but any source of clean DC power can be used. Supply switching noise is typically not a problem, as this input voltage is connected to a secondary internal regulator with distributed supply-noise filtering.

## GPS Antenna and GPS AUX

The WS-8 requires a connection to an external GPS antenna, either directly, or through a GPS antenna splitter. The WS-8 will provide 3.3V “phantom” power to the typical active GPS antenna.

The WS-8 GPS antenna port feeds an internal passive splitter, one output feeding the internal GPS receiver, and the other connected to the GPS AUX jack. This AUX jack can be used to feed an external GPSDO. This internal splitter has a 6dB loss, so low input levels may not provide enough signal for WS-8 or GPSDO operation. If an external splitter is used, it should probably be one with amplification.

## 10 MHz Reference Clock

An accurate and stable 10 MHz reference clock is required by the WS-8, with an input level (sine or square-wave) between -10dBm and +20 dBm. A GPS Disciplined Oscillator is typically used. The REF CLK port provides a 50 Ohm termination.

If no reference clock is provided, the WS-8 will optionally still function, but at a greatly-reduced accuracy and stability. See the “**`CLK`**” command for configuration details.

## USB connection (for configuration and monitoring)

The WS-8 USB port provides:

- A serial port connection used for monitoring and temporary configuration changes

- A “flash drive” style file access to the “commands.txt” configuration file
- A “flash drive” style file access used when updating the WS-8 program

The USB connection is required for initial WS-8 configuration, but is not necessary after configuration.

At least in some cases, the WS-8 USB port will not work when directly connected to a USB 3.0 port. However, it will work with an intermediate USB hub (even a USB3 hub.) In any case, I recommend using a USB hub with a fairly short cable to the WS-8.

### Channels 1-8 Output

These SMA jacks are the outputs of the six WS-8 channels. They provide a 1W square-wave signal, which *must* be passed through an appropriate filter before being connected to the antenna. While these outputs can be operated unloaded (no connection) they should not drive an impedance below 25 Ohms. Keeping the SWR at 2:1 or better is recommended. The amplifiers do have over-current protection, and will shut down when over-loaded.

## Output Filters or Filter/Combiner

For more details on the design principles of these filters, please see the document “General Technical Overview” on the Turn Island Systems downloads page: https://turnislandsystems.com/downloads/

### *Six-Band Filter/Combiner*

The 6-Band Filter/Combiner has connections for 80, 40, 30, 20, 15, and 10 meters, with about 1dB loss. The combiner has a monitor port connected to the antenna output port through a -40dB attenuator.


*Illustration 1: 6-Band Filter-Combiner*

## *Nine-Band Filter/Combiner*

The 9-Band Filter/Combiner has connections for 80, 40, 30, 20, 17, 15, 12, 10. and 6 meters, with about 1dB loss. Using hand-wound toroid core inductors instead of smaller surface-mount components the 9BFC is designed to tolerate significant antenna SWR mismatches without overheating. Extreme SWR will still cause WS8 output-channel overload and shut-down.

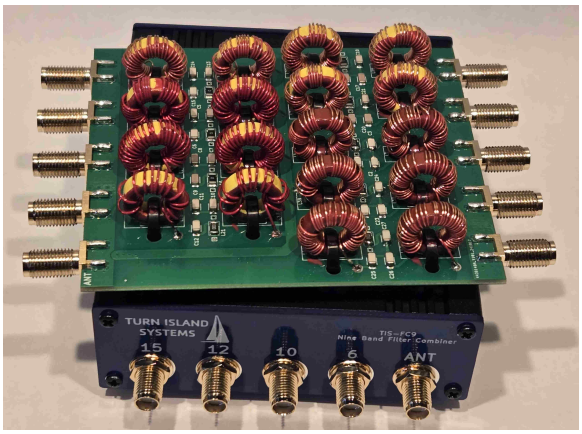




*Illustration 2: 9-Band Filter-Combiner*

### *Single-Band Filters*

Single-Band filters are available on request.

# Configuring the WS-8, Step by Step

## *Connect the Power Cable*

## *Status LED:*

When power is connected to the WS-8 the multicolor Status LED will blink to show the current state:

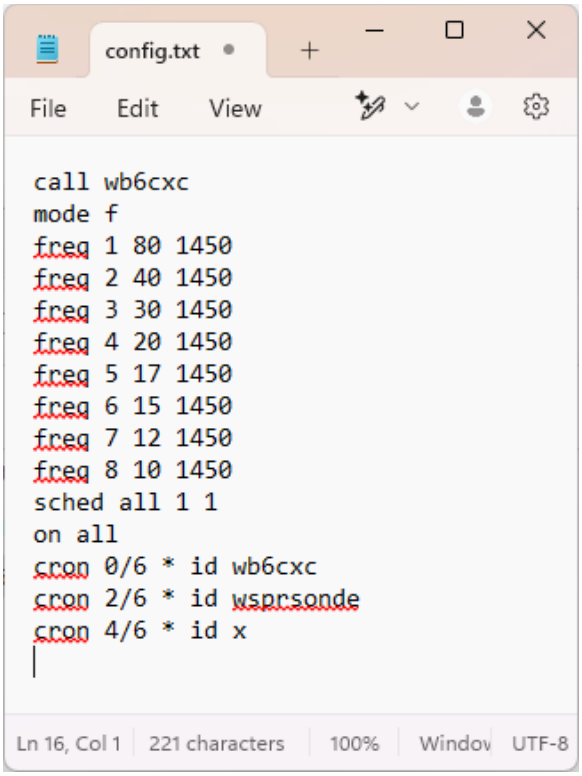
- Solid Green : Initializing
- Red/Green flash: call sign and/or grid not initialized at start of frame
- Slow Green on/off : No channels transmitting
- Blue with off-flash : One or more channels transmitting
- Red, one flash repeating : Amplifier power Voltage fault
- Red, two flashes repeating : Channel amplifier over-current
- Red, three flashes repeating : Loss of GPS
- Red, four flashes repeating : Input power supply fault
- Red, continuous flash : Loss of Reference Clock fault
- Red, continuous on : watchdog timer shutdown

## *Connect the USB Cable*

A “Flash Drive” file window will probably pop up. If not, search for the drive (it will probably be named “WS-8 #(serial #)”, but this name can be changed at will.) In some cases the drive will not appear until the USB cable is disconnected then reconnected.

There will be at least one file shown:

- “`config.txt`” – This is the configuration file for the WS-8, and is read at power-up, or when the command “**`CONFIG R`**” (read the configuration file) is entered on the command line.
- Previous versions of the WS-8 software wrote the “info.txt” file that contained hardware and software revision information. This was found in some cases to over-write the “config.txt” file. Starting with software version 2.2.3 the “info.txt” file is not updated, and if present will hold incorrect values. This file was for information purposes only and does not affect WS-8 operation.




Edit the `config.txt` file as appropriate for your station. You can also type these commands in via the serial port command line interface, but any changes will not be saved on a power-cycle. Once the configuration file is as you want it, either type “CONFIG R” (read the config file), or power off the WS-8 (unplug the power cable). When the WS-8 restarts it will read the updated `config.txt` file

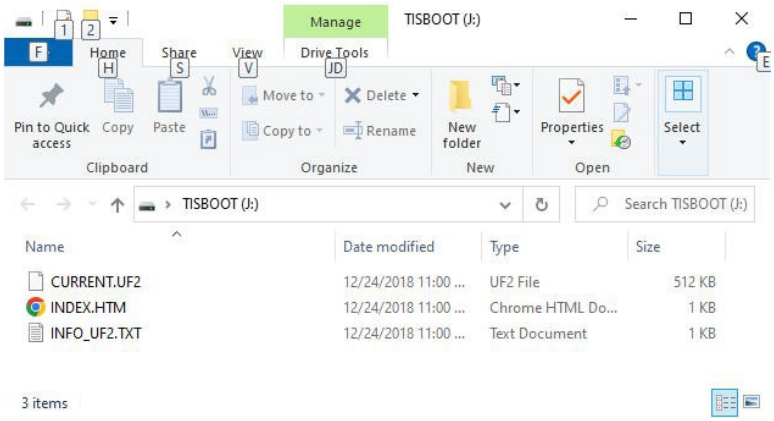
## *Typical Configuration File [`config.txt`]*

```
# this is a comment
# commands aRe NoT cAsE sEnSiTiVe
CALL [your callsign]
# GRID is optional; if not set the grid will be calculated using GPS position:
GRID [4-character grid]
# POWER is optional; if not set a power level of "30" (dBm / 1 Watt) will be used:
POW [0, 3, 7, 10, 13, 17 ... 50, 53, 57, 60]
# See configuration commands for mode options, WSPR is default
MODE WSPR

# Sets channel 1 to the 80 meter WSPR band, 1400 Hz default effective tone:
FREQ 1 80
# Sets channel 2 to the 40 meter WSPR band, 1525 Hz effective tone:
FREQ 2 40 1525
# Sets channel 3 to 10.140000 MHz (10.138 MHz + 2000 Hz effective tone
FREQ 3 10140000

# setting all channels for continuous transmission
SCHED a 1 1
# setting channel 2 to transmit every other frame, starting at minute 00:
SCHED 2 1 2
# setting channel 3 for one out of four frames, randomized:
SCHED 3 R 4

# Enable the serial port report of basic per-channel status
# at the start of each frame (this is the default):
report 1

#turn on channel 7
ON 7
#turn on all channels
ON all
```

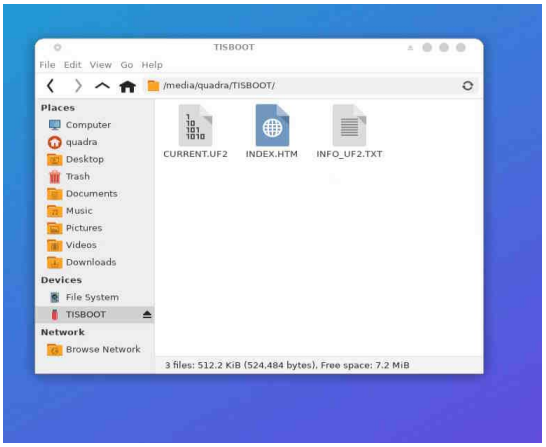
## *Updating the WS-8 Program*

You can install a different version of the WS-8 program, found at https://turnislandsystems.com/downloads/

On the command line, enter "**`LOADNEW 1`**", and the WS-8 will halt normal operations and enter the program update mode. A flash drive folder will pop up (or you may have to search for it):




On linux, the drive might look like this:




Just drag and drop the new ".UF2" file onto the drive window. The WS-8 will install the new program and reboot. Your configuration settings will not be changed.

When using command-line Linux to access the WS-8, simply copy the new ".UF2" file to the TISBOOT directory.

# Command List

To see the full list of available commands, type “?” or “??” in the command line.

These will change as the software evolves, but the basics will retain compatibility. All commands are completely case-insensitive.

In the following commands unless noted otherwise **[channel]** will be a value from 1 to 8.

Entering a command followed by a '?' will display help for that command.

## *Essential Configuration Commands*

### MODE [W/F] ([rate])

```
The MODE command sets the beacon mode: WSPR or FST4W (you can type in “WSPR” or
“W”, only the first character is used

MODE WSPR : Puts the WS-8 in WSPR mode
MODE FST4W : FST4W-120 mode
MODE F 300 : FST4W-300 mode

When the mode is changed, the WS-8 will re-configure all channel FSK rates and
frequencies

The WS-8 default is WSPR mode
```

### CALL [callsign]

```
The callsign must be entered for the WSPR or FST4W frame data to be created. Only
basic callsigns are supported.
```

### GRID [four-character grid square]

```
This optionally sets a fixed four-character grid square.
The default is that the grid be continuously updated using the GPS position.
```

### FREQ [channel] [frequency] ([optional tone offset])

```
This sets a channel frequency.

If a band number (160 to 6 meters) is entered as the frequency parameter, the
default offset (effectively a tone frequency offset from the standard WSPR dial
frequency) is 1400 Hz.

A different tone offset between -3000 and 3000 Hz can be entered.

If the frequency parameter contains a value between 600,000 and 60,000,000 then it
is interpreted as a frequency (in Hz).
```

When in WSPR mode, the requested and set frequency is "tone 1.5".

In FST4W mode the requested and set frequency is "tone 0".

The actual set frequency will generally be close to, but not exactly the frequency requested.

Entering “FREQ” with no parameters will show the set frequencies for all channels.

## SCHED [channel] [sequence] [repeat]

This sets the channel transmit schedules. The channel parameter will be a number between 1 and 8, or optionally 'A' (or “ALL”), which will apply the following parameters to all eight WS-8 channels.

If a channel mode (see the following CHAN command) has not already been set, the SCHED command will set the channel mode to the default “Beacon”.

Sequence can be set to Random. Each channel is independently randomized

Sequence and Repeat establish the transmit rate as follows (two-minute WSPR frames):

```
SCHED A 0       All channels disabled
SCHED 7 0       Channel 7 disabled
SCHED A 1 1     All channels transmit every frame
SCHED 1 1 2     Channel 1 transmits every other frame, starting at minutes = 00
SCHED 2 2 2     Channel 2 transmits every other frame, starting at minutes = 02
SCHED 3 3 3     Channel 3 transmits every third frame, starting at minutes = 04
SCHED 4 R 1     Channel 4 transmits one out of two frames at random
SCHED 5 R 4     Channel 5 transmits one out of eight frames at random
```

Entering SCHED with only the CHANNEL parameter will display that channel's schedule

Entering SCHED with no parameters will display the schedule for all channels

## ON [channel]

## OFF [channel]

ON [ALL] / OFF[ALL] enables / disables all channels.

The ON and OFF commands enable or disable the WS-8 transmitter outputs. The default is OFF.

## POWER [dBm]

This optionally sets the WSPR/FST4W indicated power parameter.

The default value is 30 dBm (1 Watt), or 23 dBm (as close to 250 mW as the protocol allows), depending on the WS-8 "**1WATT []**" output power setting. The valid settings are 0, 3, 7, 13, 17,..., 53, 57, 60.

## CHAN [channel / ALL] [Beacon / CW / Fixed / Unconfigured]

Sets channel mode

- Beacon mode: send WSPR or FTS4W according to the channel transmit schedule.
- CW mode: transmit "Tone Zero" for the duration of a scheduled frame.
- Fixed mode: transmit Tone Zero continuously.
- Unconfigured : channel disabled pending configuration.

## *Other Configuration Commands*

## ID [short message]

This optionally enters a short ID message that will be sent at the end of every frame transmission using on/off keyed Morse code.

"ID X" will delete the ID message

The STATUS LED will flash blue and green during transmission of the ID message

## CRON [mm] [hh] [command]

Scheduled command option

```
mm : minute (00 – 59)
hh : hour (0 – 23)
command : up to 31 characters (including spaces)

CRON X [n / all] deletes cron entry [n / all]
mm and hh use a subset of Linux crontab syntax, including '*' and '/'
NOTE: cron only runs at the start of mode frames, so an odd-minute mm parameter
    will not be executed when in WSPR or FST4W-120 modes
    Use [*, 0, 2, 4, ... 58] when in WSPR or FST4W-120 modes, and [*, 0, 5, 10, ...
    55] when in FST4W-300 mode
```

Examples:

- `cron 0 0 sched a 1 1` (set all channels to a 1:1 transmit schedule at 00:00 Z)
- `cron 30 12 sched a 1 5` (set all channels to a 1:5 transmit schedule at 12:30 Z)
- `cron 0/12 * chan 3 c` (set channel 3 to CW mode every 12 minutes starting at minute 0)
- `cron 6/12 * chan 3 b` (set channel 3 to beacon mode every 12 minutes starting at minute 6)

The cron task list is checked at the start of each frame (2 minutes in WSPR or FST4W-120 modes, 5 minutes in FST4W-300 mode). The cron task list can contain up to 32 entries. Entering “cron” (with no parameters) will show all list entries.

## LOADNEW [1] (include the "1")

```
This will halt the WSPRSONDE for the loading of a new program

Copy the new "UF2" file into the TISBOOT directory, and the WSPRSONDE will restart
```

## Watchdog [minutes]

```
Force transmitter off if no command-line activity for [minutes].  Set to zero to
disable watchdog.
```

## REPORT [1/0]

```
This command enables or disables a basic status report at the start of a frame

"1" enables the per-timeslot report (this is the default setting)
```

## STATUS [#]

```
This shows various status messages

All: show all status reports
0: Channel status
1: Channel schedules
2: Current and Voltage monitors
3: Channel frequencies
4: Channel Frequency-Hop settings
5: Channel synthesizer settings ("Tone 0" frequency shown)
6: Reference Clock and GPS status
7: Fault condition report
8: Time display (hh:mm:ss)
9: Callsign, Grid, Power
10: About this WS-8
11: List of LED status states
12: List of board parameters and monitor conditions in csv format
13: Channel ON/OFF settings
14: Transmit power setting
15: Watchdog timeout setting
16: Reference clock slip count
17: cron list
```

## 1WATT [1 / 0]

```
Sets the channel output power: 1 = 1W, 0 = 250mW
```

## HOP [channel / "all"] [1 / 0]

"1" enables frequency-hopping on a given channel

The hopped frequency range runs from +0 to +127 * the FSK shift, or about +186 Hz in WSPR mode.

## CONFIG [R/D] (filename)

"R" (optional filename): reads the configuration file. The default filename is "config.txt"

"D" : displays all files on the internal drive. Please note that filenames must not include spaces!

## FILTER[1/0]

"1" enables the Gaussian FSK filter (default in FST4W mode)
"0" disables the Gaussian FSK filter (default in WSPR mode)

## FILE [R/D] (filename)

"R" (filename): displays the file contents.
"D" : displays all files on the internal drive. Please note that filenames must not include spaces!

## REF [1/0]

This command enables or disables the loss-of-Reference-Clock fault. Setting this parameter to 0 will disable the loss-of-clock fault

The default is 1 (enabled)

## GPS [timeout]

This command sets the timeout before the loss of GPS fault is declared.
The default is ten seconds, but this can be set between 1 and 600 seconds (default = 10 seconds).
Setting this parameter to 0 will disable the loss-of-GPS fault

## V5 [mV]

V5 : shows amplifier voltage and fault value (4500 mV default)
V5 [mV]: sets amplifier voltage fault value in millivolts (zero to disable fault indication).

The typical voltage is about 4.9V

## V12 [minimum voltage in millivolts] [maximum voltage in millivolts]

This command sets the allowable voltage range for the WS-8 power supply (nominal 12V)

The default is 8500 (8.5V) and 24000 (24V)
In normal operation there should be no need to change this setting
Entering "V12 0" will disable power supply monitoring
Entering V12 with no parameters will display the current values

## OVER: [maximum amplifier current in milliamps] (700 mA upper limit)

This command sets the allowable maximum DC current level for the channel output amplifiers.

When the current in any of the amplifiers exceeds this value it will be shut down for the remainder of the transmit cycle and a fault declared.

In normal operation there should be no need to change this setting.

## TIME [0 / 1]

TIME 1 : enables continuous display of the GPS time once per second
TIME 0 : disables display of the GPS time
Entering TIME with no parameters will display the current time (hh:mm:ss)

## NMEA: [0 / 1 / 2]

This command enables GPS NMEA sentences to be displayed as they arrive.

NMEA 0 : monitor none
NMEA 1 : monitor "RMC" sentence (RMC contains time and location).
NMEA 2 : monitor all sentences.

## TEST [option]

"0" : Transmit continuous Tone 0
"1" : Transmit continuous Tone 1
"2" : Transmit continuous Tone 2
"3" : Transmit continuous Tone 3
"4" : Transmit continuous Tone 0-3 stair-step
"5" : Transmit continuous random Tone 0-3
"OFF" or 'X' : Resume normal operation

## PLL [channel] [Out A] [Out B] [Out C] [PLL A] [PLL B] [PLL C] ([Step])

This command allows a channel clock generator PLL and Output Divider to be set to arbitrary fractional values. The parameters are:
channel : channel # (1 – 8)

```
Out A : output divider integer
Out B : output divider fractional numerator
Out C : output divider fractional denominator
PLL A : PLL integer divider value
PLL B : PLL fractional numerator
PLL C : PLL fractional denominator
Step : (optional) Integer value to be added to the B parameter for FSK shift.  This
can be negative or positive.
```

## DEBUG [?]

```
This command will do something, or nothing, depending on the most recent needs of
the designer
```

## DEFAULT

```
Default reverts all settings to start-up defaults, and re-loads the config.txt file
```

## Man [command name]

```
shows help for a command
Man * shows help for a all commands
```

## LED

```
When power is connected to the WS-8 the multicolor Status LED will blink to show
the current state:

 - Solid Green : Initializing
 - Red/Green flash: callsign and/or grid not initialized at start of frame
 - Slow Green on/off : No channels transmitting
 - Blue with off-flash : One or more channels transmitting
 - Red, one flash repeating : Amplifier power Voltage fault
 - Red, two flashes repeating : Channel amplifier over-current
 - Red, three flashes repeating :  Loss of GPS
 - Red, four flashes repeating : Input power supply fault
 - Red, continuous flash :  Loss of Reference Clock fault
 - Red, continuous on : watchdog timer shutdown
```

## CSV

This will output a Comma Separated Value line of text to the command line, showing numerous parameter values.  This is used during unit test.

# Technical Details

## *Transmit Spectrum*

Each of the eight WS-8 channels have a frequency-flexible Digital One-Watt Class-D amplifier (DOW), which generates a square-wave output. These outputs can be set to operate between 1 MHz and 60 MHz, and will require an external filter to attenuate the strong harmonic content of the square-wave. This is the output of a DOW Amplifier transmitting a 3.5 MHz signal:

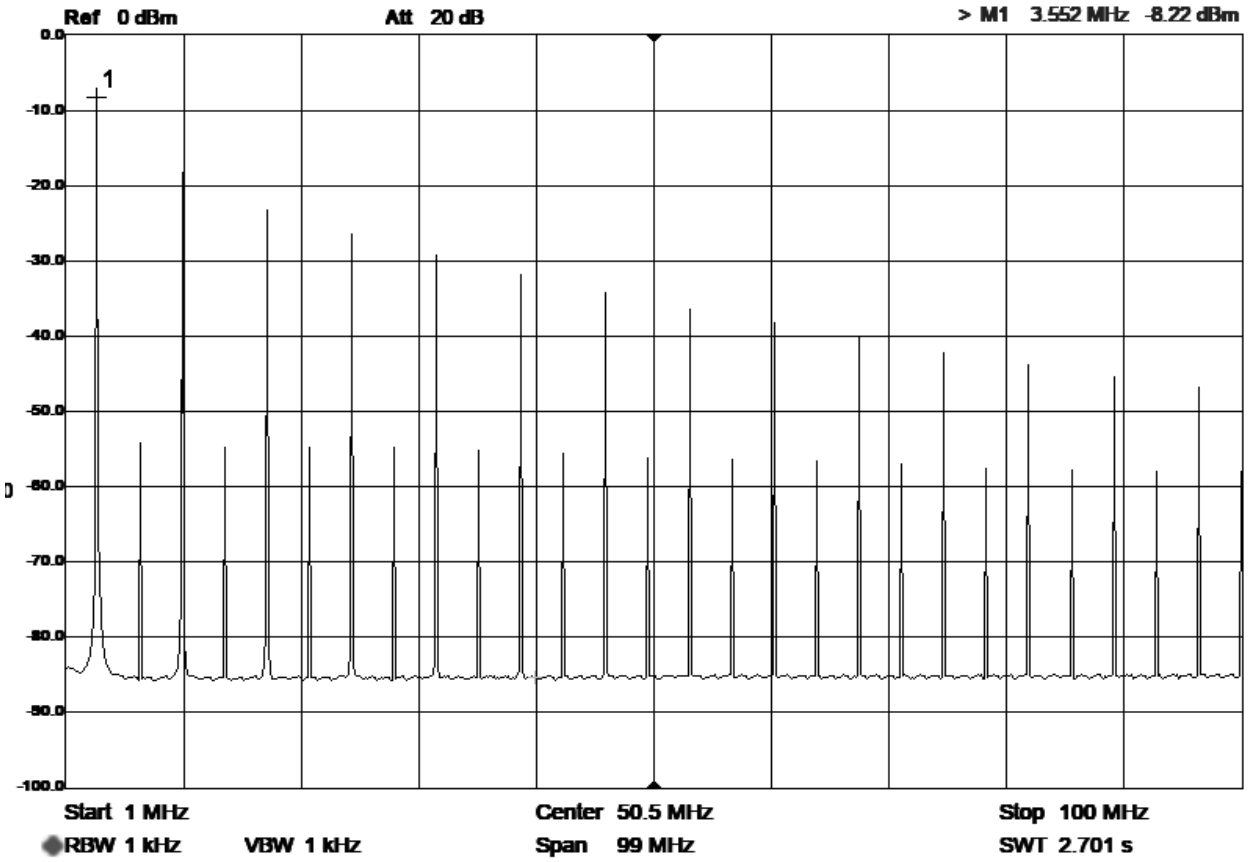



*Illustration 3: 80 Meters Without Filter*

The Filter/Combiners are designed to attenuate these harmonics, and the resulting output signal will have harmonic content better than -50 dBc (decibels relative to the carrier.)

But the transmit signals will also have close-in spurious content, due to the synthesis method being used. These are typically better than -90 dBc. The following spectrum plots show the typical performance of the WS-8 outputs at the filter-combiner output.

## 80 Meters:

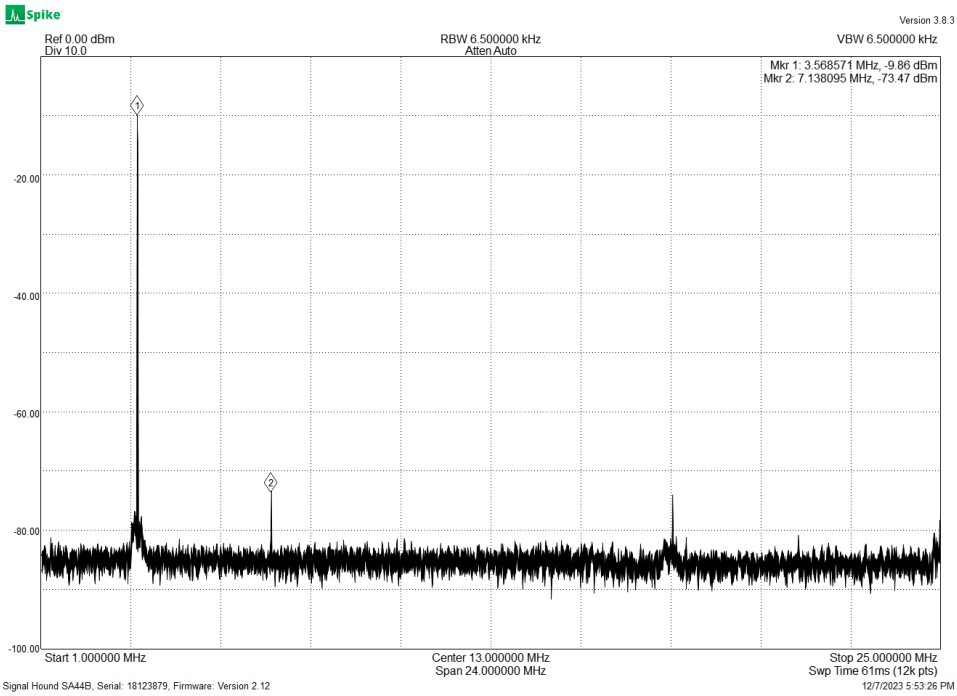



*Illustration 4: 80 meters with Filter-Combiner*

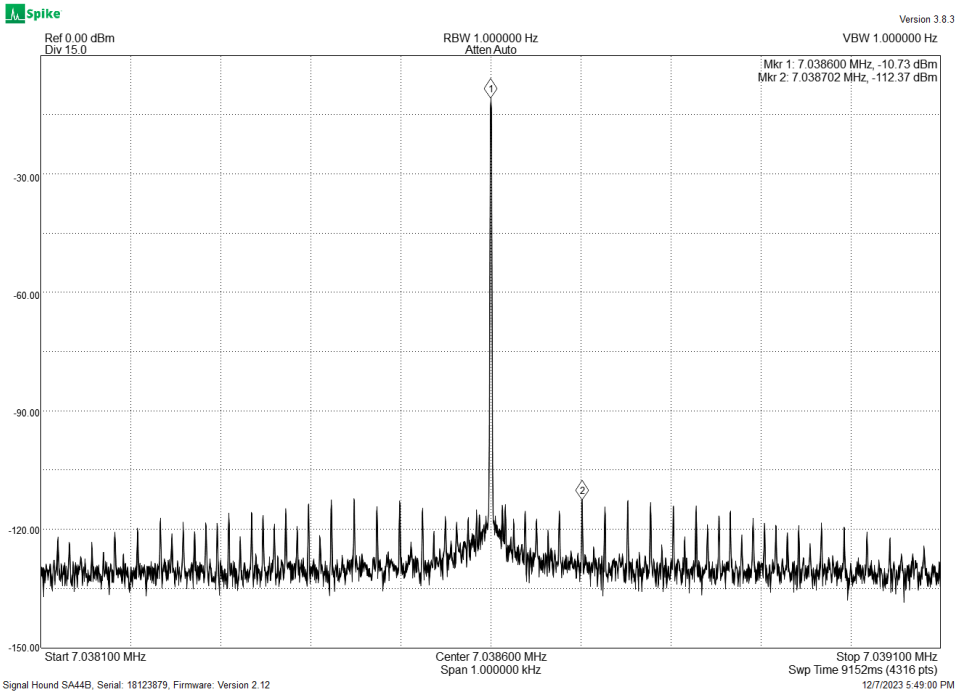



*Illustration 5: 80 Meters with Filter-Combiner, 1 kHz span*

## 10 Meters:

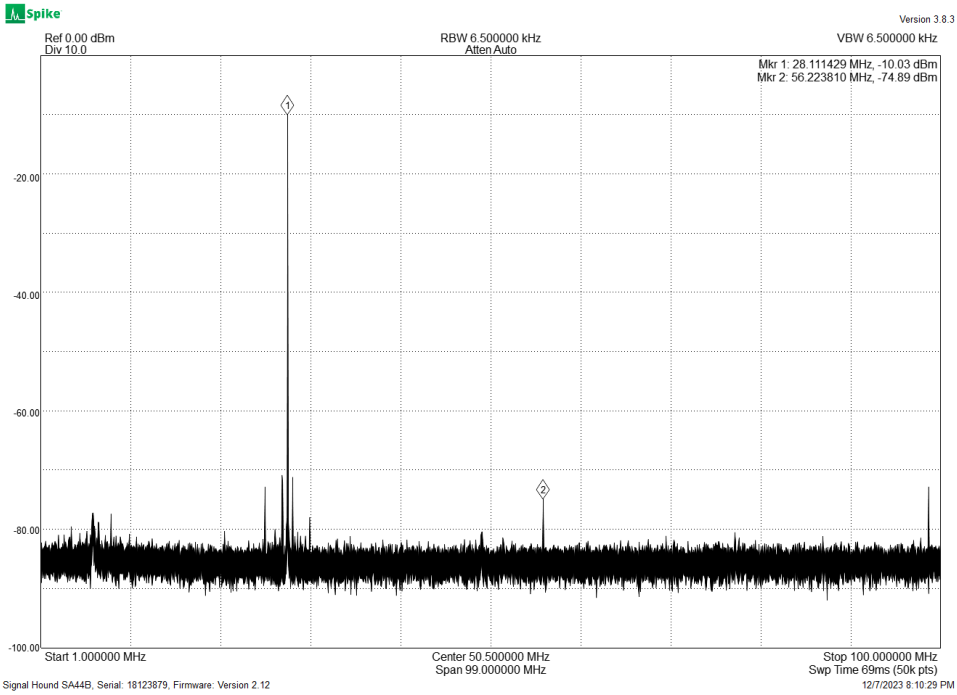



*Illustration 6: 10 meters*

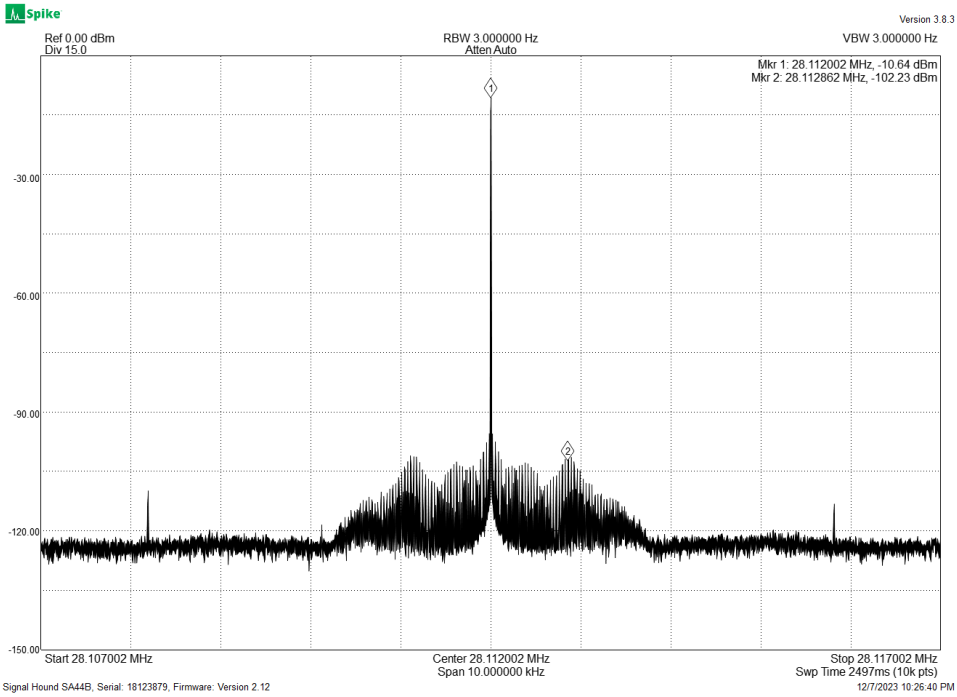



*Illustration 7: 10 meters, 10 kHz span*

## *Frequency Shift Keying*

### WSPR

The WSPR modulation is four-level FSK, symbol rate 0.683 seconds, tone spacing 1.45 Hz. More precisely, the WSPR tone spacing = 12,000 Hz / 8192 = 1.46484375 Hz, and the symbol rate is the reciprocal of this, or 0.6826666... Hz.

In WSPR mode the WS-8 FSK generally accurate to better than 1 microHz.

WSPR uses plain FSK, with no filtering of the frequency shift transitions.

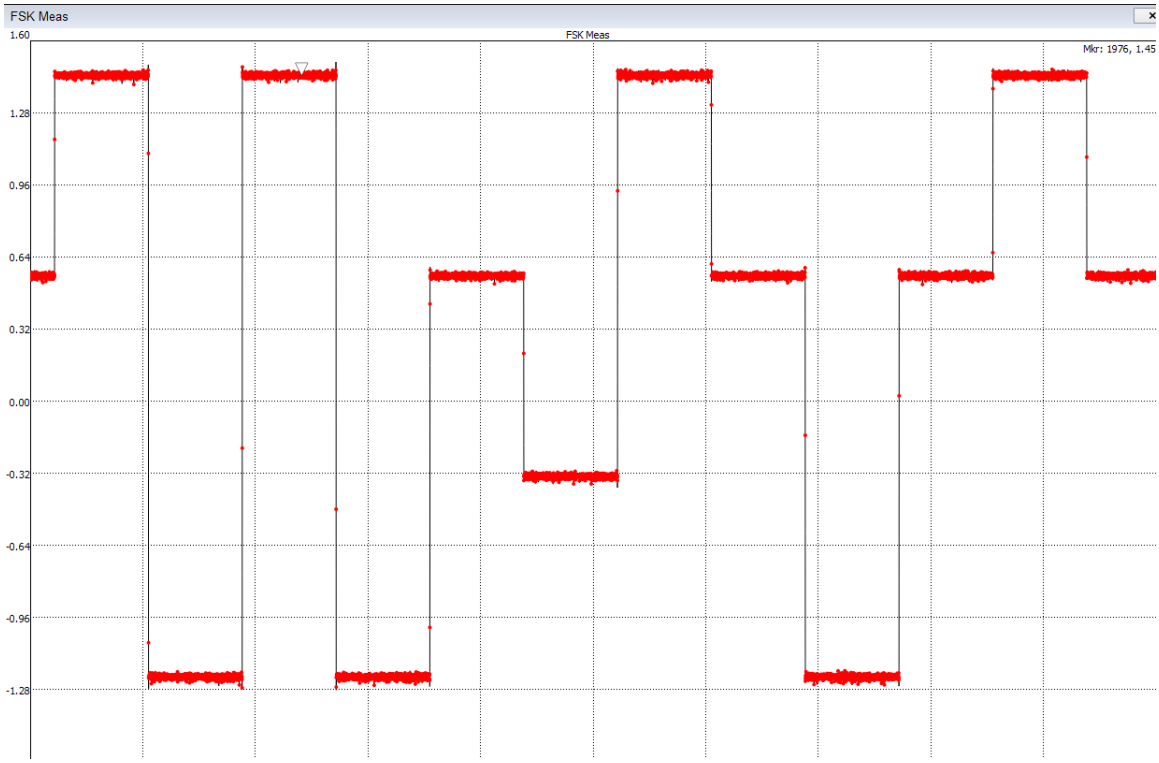



*Illustration 8: WSPR - FSK*

### FST4W-120

The FST4W-120 modulation is four-level FSK, symbol rate 0.683 seconds, tone spacing 1.46 Hz. More precisely, the FST4W-120 tone spacing = 12,000 Hz / 8200 = 1.463414634 Hz, and the symbol rate is the reciprocal of this, or 0.68333... Hz.

In FST4W-120 mode the WS-8 FSK generally accurate to better than 1 microHz.

FST4W uses 4-GFSK (4-level Gaussian Frequency Shift Keying).

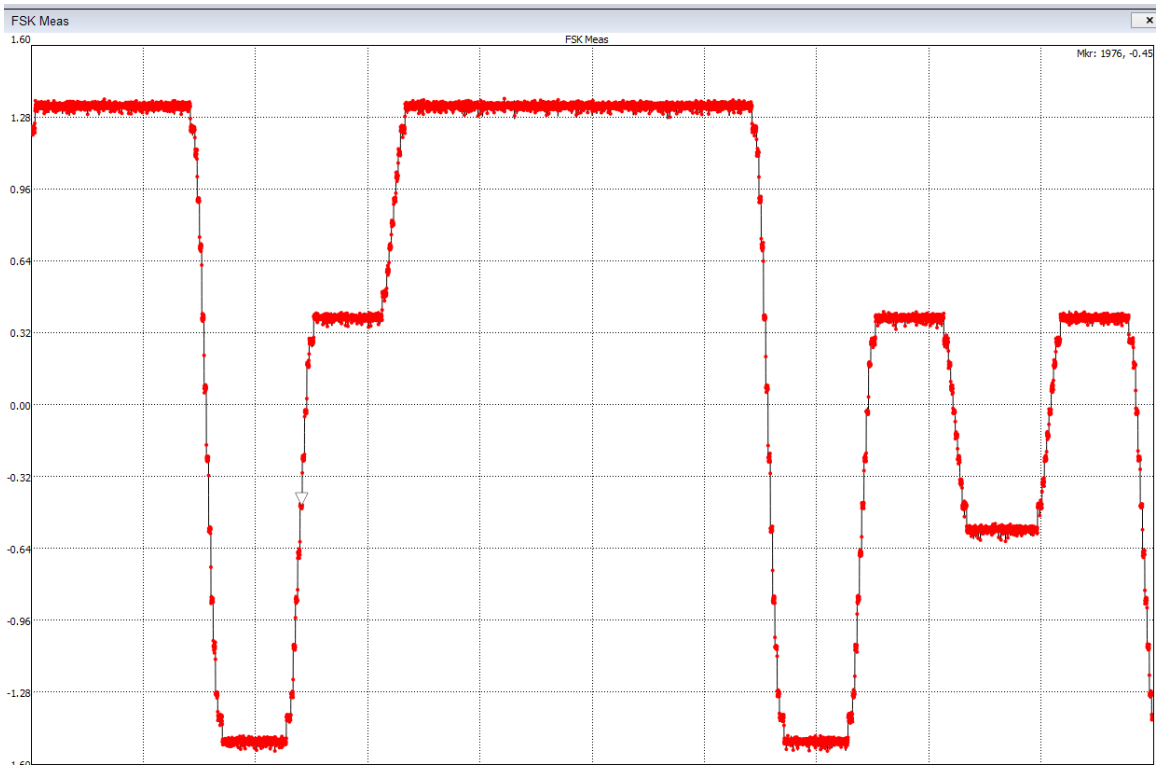


*Illustration 9: FST4W-120 GFSK*

For a good introduction to FST4W and GFSK, see **FST4 Quick Star**t and **FT4_FT8_QEX,** copies on the Turn Island Systems App Notes section:

https://turnislandsystems.com/downloads/

Please note that FST4W uses a Gaussian filter with a “BT = 2”, rather than the slower “BT = 1”. While the FST4W spec also includes a filtered amplitude ramp up and down at the start and end of transmission, the WS-8 does not implement this. In theory this will cause “key clicks” a the start and end of the transmission, but in practice these are barely noticeable.

## FST4W-300

FST4W-300 uses a slower and narrower 4GFSK modulation, the FSK rate being 12000 Hz / 21,504 (0.48971596... Hz), with the symbol rate the reciprocal of this (2.042 Hz).

## *Gaussian Filtering*

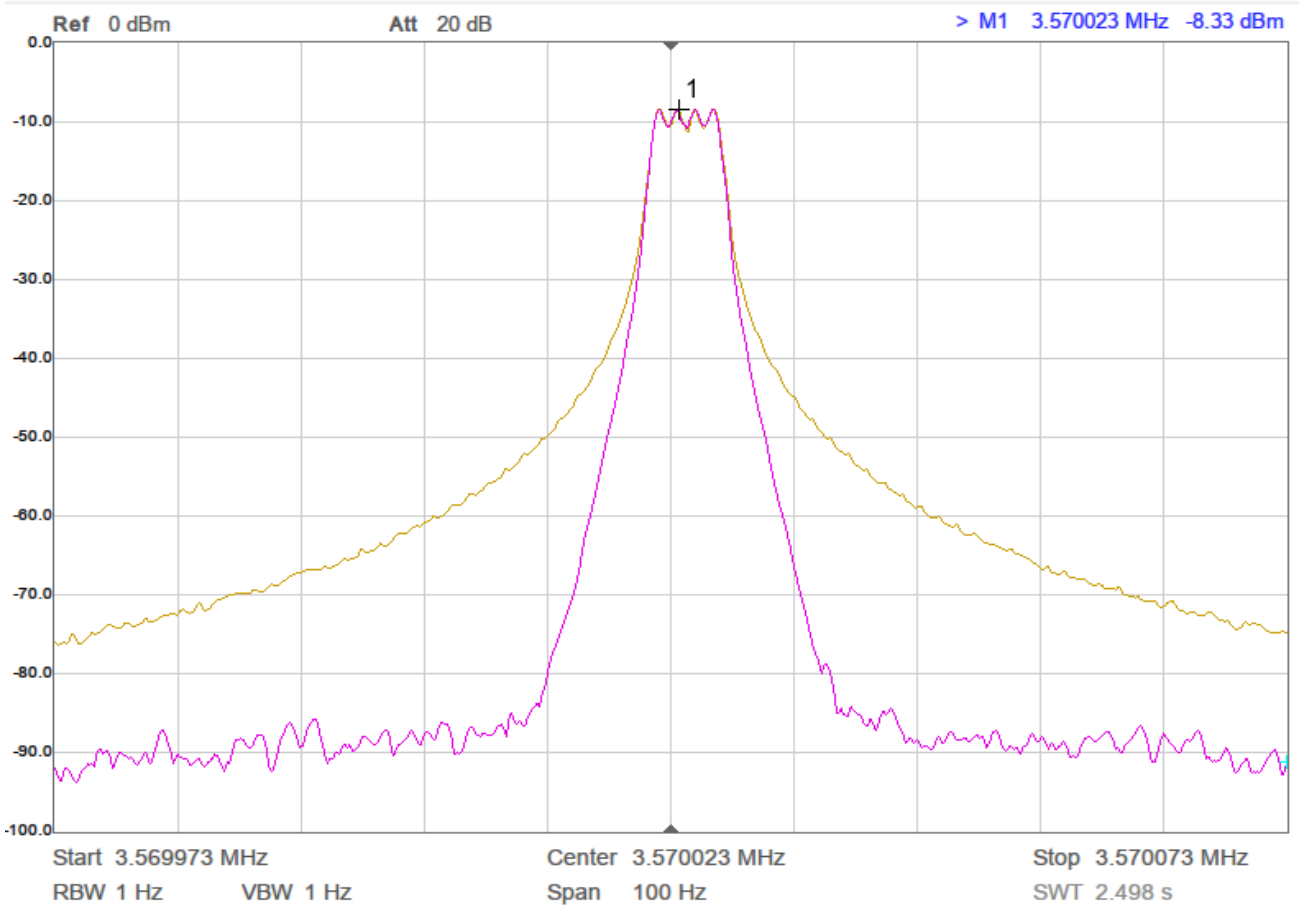



*Illustration 10: Gaussian Filter On / Off*

Here you can see the spectrum of the Gaussian Frequency Shift Keying (GFSK) and unfiltered Frequency Shift Keying (FSK). There is little difference until you get below -20dBc, but after that the modulation artifacts become quite obvious, and an unfiltered FSK signal will be more likely to interfere with neighboring transmissions.

In fairness, while FST4W specifies GFSK, WSPR uses unfiltered FSK. With WSPR there is some filtering effect caused by the traditional SSB modulation technique, where the 3 KHz audio bandwidth attenuates the modulation sidebands, but this will not be apparent in the narrow-span measurement shown here.

Many WSPR and FST4W “direct digital” beacons generate unfiltered FSK for both WSPR and FST4W, and no ill effects have been noticed (although the “signal subtraction” decoder in the WSJTX program supposedly does better with GFSK signals.) The WS-8 uses GFSK just because it seems the proper thing to do.

You can enable (and disable) the WS-8 Gaussian Filter through the configuration file or the command-line (see the command list). The default is “filter on”.

This filter is implemented in software. In the FST4-120 mode, the frequency update rate is 41 x the symbol rate (which happens to equal 60 Hz.) The available frequency steps vary from

band to band, but range from 3 to 440 steps per shift.  Even with only three steps per shift, the filtering makes a dramatic improvement in the sideband level.

When in WSPR mode the filter default is OFF.

## Make Your Own Harmonic Filter

The WS-8 outputs are square-wave, and so have strong harmonic components that must be attenuated. The Filter/Combiners use series band-pass sections, which permits the multiple filters to be connected to a common output with minimal interaction.

But a basic single-band filter need only be a low-pass design. While the typical capacitor-input “C/L/C Pi” network will work, the shunt capacitor at the filter input will cause heavier loading of the amplifier than necessary. A better option is to use an inductor-input “L/C/L Tee” design. The filter need not have a lot of attenuation at the second-harmonic, as this is generally already down below -30 dBc. But filter attenuation at the third and higher odd harmonic frequencies should exceed 30dB at a minimum.

Here is an example filter for the 80-meter band. It includes a 3rd harmonic notch, improving the overall filter performance where it counts. The inductors are CoilCraft surface-mount “1812CS” and “1206CS” types, although toroid cores offer even better performance.

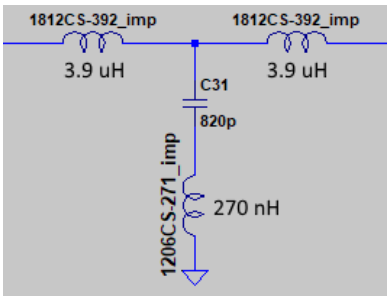



*Illustration 11: LPF with Notch Schematic*

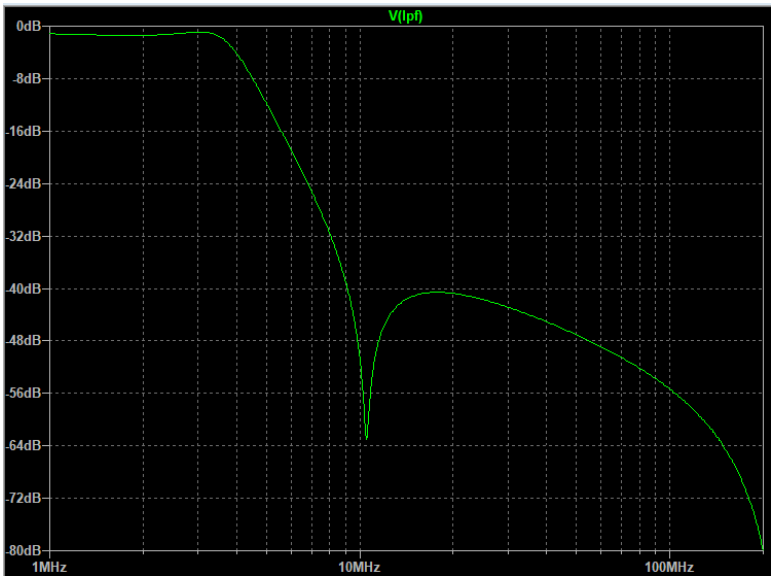



*Illustration 12: LPF Frequency Response*