PL-Tone & DCS Detector Card

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The PL-tone and DCS detector card will take audio input from a suitable radio and analyze it to see if any of the 50 standard PL tones or any DCS codes are present. When a PL tone or DCS code is detected, the frequency or code is displayed on the 7-segment LED display. If no tone or code is present, the display remains blank. In addition, the frequency of the detected tone or the code value will be sent out over a serial port as described below.

The PL-Tone/DCS card can be used as a stand-alone card or can be plugged into a Raspberry-Pi. Power for the card is 5v DC, which is supplied through the USB cable when used stand-alone or from the Raspberry-Pi through the standard 40-pin connector. When the card is plugged into a Raspberry-Pi the USB cable is not needed and the USB connector remains unused.

Parts of the PL-Tone/DCS card

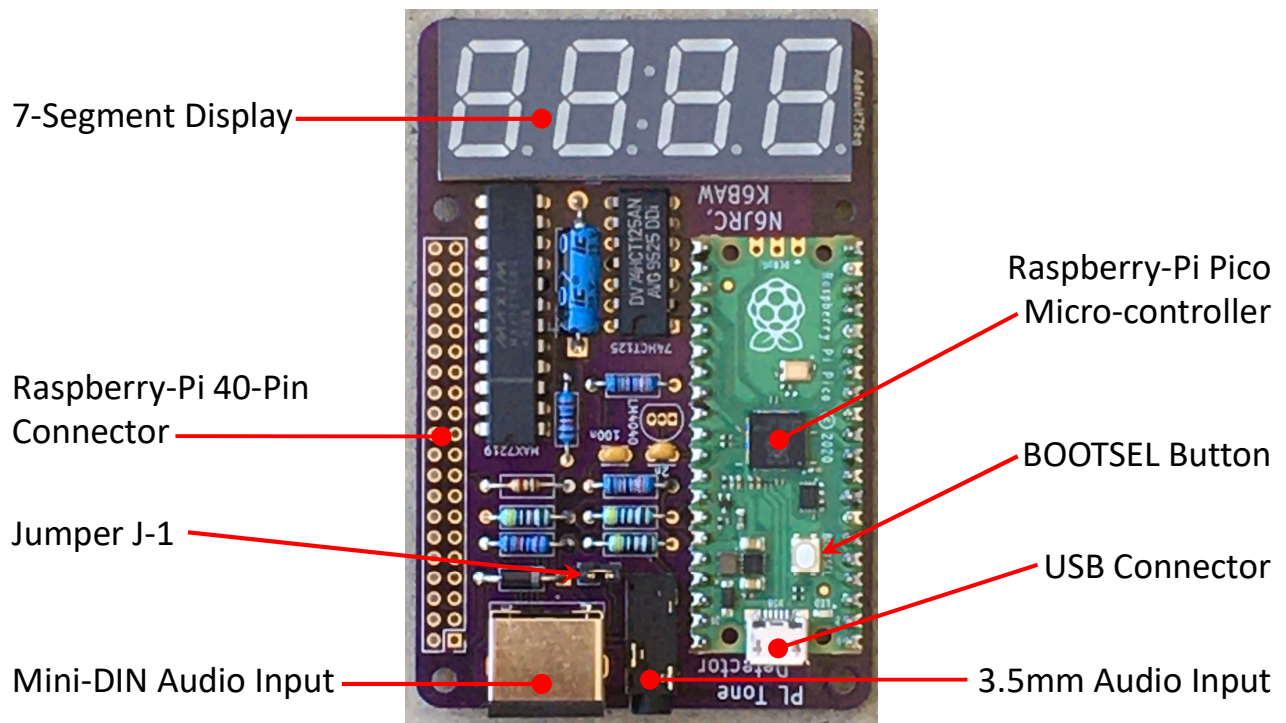The major parts of the card are shown in figure 1 below:

Figure 1: Main parts of the PL-Tone/DCS card

The USB connector is a USB micro-B connector.

Audio Inputs

The radio volume must be turned up to provide sufficient audio signal to the card.

The Audio signals from the radio can be input to the card in 2 ways:

1 - The Mini-DIN Audio Input

The pinout of the 6-pin mini-DIN socket matches a number of Kenwood and Yaesu radios TNC (Terminal Node Controller) data output and has been tested with both. These pictures are from the Kenwood TM-V71 manual; first the TNC or DATA socket location on the back of the radio:
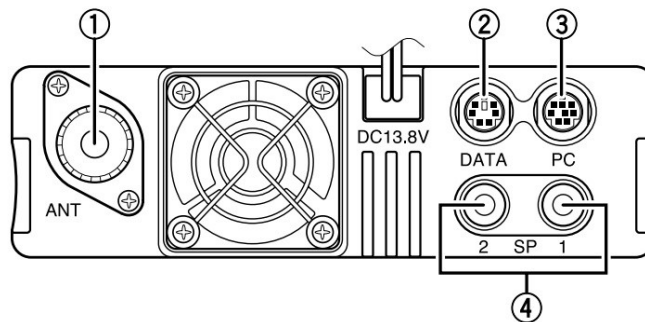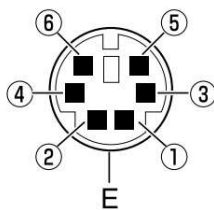

Figure 2: Kenwood TM-V71 6-pin mini-DIN TNC socket location

The Kenwood manual says "DATA: Connect a TNC unit to this terminal, via a 6-pin mini-DIN connector". The pinout is as follows:

No.	Name	I/O	Function
①	PKD	Input	Audio signal for packet transmission
②	DE	—	PKD terminal ground
③	PKS	Input	'L' is transmitted and the microphone is muted
④	PR9	Output	9600 (bps) repeat signal
⑤	PR1	Output	1200 (bps) repeat signal
⑥	SQC	Output	Squelch control signal; Closed: 'L', Open: 'H' (The default settings can be changed in Menu 520)
	E	—	Common ground

Figure 3: Kenwood DATA connection pinout diagram

The PL-Tone/DCS card only makes connections to three of these signals:

> Pin 2: DE, ground
> Pin 4: PR9, which is the audio output from the radio
> Pin 6: SQC, the squelch output from the radio. This is currently unused by the card, this may change in the future

E – Common ground is also used, with both pin 2 and the shield both being connected to the card ground. On Yaesu radios, common ground is on Pin 2.

The PR9 signal is used rather than the PR1 signal, because the PR9 signal comes from the discriminator and has less high pass filtering.

A 6-pin mini-DIN male to male cable can be used to connect the radio directly to the card. If your radio has an incompatible pin-out, please contact the author for assistance.

2 - The 3.5mm Audio Input

The 3.5mm input socket on the card uses a three-pin connector: tip, ring and sleeve. Connect the audio output from the radio to the tip. The audio ground must be connected to the sleeve. The card is wired for a squelch signal from the radio on the ring input. This is currently unused by the card, this may change in the future
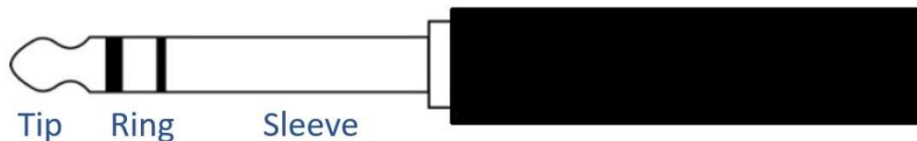

Figure 4: 3-pole 3.5mm input signal names

The aim of this card is to make audio connection simple and if your radio has a 3.5mm output (or a 2.5mm output), it is expected that a male to male cable will be used to connect the radio to the card. But there can be some complications …

If your radio has a TNC (Terminal Node Controller) output mode on the 3.5mm socket, check that it will provide audio on tip, squelch on ring and ground on sleeve. This case should be simple, just plug it in with a 3-pole male to male 3.5mm cable. Leave Jumper J-1 in place.

If your radio has a 2-pole output socket, with audio on tip and ground on sleeve, you can connect your radio to the card with a 2-pole or 3-pole male to male cable. Leave Jumper J-1 in place. This is likely the case for a receiver such as a scanner.

If you are connecting the card to a PC or other computer for testing, where the output is a stereo audio signal, a 3-pole male to male cable can be used. Only the channel carried on the tip (generally the left audio channel), will be input into the card. Leave Jumper J-1 in place.

If your radio has SP/MIC outputs, use a 3-pole male to male cable. Connect the speaker output to the card with a male to male 3.5mm cable. One possible issue that may arise is that the card will appear as if it's an input switch to the radio. To avoid any problems that may cause for the radio, remove Jumper J-1. That will disconnect the ring input to the card, leaving just the audio input and ground connected.

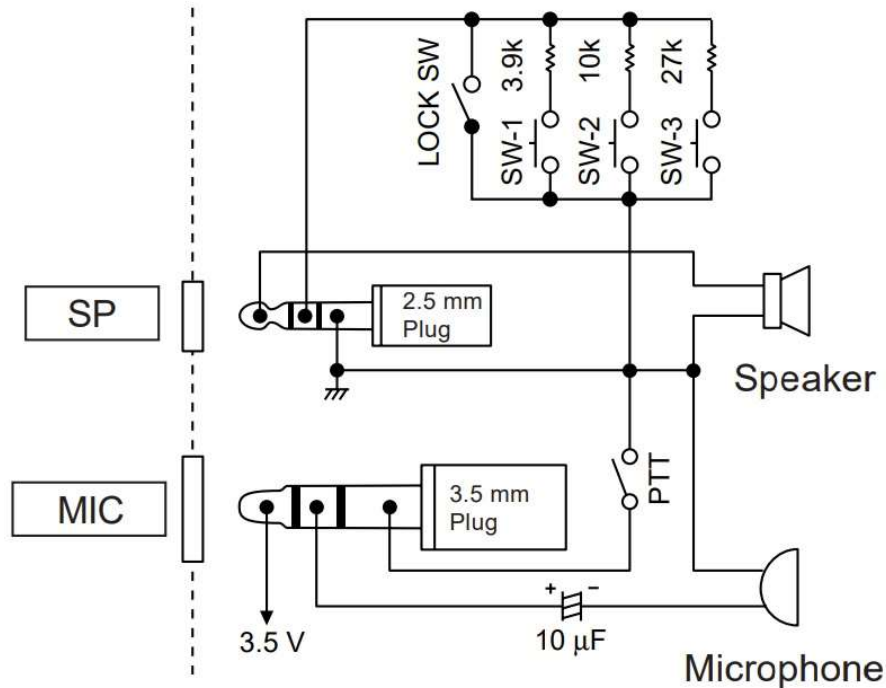As a further explanation, consider the SP/MIC connections for some radios …

Figure 5: Example connection of external Speaker and Microphone to Radio

As can be seen from figure 5, a resistor between the ring input and the sleeve input of the SP plug will make the radio "think" an input switch is being pressed on the external microphone. The card will appear like a resistor and that may cause the radio to do weird things, specifically the radio may "interpret" the card as an input switch being held down. As mentioned above, remove Jumper J-1 to break that circuit on the card, which should resolve this issue.

Known Issues with Radios

The radio volume should be turned up to provide sufficient audio signal to the card.

For the card to work, the radio must pass the PL tones or DCS codes to its audio output and on to the card. HAM radios often filter PL tones and DCS codes out of the audio output with a high pass filter. This means that the PL tones and DCS codes are not available in the audio signal for the card to detect.

The TNC (Terminal Node Controller) or DATA radio outputs have less audio filtering, so the PL tones and DCS codes are passed to the output. The 9600 b/s output has less filtering than the 1200 b/s output, so use 9600 b/s where possible.

How do you know if you have this problem? Simple; if your radio detects and displays the 254.1Hz PL tone and does not detect the 67.0Hz PL tone, you have this problem. If you have this problem, DCS codes and unlikely to work at all.

Supported PL Tones

This table shows the 50 PL tones (frequency in Hz) supported by the card.

67.0	79.7	94.8	110.9	131.8	156.7	171.3	186.2	203.5	229.1
69.3	82.5	97.4	114.8	136.5	159.8	173.8	189.9	206.5	233.6
71.9	85.4	100.0	118.8	141.3	162.2	177.3	192.8	210.7	241.8
74.4	88.5	103.5	123.0	146.2	165.5	179.9	196.6	218.1	250.3
77.0	91.5	107.2	127.3	151.4	167.9	183.5	199.5	225.7	254.1

Table 1: PL Tone frequencies supported by the PL-Tone/DCS card

If multiple tones are present, only the single "loudest" tone will be displayed.

Supported DCS Codes

The card supports all DCS codes, including the usual extended list of 112 codes shown in the table below. Some radios only support a subset of these codes.

006	031	054	116	145	205	245	266	332	411	452	506	612	703
007	032	065	122	152	212	246	271	343	412	454	516	624	712
015	036	071	125	155	214	251	274	346	413	455	523	627	723
017	043	072	131	156	223	252	306	351	423	462	526	631	731
021	047	073	132	162	225	255	311	356	431	464	532	632	732
023	050	074	134	165	226	261	315	364	432	465	546	654	734
025	051	114	141	172	243	263	325	365	445	466	565	662	743
026	053	115	143	174	244	265	331	371	446	503	606	664	754

Table 2: DCS codes supported by the PL-Tone/DCS card

There are however, some issues with DCS codes.

1. Many codes have aliases. For example, the codes 023, 340 and 766 all produce the same "over the air" digital signal. So only 023 is used as a valid code.
2. Most codes have an inverse. 023 (as well as 340 and 766) have a set of inverse values of 047, 707 and 375.

Because of differences between some radios, when they are sent a code, it can come out of the audio as the positive code or as the negative code. Some radios also allow you to select a code as +023 or -023 to allow interworking with repeaters. However this is exactly the same as using +023 or +047.

In order to completely simplify all the DCS incompatibilities, the default action for this card is to only supports 56 different codes. All positive and negative codes are mapped to a single code, so that, no matter if you send +047 or -047 and no matter if the radio receives and outputs the

signal correctly or as an inverted version, all the codes will map back to a single value. This is the default configuration with this card. The codes supported are shown in the table below:

021	134	214	306	411	503	612	703
043	141	225	331	423	506	627	712
047	143	244	332	446	516	631	723
050	152	251	351	452	523	632	731
051	156	263	356	454	526	654	732
054	172	271	364	462	532	662	734
072	174	274	365	464	546	664	754

Table 3: Default 56 codes supported to avoid inverted code issues with radios

If a radio is set to use a code shown in the table above, the card will always display the correct DCS code, irrespective of the way in which the radio works.

The card can be configured to use the wider set of 112 codes, shown in table 2. If you need to do that, please contact the author for instructions.

DCS is only supported of version 1.4 and higher of the PL-Tone and DCS detector card software.

Software Version and Upgrade

When the card is powered up a message of the form "Hi 1.2" is displayed for 2 seconds on the 7-segment display. The 1.2 is the current version of software for the card at the time of writing this document.

When a new release of software for the Raspberry-Pi Pico is available, a file called PLTone13.uf2 will be available. To install this file, the card must be disconnected, powered down and disconnected from a Raspberry-Pi. To get the Pico into software download mode the following steps must be done:

1. With the Pico powered down, Press and HOLD DOWN the BOOTSEL button on the Pico.
2. HOT Plug in the USB connector to a Raspberry-Pi or to a PC or Mac.
3. After the USB connector is inserted, RELEASE the BOOTSEL button on the Pico.

After a few seconds the Pico will come up on the system it's connected to as a small USB based filesystem.

4. Drag and drop the PLTone13.uf2 file into the filesystem.

The Pico will automatically detect the new software, install it and start running it. After a couple of seconds, the Pico will display "Hi 1.3" (or the version you just installed). At this point the software upgrade is complete.

Serial Port considerations

The Serial Port interface to the card is there to facilitate a future development of a PC, Mac or Raspberry-Pi improved user interface.

If the card is connected over the USB interface, the Pico will setup communications at 115200 b/s to the USB serial interface. If the card is plugged into a Raspberry-Pi, it will detect the Pi and will switch the serial interface it uses to be the one going to the Raspberry-Pi 40-pin connector, again at 115200 b/s.