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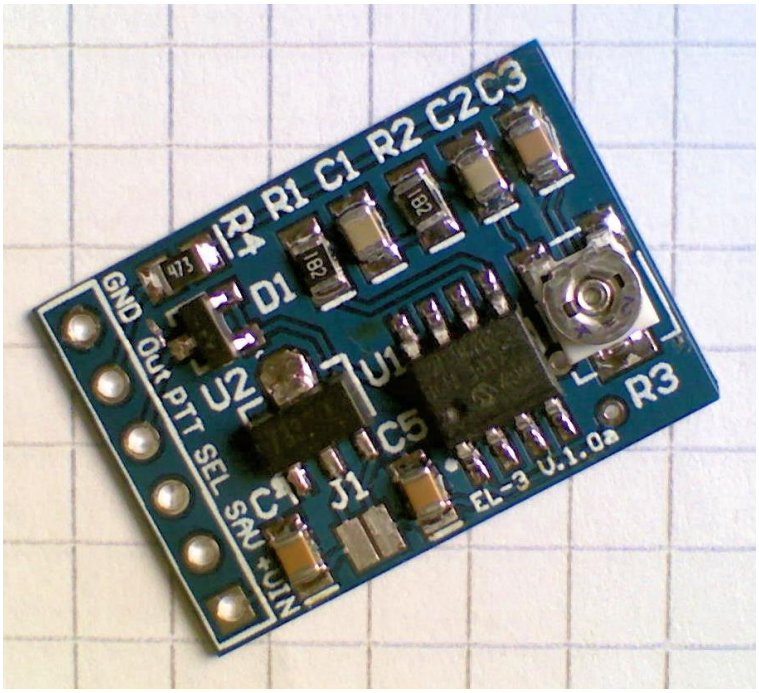
EL-3

Mini CTCSS Encoder



Functional description and installation instructions

Version 1.0c

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1 Introductory remarks

Many radio amateurs still use older 2 m or 70 cm radios, which are not able to produce the subtones required more and more often for traffic via relay radio stations, but from which they do not want to separate either. We will show you a variant of how you can prepare your beloved device for the new operating technology and how the sub-tone squelch of relay radio stations can be opened.

For some time now, more and more relay radio stations have been converting to the Subton-Squelch method (CTCSS, Continuous Tone Coded Squelch System), not only in Switzerland. The reason is that more and more strong disturbances occur at their locations, e.g. caused by computer cash registers or webcam systems. The carrier keyed repeaters were kept permanently on transmit by these disturbances. The CTCSS method prevents carriers from touching the repeaters without sub-tone modulation due to the sound emitted at the same time as speech.

Many older devices and those that have been specially manufactured for the European market only have the option of outputting a 1750 Hz ring tone. The CTCSS function, which is very common in North America, is often missing.

2 Function

2.1 Pulse width modulation

In order to better understand both the circuit and the processes of the microcontroller program, I would like to briefly explain what pulse width modulation (PWM) is by means of an example. If we want to convert any analog signal into pulse width modulated pulses, the easiest way is to use a comparator. I want to show this with the example in A triangular signal (green) with constant frequency, here 2 kHz, is applied to the first input of the comparator. The analog signal, here a sine wave (red), is fed in via the second input of the comparator. If the level of the analog signal is higher than that of the triangle signal, then the output voltage of the comparator is 1 V, otherwise -1 V. The output signal of the mass comparator is the PWM signal (blue). For the CTCSS tone generator, we want to generate sinusoidal signals with predefined frequencies. In my circuit a microcontroller generates such a PWM signal, which is modulated with a sine of the desired CTCSS frequency, e.g. 88.5 Hz. The advantage of this method is that only a single output is required on the controller and no D/A conversion is required.

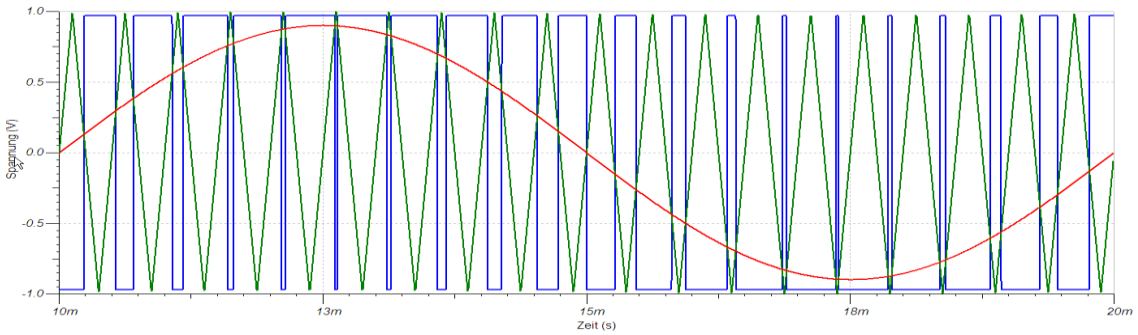


Figure 1

2.2 Pulse width demodulation

In order to recover the desired analog signal from the PWM pulses, the PWM signal must be demodulated. By averaging with a low-pass filter, the analog useful signal can be recovered from the PWM signal. The circuit for our application contains a three-stage RC low-pass filter. I want to show that this actually works by using the 2 kHz PWM signal generated in the previous section. The example in shows the PWM signal (blue) and the signals after the first (red), the second (green) and the third RC low pass filter stage (black). The red signal clearly shows the charging and discharging phases of the first capacitor. Already after the second filter stage the signal looks quite similar to our original sinus.

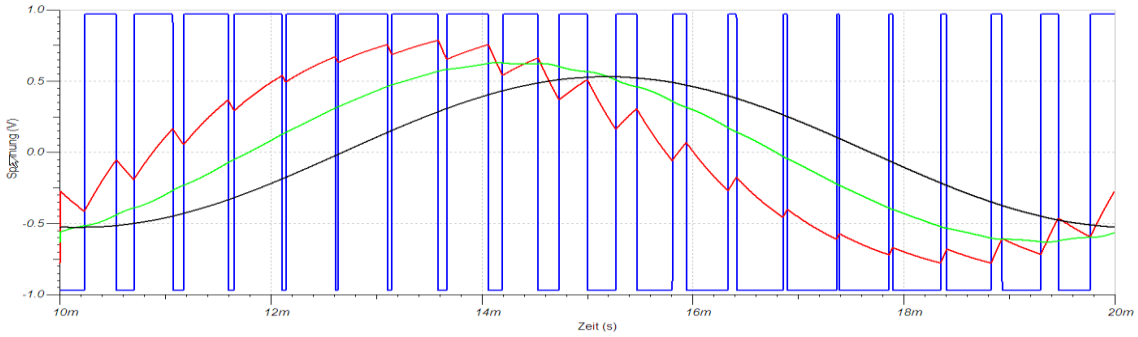


Figure 2

3 Installation

The circuit (see chapter 6.3) consists of a microcontroller (PIC) which generates rectangular, pulse-width modulated pulses. A downstream low-pass filter demodulates the desired sinusoidal signal. Depending on the version, the module requires a DC voltage of 5 V or 6 to 12 V maximum. These voltages are usually present in the radio set. The additional approx. 3 mA is usually provided by every device without any problems.

The shows the connection points of the module.

Attention: There is no reverse polarity protection for the power supply!

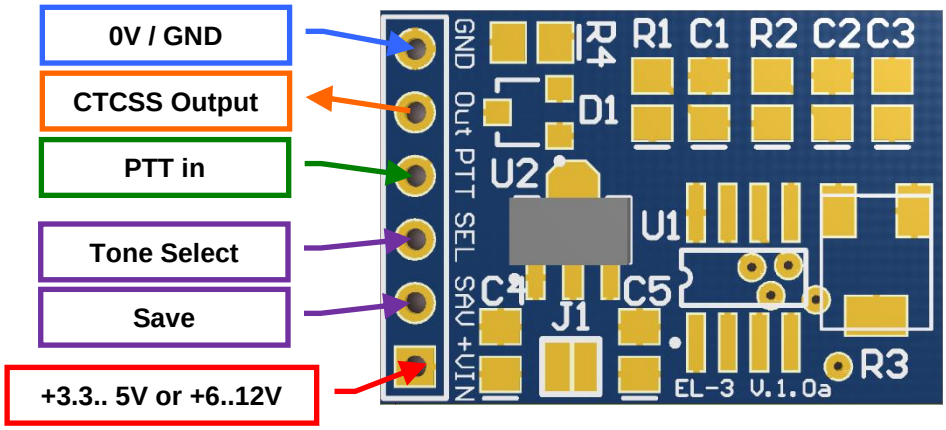


Figure 3

The CTCSS audio output of the module is connected to the FM modulator after the microphone amplifier. Many devices are already prepared for CTCSS. Then the installation is very simple. A shielded single-core cable must be used for the sound output.

As an example, in Figure 4 the sound feed from an ICOM device: The sound is fed in via a resistor (R271 = 10kΩ) at the capacitance diode with which the quartz oscillator FM is modulated.

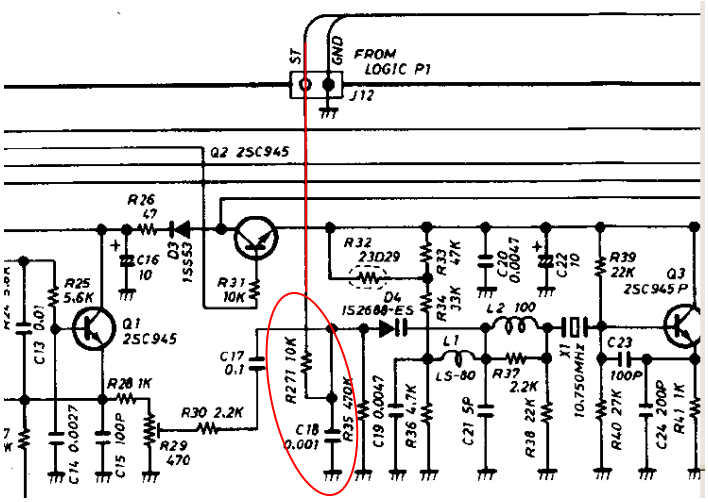


Figure 4

The PTT input of the CTCSS tone generator is low active. It must therefore be connected in such a way that the PTT line is switched to 0 V during transmission. Of course, it can also be permanently connected to mass - then the sub ton is always emitted as well.

4 Operation

The R5 trim potentiometer is used to adjust the output level so that the maximum stroke is ±300 Hz. If you do not have a deviation meter at hand, the setting must be found by experimenting. The CTCSS level should only be set so high that the relay responds safely!

5 Change CTCSS tone

The Mini-CTCSS encoder is fixed to a CTCSS tone and the frequency cannot be changed during normal operation.

However, the EL-3 CTCSS module can be upgraded to a new standard CTCSS tone if required. (see Table 1) can be reprogrammed.

5.1 Auxiliary circuit

To program a new fixed frequency, you need the following auxiliary circuit (see Figure 5).

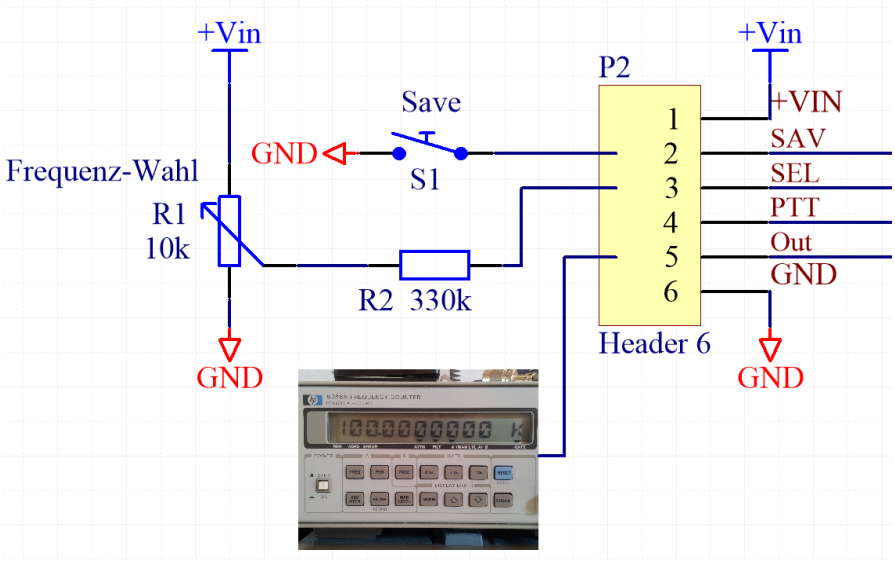


Figure 5

You will need the following components:

number	Component No.	Description of the
1	P1	10kΩ Potentiometer
1	R1	330kΩ 1/8 W (orange-orange-yellow)
1	S1	1 pole push button
1		Frequency counter (low Freq.)

Table 1

5.2 Change CTCSS tone

Supply the CTCSS module with 3.5V to max. 12V (Attention: no reverse polarity protection).

Proceed as follows:

1. Switch off the supply to the CTCSS module EL-3.

2. Press and hold the "Save" button and switch on the power supply.

3. Release the "Save" button, the module is now in programming mode.

4. Select the new CTCSS frequency by changing the potentiometer P1.
   (see Table 2) You control the frequency using the frequency counter.

5. Press the "Save" button for at least 2 seconds to save the new frequency.

6. Switch off the power supply to the EL-3 CTCSS module and install the module in your transceiver.

No.	PL	Freq.	Input voltage at SEL
00	XZ	067.0 Hz	0.042V ±41.8mV
01	XA	071.9 Hz	0.129V ±41.8mV
02	WA	074.4 Hz	0.215V ±41.8mV
03	XB	077.0 Hz	0.302V ±41.8mV
04	WB	079.7 Hz	0.389V ±41.8mV
05	YZ	082.5 Hz	0.476V ±41.8mV
06	YA	085.4 Hz	0.563V ±41.8mV
07	YB	088.5 Hz	0.650V ±41.8mV
08	ZZ	091.5 Hz	0.737V ±41.8mV
09	ZA	094.8 Hz	0.823V ±41.8mV
10	ZB	097.4 Hz	0.910V ±41.8mV
11	1Z	100.0 Hz	0.997V ±41.8mV
12	1A	103.5 Hz	1.084V ±41.8mV
13	1B	107.2 Hz	1.171V ±41.8mV
14	2Z	110.9 Hz	1.258V ±41.8mV
15	2A	114.8 Hz	1.344V ±41.8mV
16	2B	118.8 Hz	1.431V ±41.8mV
17	3Z	123.0 Hz	1.518V ±41.8mV
18	3A	127.3 Hz	1.605V ±41.8mV

No.	PL	Freq.	Input voltage at SEL
19	3B	131.8 Hz	1.692V ±41.8mV
20	4Z	136.5 Hz	1.779V ±41.8mV
21	4A	141.3 Hz	1.865V ±41.8mV
22	4B	146.2 Hz	1.952V ±41.8mV
23	5Z	151.4 Hz	2.039V ±41.8mV
24	5A	156.7 Hz	2.126V ±41.8mV
25	5B	162.2 Hz	2.213V ±41.8mV
26	6Z	167.9 Hz	2.300V ±41.8mV
27	6A	173.8 Hz	2.387V ±41.8mV
28	6B	179.9 Hz	2.473V ±41.8mV
29	7Z	186.2 Hz	2.560V ±41.8mV
30	7A	192.8 Hz	2.647V ±41.8mV
31	M1	203.5 Hz	2.734V ±41.8mV
32	M2	210.7 Hz	2.821V ±41.8mV
33	M3	218.1 Hz	2.908V ±41.8mV
34	M4	225.7 Hz	2.994V ±41.8mV
35	M5	233.6 Hz	3.081V ±41.8mV
36	M6	241.8 Hz	3.168V ±41.8mV
37	M7	250.3 Hz	3.257V ±41.8mV

Table 2

5.3 Select CTCSS sound externally

If the "SAV" terminal is connected to GND (0V), the CTCSS module accepts the analog value at the "SEL" input when it is activated (PTT).

Instead of a potentiometer, the desired voltage (see Table 2) can also be generated via a voltage divider with two resistors. The voltage at pin 3 can be measured with a high-impedance multimeter.

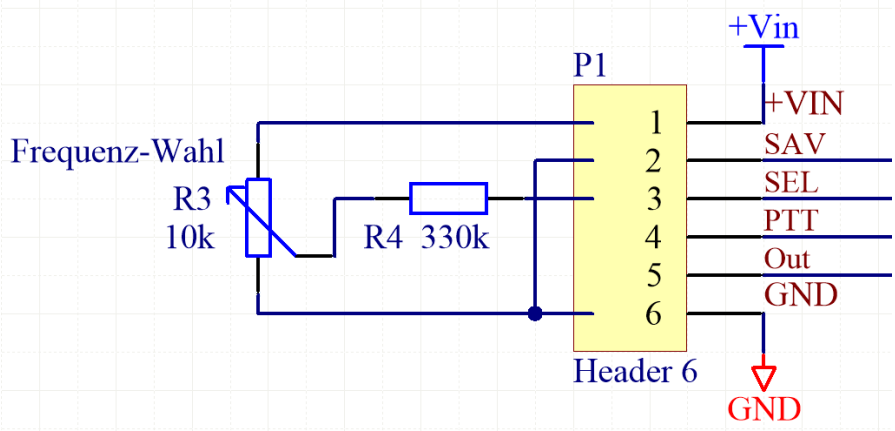


Figure 6

5.4 Programming via USB to Serial Adapter

The EL-3 CTCSS module has a serial interface (3.3V TTL, no RS-232 levels). With a USB to Serial Adapter (e.g. TTL-232R-3V3 or TTL-232R-3V3-PCB from FTDI) the CTCSS module can be connected to the PC or laptop.

The connection is made with spring-loaded "pogo pins" via the programming contacts on the back of the board. An adapter can be easily built (see also Figure 7 on the right).

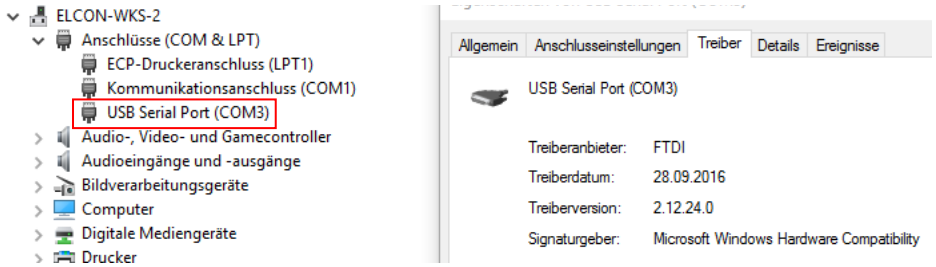
Figure 7

The power supply is via USB adapter with 3.3V, so that no further power supply is necessary.

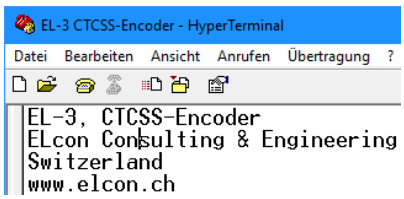
Proceed as follows:

1. Plug the "USB-to-TTL" adapter into the PC. The power supply is via USB adapter with 3.3V, so that no additional power supply is necessary.

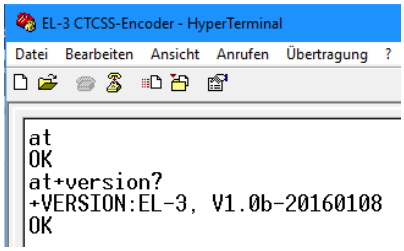
2. A connection to the EL-3 CTCSS module is opened on the PC with any terminal program (e.g. the HyperTerminal of Windows XP also runs on Windows 10) (baud rate: 9600, flow control: none). Use the device manager to check which virtual COM port number the adapter has received.



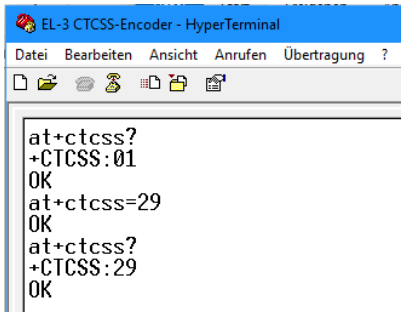
3. Connect the PTT line to GND. Programming is only possible if the module is active!
   The following message is output on the terminal.



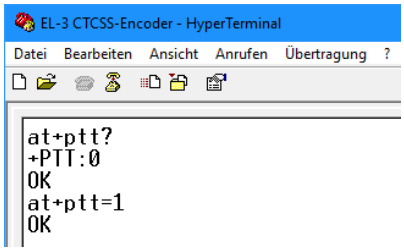
4. Enter "AT" or "at" in the terminal and you will receive a confirmation. This ensures that the communication with the module functions correctly.
   The module version can be upgraded with "at+version?".



5. The CTCSS frequencies can be checked and reprogrammed with the following commands. For the two-digit numbers (00 to 37) see Table 2.



6. The PTT logic is "Low-Active" on delivery, i.e. the encoder is active when the PTT line is switched to GND (0V).
   If your application uses a "High Active" PTT logic, this can be checked and reprogrammed in the module with the following commands.



6 Appendix

6.1 Specifications

Frequency range:

CTCSS frequency:	all 38 standard frequencies in the range 67.0 - 250.3Hz
Power supply:	3.5V to max 12V, 3mA (30uA module, PTT off)
Dimensions:	23(L) × 16(W) × 3(H) mm

All specifications are subject to change by ELcon without notice or obligation.

6.2 Special programming

The module can generate all standardized tones in the sub-tone range. You can program your desired frequency yourself.

On request we can program the microcontroller according to your wishes.
Get in touch with us so that we can discuss your concerns.

6.3 Scheme

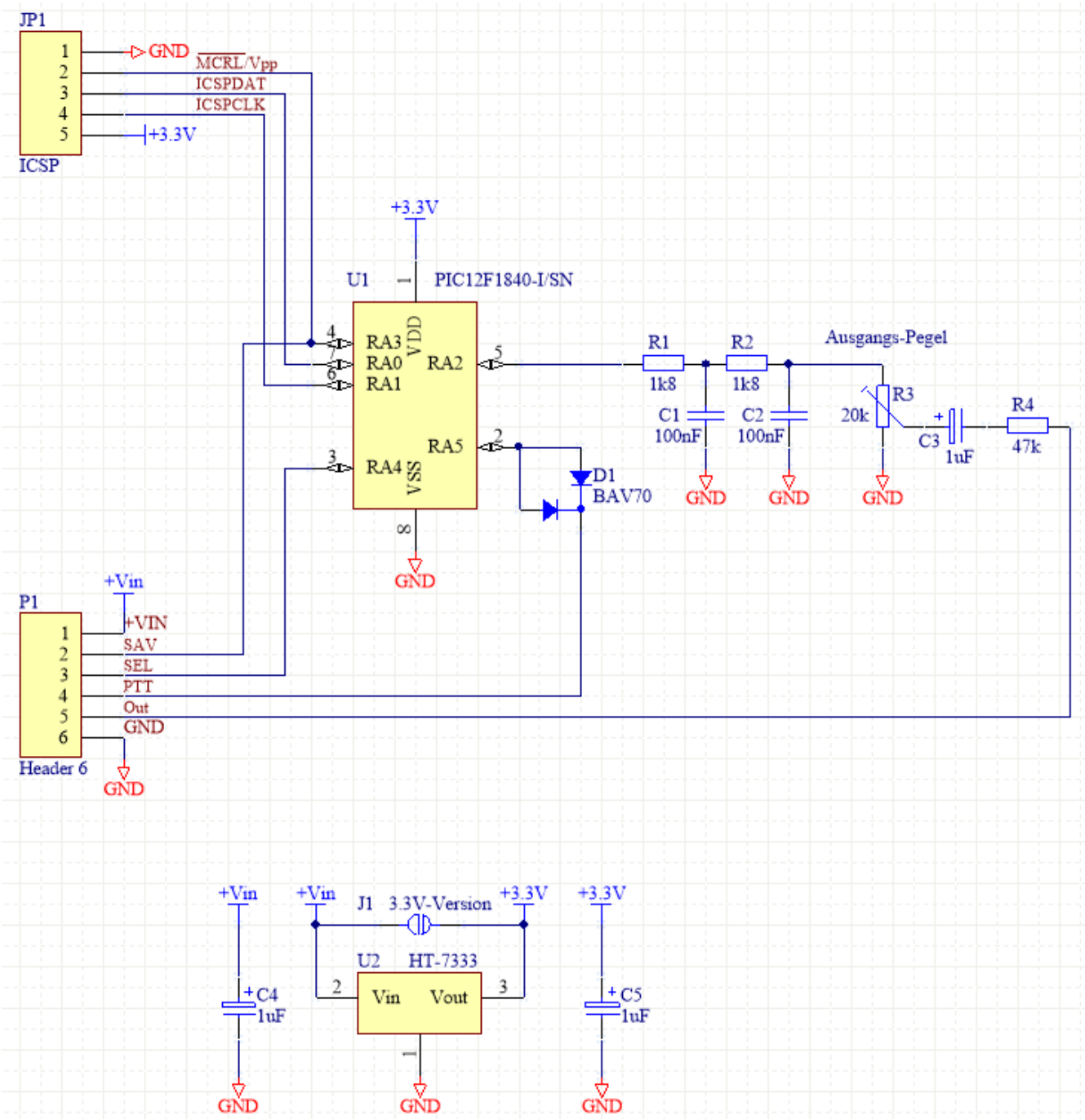


Figure 8