

TF0 APRS Digipeater

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1. Intro

APRS® stands for Automatic Packet Reporting System and was originally designed by the radio amateur Bob Bruninga (WB4APR) and is built upon the old AX.25 packet standard. APRS has a long history in the world of radio amateurs and has been used for decades to relay messages, position and telemetry data amongst other information. It is in its core, an information relay system designed to work both via the Internet as well as on the air.

2. Main purpose of device

It was designed by Samúel Þór Hjaltalín Guðjónsson (TF3SUT) to be a low power digipeater for remote repeater sites powered by solar power or other self-sustainable energy source. It has external I/O connector for future use. Such as monitoring battery voltage, voltage of solar charger etc.

3. Technical details

- Input voltage: 6~16V
- Current draw RX: 35mA
- Current draw TX: 291mA
- Maximum supply of 5V **or** 12V: 1A.
- Transmit frequency: 144,800MHz
- Output Power: 300mW
- Sensitivity: -13dBµV
- Dimensions box 160x103x36mm
- Dimensions PCB: 100x102mm

4. Technical description

1. Power Supply

From external power supply or battery comes 12V DC. It goes through fuse F1 (1A) into the voltage regulator LM78RE which is a high efficiency SMPSU voltage regulator for 5V. C1, C2, and C3 filter noise on the voltage supply line.

2. TX / RX Relay switch

The TX/RX switch is simple in its design. It's a G5V-2 DPDT relay that switches between transmit and receive. From the ATmega328P comes a 5V signal to the HX1 transmitter module as well as to the transistor Q1 that drives the relay's GND pin low upon transmit. Measurements have shown that with the relay shielded it has about 0.1dB insertion loss.

3. Transmitter

HX1 transmitter module from Radiometrix receives AFSK on audio frequency between 1200Hz and 2200Hz from the ATmega328P. The module then modulates that to FM on the frequency 144.800MHz (or 144.390MHz for US version). R10 is used to adjust the modulation voltage.

4. Receiver

NRX1 receiver module from Radiometrix decodes the received signal and outputs an audio frequency at 0.5Vpp. The LM385 operational amplifier is used to boost the signal to approximately 3.5Vpp and is the signal to the MCU adjusted with R14.

5. MCU

The MCU (Microcontroller Unit) is ATmega328P and does the signal processing. It also runs the software to determine whether packets should be digipeated or not. The software used is Extdigi from Alejandro Santos (LU4EXT) with later modifications by Samúel Þór Hjaltalín Guðjónsson (TF3SUT). The software is built on BertOS.

6. Programming of the device

To program the device you'll need the following. This can also be found in the readme file that comes along the software packate.

- USBASP AVR programmer for 6pin ICSP pin header.
- Computer that supports avr-gcc (Windows, Linux, FreeBSD or MacOSX).
- Simple text editor such as notepad, notepad++, vim, Atom or similar.
- The program with adjustments: <https://ulfr.net/aprs/tf0-aprs-extdigi.zip>
- These packets/programs: avr-libc avrdude gcc-avr make

Fyrsta skrefið er að setja upp avr-gcc vistþýðara ásamt avr-libc, avrdude og make. Í MacOSX er þetta gert með t.d. homebrew. „homebrew install avr-libc avrdude gcc-avr make“ eða í Linux með þeim pakkaskjalara sem er til staðar. T.d. dnf eða apt fyrir Fedoru eða Debian/Ubuntu. Sem væri þá „dnf install avr-libc avrdude gcc-avr make“ eða „apt install avr-libc avrdude gcc-avr make“

Næsta skref væri að ná í zip skránnu og afþjappa henni. Undir src möppunni má sjá skjal nefnt main.c. Þar eru helstu stillingar (einnig eru ítarlegri stillingar undir include/cfg/ möppunni).

Four parameters are the most important.

- MYCALL
- MYCALL_SSID
- APRS_BEACON
- APRS_BEACON_TIME

MYCALL is the callsign of the digipeater.

MYCALL_SSID 0 up to 15. Should be 0 for a W2 digipeater

- 0 - Aðal heimastöð eða W2 stafvarpi
- 1 - Heimastöð auka
- 2 - Heimastöð auka
- 3 - Heimastöð auka
- 4 - Heimastöð auka
- 5 - Stöð sem er tengd í gegnum farsímanet (t.d. snjallsími)
- 6 - APRS í gegnum gervihnött
- 7 - Handstöð
- 8 - Tæki er um borð í bát.
- 9 - Bílstöð eða tæki sem getur sent út staðsetningu, skilaboð og móttökið þau
- 10 - IGáttir eða tæki sem notar internetið til að skila upplýsingum frá sér.
- 11 - Loftbelgur
- 12 - Tæki sem sendir eingöngu út staðsetningu en getur ekki móttökið
- 13 - Veðurstöðvar
- 14 - Vörubíll
- 15 - Auka, eða fyrir aðra notkun sem fellur ekki undir fyrrnefnd tæki.

APRS_BEACON er það vitamerki sem stafvarpinn sendir út. T.d.

"!6408.55N/02155.52W#>APRS Stafvarpi". ! í byrjun gefur til kynna að vitamerki hefjist. Síðan koma hnit í dd°mm.mm(m)' það er gráður, mínútur, þúsundustupartar úr mínútu en einungis tveir fyrstu stafirnir eru notaðir. Fyrirnefnd hnit væru því 64°08.550' Norður, 21°55.520 Vestur. Skástrikið „/“ segir til um val á merki úr banka A eða B. A er „/“ en B er „\“. Myllumerkið er merki úr banka, en # stendur fyrir stafvarpa (Sjá nánar undir heimildaskrá þar sem vísað er í vefsíðu með útlistun á merkjunum). Að lokum má svo setja inn textastreng sem kemur þá á eftir „>“.

APRS_BEACON_TIME er sá tími í mínútum sem líður á milli þess að stafvarpinn sendir út sína eigin staðsetningu og lætur aðrar stöðvar vita af sér. Algengur tími er 15~30 mínútur.

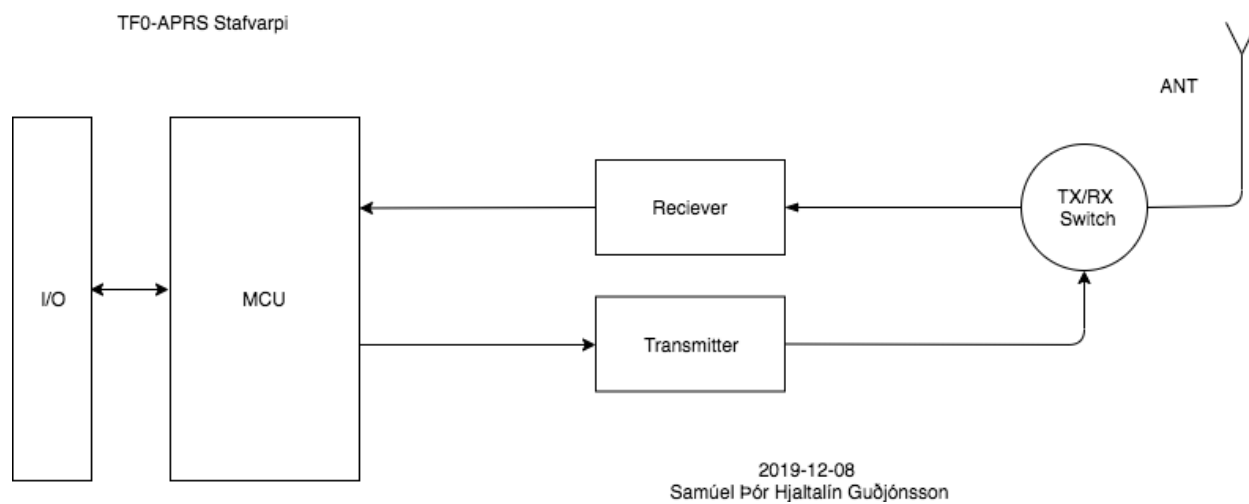
Að lokum er skjalið vistað, og „make“ skráin keyrð. Þegar forritið er búið að vistþýðast þá má nota burn.sh Bash skeljarskriftuna til að skrifa forritið inn á ATmega rásina.

7. Extra I/O

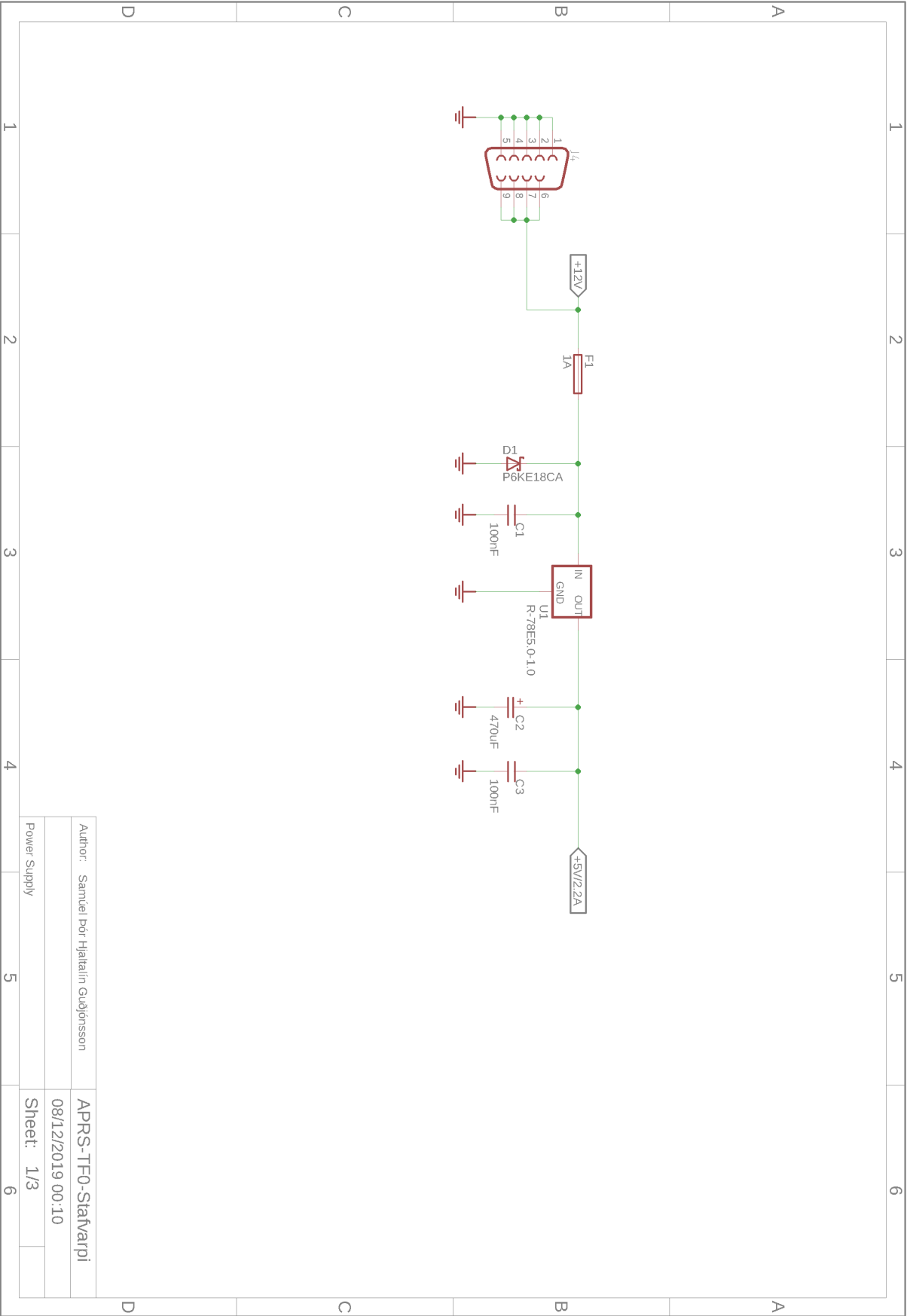
TF0 APRS Stafvarpi has the possibilities to connect an external I/O board to the ATmega328P. The connector reads from left to right:

| | | |
|----|------|--|
| 1 | F1 | +12V via F1 (1A) |
| 2 | +5V | +5V from voltage regulator U1 (Max 1A) |
| 3 | GND | GND |
| 4 | ADC2 | Analog to Digital input 2 |
| 5 | ADC3 | Analog to Digital input 3 |
| 6 | ADC4 | Analog to Digital input 4 |
| 7 | ADC5 | Analog to Digital input 5 |
| 8 | RXD | UART Rx ATmega |
| 9 | TXD | UART Tx ATmega |
| 10 | D2 | Digital output D2 |
| 11 | D3 | Digital output D3 |
| 12 | D8 | Digital output D8 |
| 13 | D9 | Digital output D9 |
| 14 | D10 | Digital output D10 |

5. Block Diagram



6. Schematics



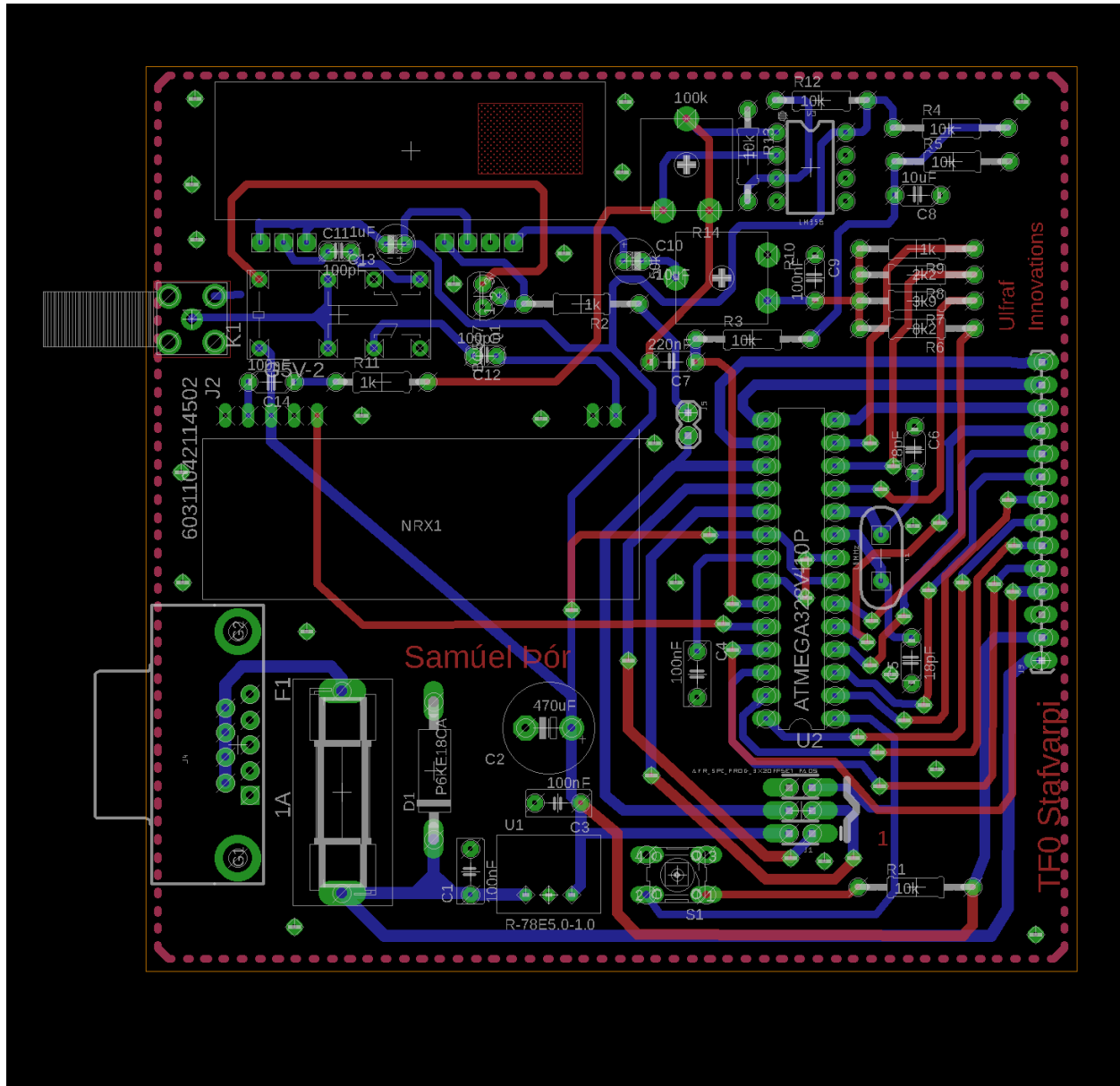
| | |
|---|--------------------|
| Author: Samuel Þór Hjaltalín Guðjónsson | APRS-TF0-Statvarpi |
| 08/12/2019 00:10 | |
| Power Supply | Sheet: 1/3 |



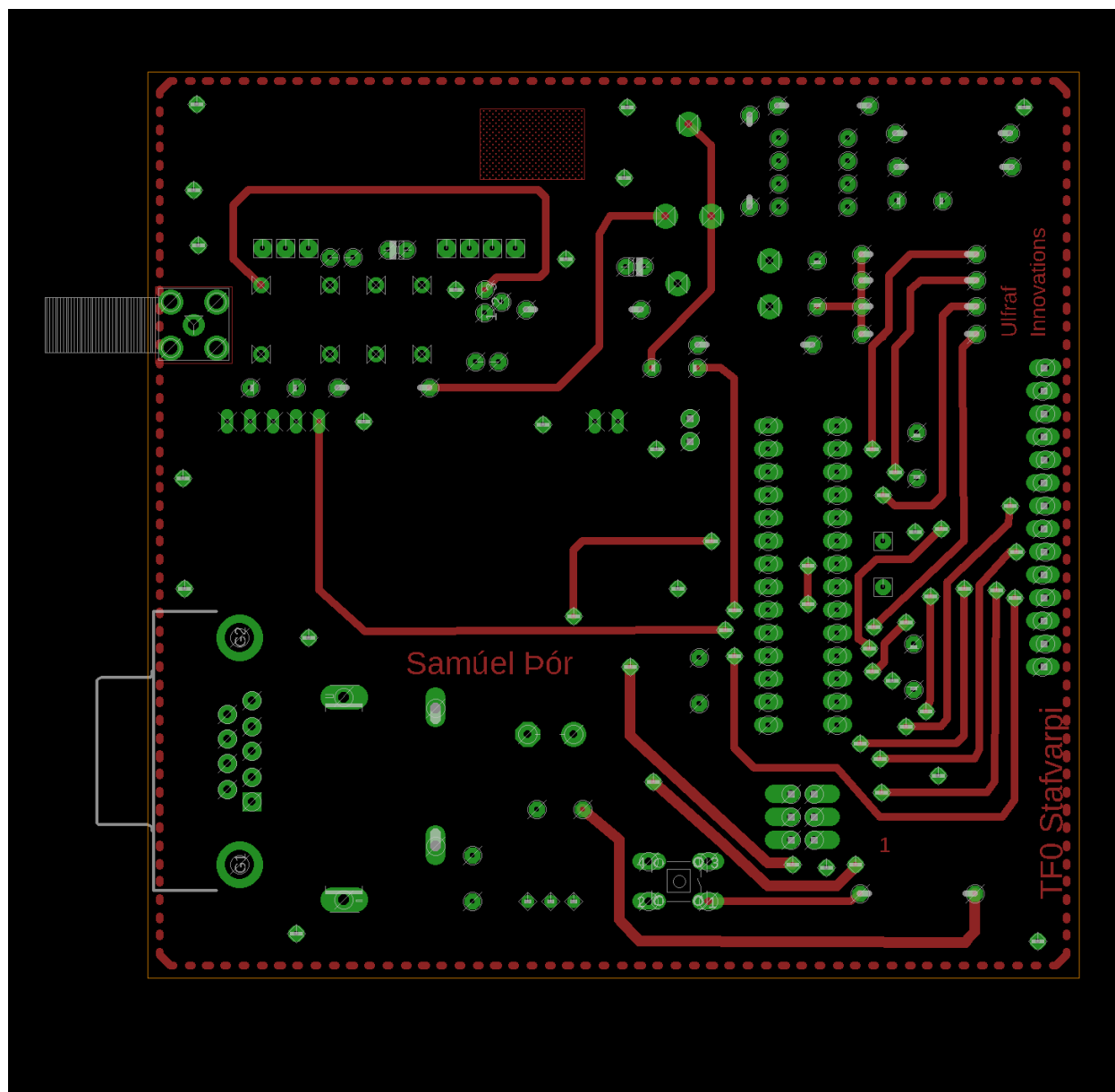


8. PCB

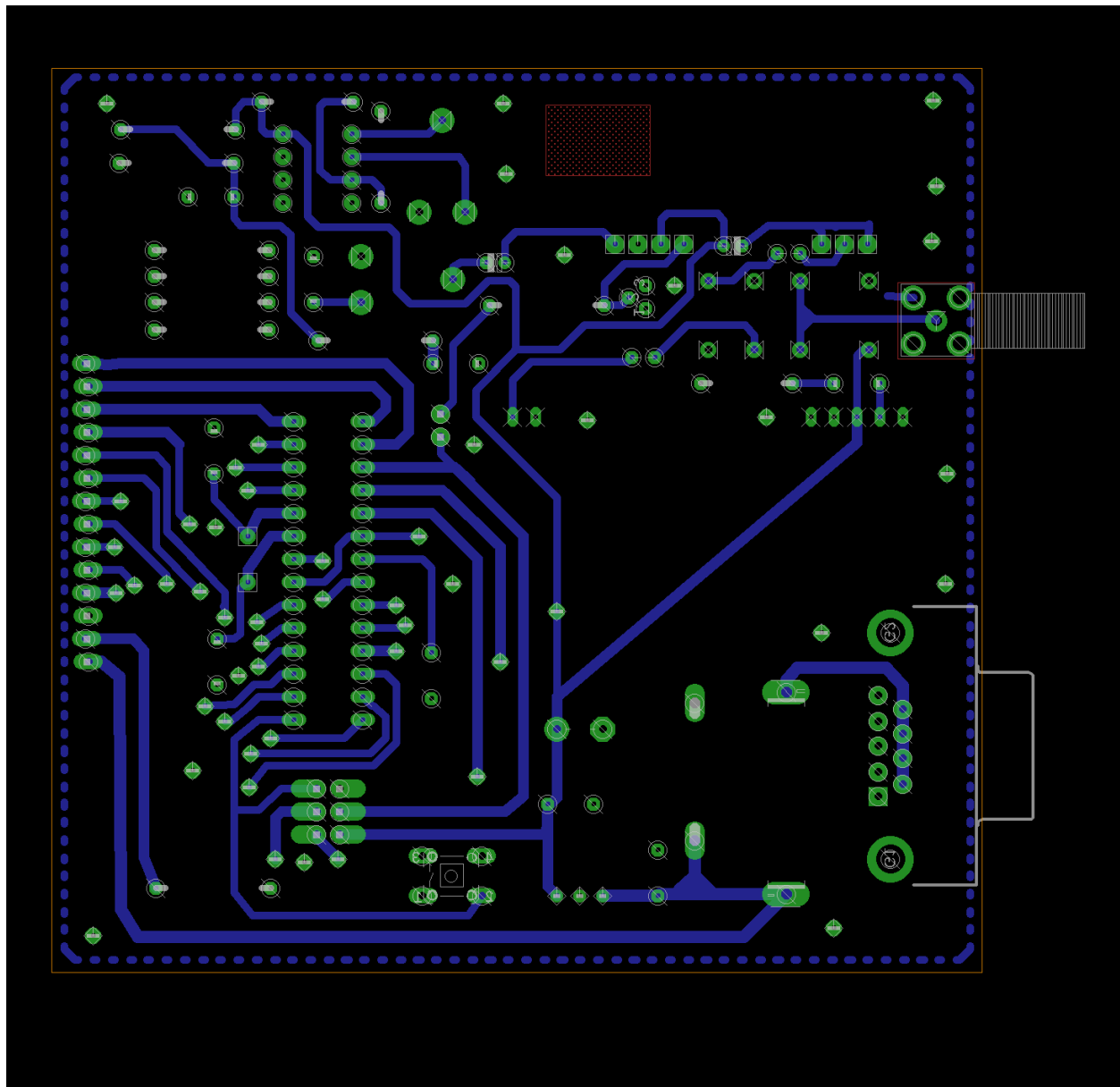
1. PCB Overview



2. PCB Top view

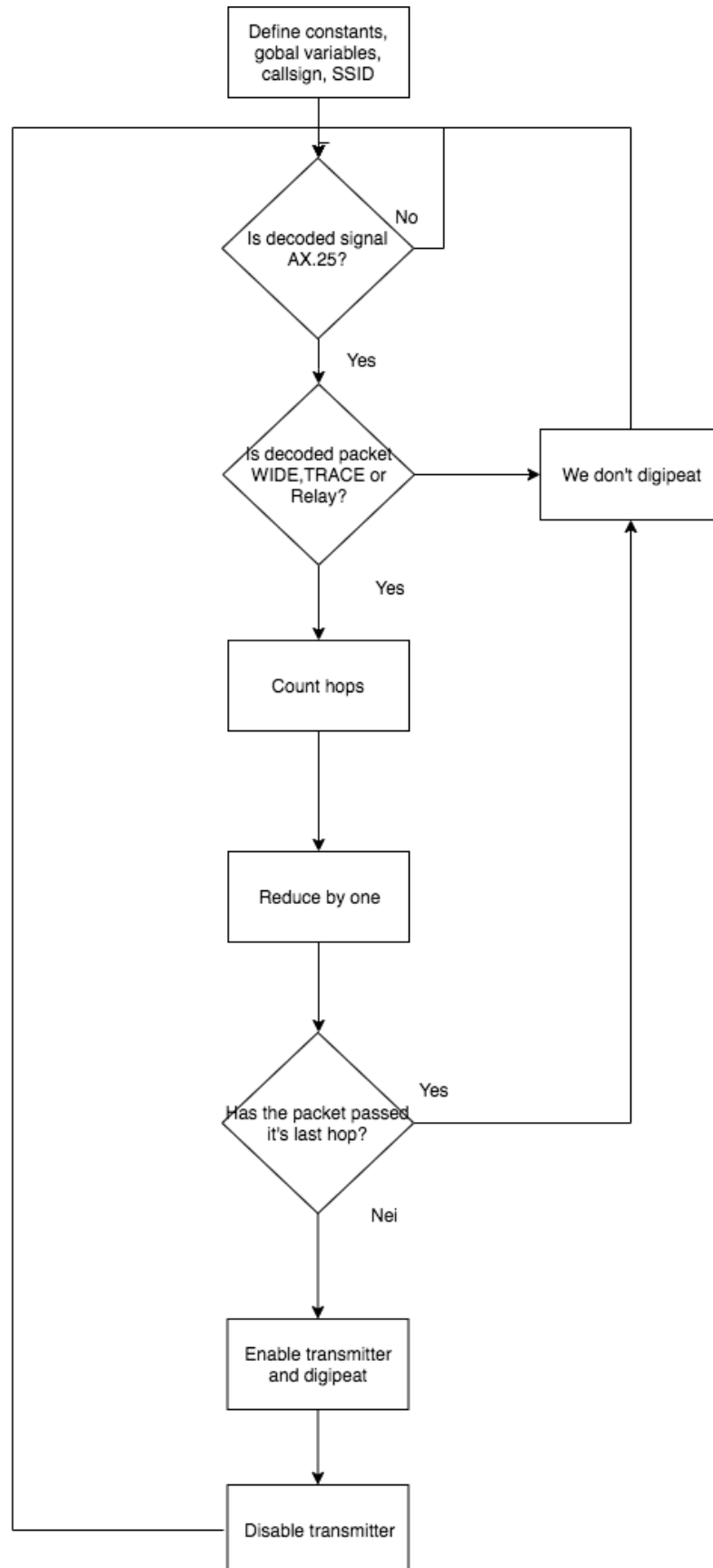


3. PCB Bottom view

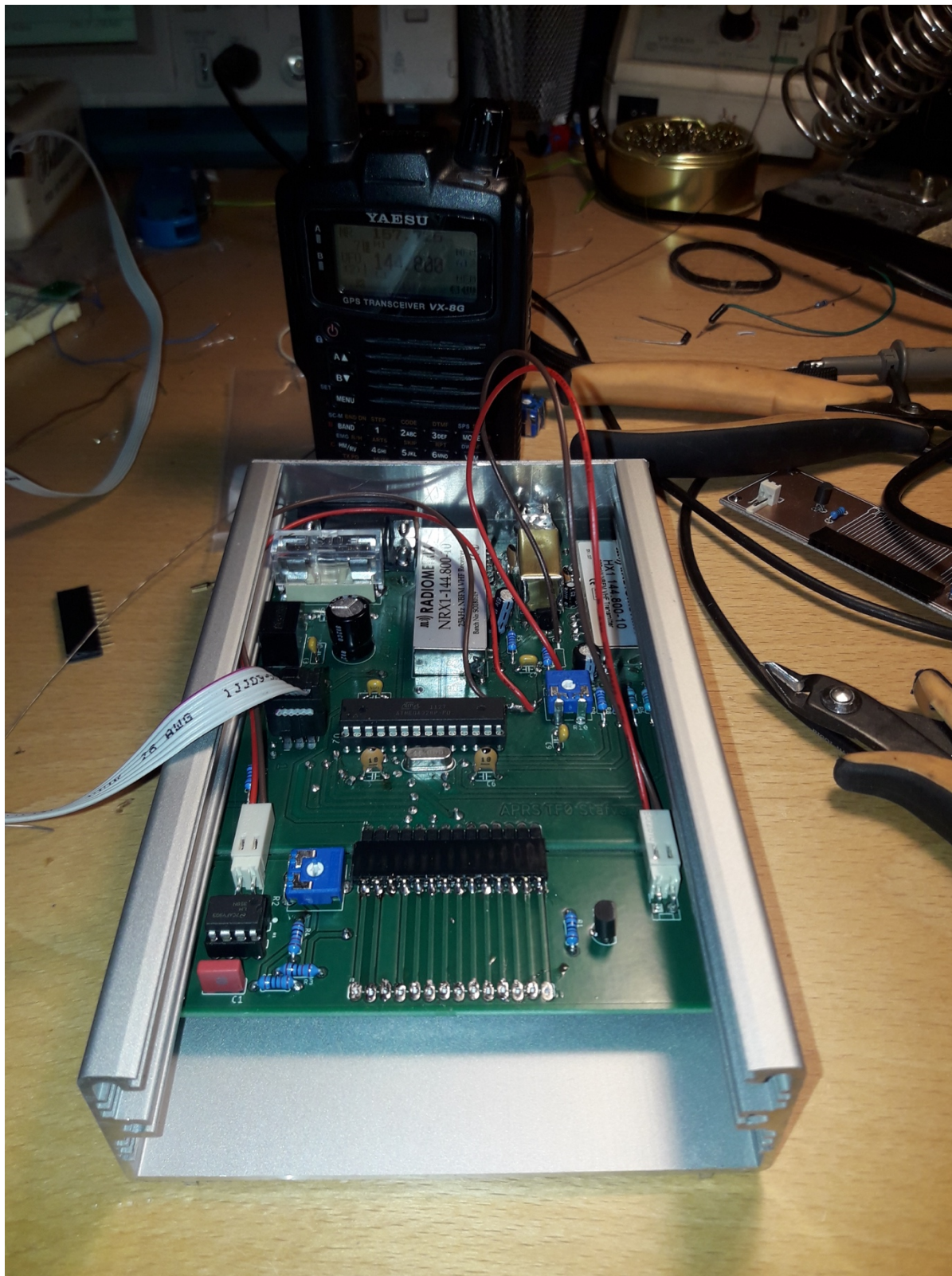


9. Program Flowchart

TF0 APRS Stafvarpi



10. Picture of device (prototype)



11. Component list

| ID | Size | Description |
|---------------------|-------------------------|-----------------------|
| C5,C6 | 18pF | Capacitor |
| C11,C12 | 100pF | Capacitor |
| C1,C3,C4,C9,C14 | 100nF | Capacitor |
| C7 | 220nF | Capacitor |
| C13 | 1uF (25V) | Capacitor |
| C8,C10 | 10uF (25V) | Capacitor |
| C2 | 470uF (25V) | Capacitor |
| D1 | P6KE18CA | Supressor diode |
| F1 | 1A | Fuse |
| X1 | 16MHz | Crystal |
| J1 | Pin header | ICSP |
| J2 | SMA F | Antenna connector |
| J3 | Pin header | I/O connector |
| J4 | DB9 Male | Power connector |
| K1 | G5K-2 | TX/RX Relay |
| Q1 | BC547 | NPN Transistor |
| R1,R3,R4,R5,R12,R13 | 10k Ω (1%, 0,5W) | Resistor |
| R2,R9,R11 | 1k Ω (1%, 0,5W) | Resistor |
| R6 | 8k2 Ω (1%, 0,5W) | Resistor |
| R7 | 3k9 Ω (1%, 0,5W) | Resistor |
| R8 | 2k2 Ω (1%, 0,5W) | Resistor |
| R10,R14 | 100k Ω | Trim resistor |
| S1 | n/a | PTM switch |
| U1 | R-78E5.0-1.0 | Voltage Regulator |
| U2 | ATmega328P | MCU |
| U3 | Radiometrix-HX1 | Transmitter module |
| U4 | Radiometrix-NRX1 | Receiver module |
| U5 | LM358 | Operational amplifier |

13. External sources and material

Extdigi software: Fetched 2019-11-20: <http://extradio.sourceforge.net/extdigi.html>

BertOS: Fetched 2019-11-20: <https://github.com/develersrl/bertos>

Web page of Bob Bruninga. Fetched 2019-11-20: <http://www.aprs.org>

APRS Standard. Fetched 2019-11-20: <http://www.aprs.org/doc/APRS101.PDF>

APRS-IS upplýsingar á netinu: Sótt 2019-11-20: <https://aprs.fi/>

Information on using relays. Fetched 2019-11-20: https://www.w6pql.com/using_inexpensive_relays.htm

Datasheet for G5V-2 relay. Fetched 2019-09-05 http://omronfs.omron.com/en_US/ecb/products/pdf/en-g5v_2.pdf

Datasheet Atmega328P. Fetched 2019-09-05:
http://ww1.microchip.com/downloads/en/DeviceDoc/Atmel-7810-Automotive-Microcontrollers-ATmega328P_Datasheet.pdf

Datasheet for HX1. Fetched 2019-09-05: <http://www.radiometrix.com/files/additional/hx1.pdf>

Datasheet for NRX1. Fetched 2019-09-05: <http://www.radiometrix.com/files/additional/nrx1.pdf>

Datasheet for R-78E05. Fetched 2019-11-19: <https://recom-power.com/pdf/Innoline/R-78E-1.0.pdf>

Datasheet for D-Sub 9 pin connector. Fetched 2019-11-20:
https://www.te.com/commerce/DocumentDelivery/DDEController?Action=srchtrtv&DocNm=82068_A MPLIMITE_Right-Angle_Posted_Conn&DocType=CS&DocLang=English

Datasheet for LM385 op-amp. Fetched 2019-12-02: <http://www.ti.com/lit/ds/symlink/lm2904-n.pdf>