Kenwood TS-890/ ICOM IC-7300MK2 Band Decoder

By kuzysk in Circuits > Electronics 1.499 10 Featured

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In March 2025, I bought a **Kenwood TS-890** transceiver. To fully utilize its capabilities, I needed a reliable **band decoder** to automatically control an antenna switch. Unfortunately, I couldn't find a commercially available solution that met my requirements — so I decided to build my own.

This project is a **fully automatic band decoder** that communicates directly with the transceiver and controls an external antenna switch. When combined with a suitable antenna switch, the system automatically selects the correct antenna for every amateur radio band. Of course, **manual band and antenna switching** is also supported.

The device communicates with the transceiver via the **COM port**. The microcontroller periodically queries the radio, and the transceiver responds with its current operating frequency along with additional status information such as TX/RX state. Based on this data, the decoder determines the active band and

switches the corresponding output.

To make configuration simple, the band decoder includes a **built-in menu system**, allowing all settings to be adjusted directly on the device — no reprogramming of the microcontroller is required.

This article describes the **“GND-switched” version** of the decoder. The hardware provides **12 usable outputs**, covering all amateur bands from **160 m to 6 m**, including the **CB band**. However, since very few operators actually use all 12 bands, the design uses a **6-pin connector** (the same type used by Yaesu rotator controllers). The desired outputs are selected using simple wire jumpers on the PCB, making it ideal for controlling a **4-to-1 antenna switch** (or **5-to-1 in the VCC-switched version**).

Firmware evolution – December 2025 update

By December 2025, the project received a **major firmware update** featuring a completely new **user interface and menu system**. The concept of band groups was removed and replaced with a much more flexible approach:

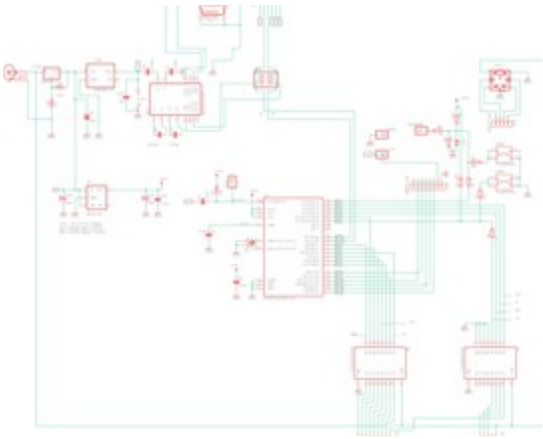
- Support for **multiple multiband antennas**
- Up to **12 antennas** in total
- **Preferred antenna selection for each band**
- **Manual antenna switching**
- Free assignment of any antenna to **OUT 1–12**
- Custom **antenna icons** for clear visual identification

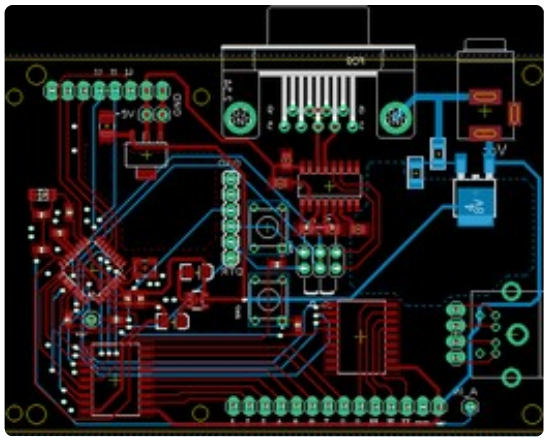
The result is a highly flexible, modern band decoder that adapts to virtually any antenna setup — from simple installations to complex multi-antenna stations.

January 2026 update: My **ICOM IC-7300MK2** is at home so I already tester ICOM software version. (No detection by voltage but CI-V! It means band decoder can detect all bands!) I already designed ICOM only board where RS232 connector is replaced to 3.5mm jack but it is small job comparing to create schema and software. ICOM version is VCC switched as new used transistor array has short circuit protection.

As ICOM uses the same "protocol" for all radios with a CV-I 3.5mm jack, device should work on all such ICOMs. Tested on 7300 and much older 706. Here is the list of compatible rigs: IC-7300MK2, IC-7760, IC-9700, IC-7610, IC-7300, IC-7100, IC-9100, IC-7410, IC-7600, IC-7700, IC-7200, IC-7000, IC-703, IC-7800, IC-756 Pro III, IC-756 Pro II, IC-746 Pro, IC-756 Pro, IC-718, IC-746, IC-706 MkIIG, IC-756, IC-706 MkII, IC-706. I am not sure I will publish new article here on Instructbles because there is not many radio-amateurs. If there is interest, I will create an article. We'll see.

Supplies





Option A – Standard Arduino board + custom interface PCB

- **Arduino-compatible board**
- You can use a standard Arduino board (for example Arduino Pro Mini, Nano, or Uno).
- **Custom PCB according to the schematic**
- In this option, the Arduino is a separate module and the remaining circuitry (level shifters, drivers, connectors, etc.) is placed on a dedicated PCB designed according to the schematic.

Advantages:

- Easy to build and debug
- Ideal for prototyping and first-time builders

Limitations:

- Larger physical size
- Slightly higher cost due to the separate Arduino module

Option B – Fully integrated Arduino-compatible clone (single PCB)

- **Custom Arduino-compatible microcontroller circuit**
- Instead of using a ready-made Arduino board, the Arduino Pro Mini–compatible circuit is integrated directly into the main PCB.
- **All components on a single board**
- The microcontroller, power supply, interface electronics, and connectors are combined on one PCB.

Advantages:

- Smaller dimensions
- Lower overall cost
- Cleaner and more professional hardware design

Limitations:

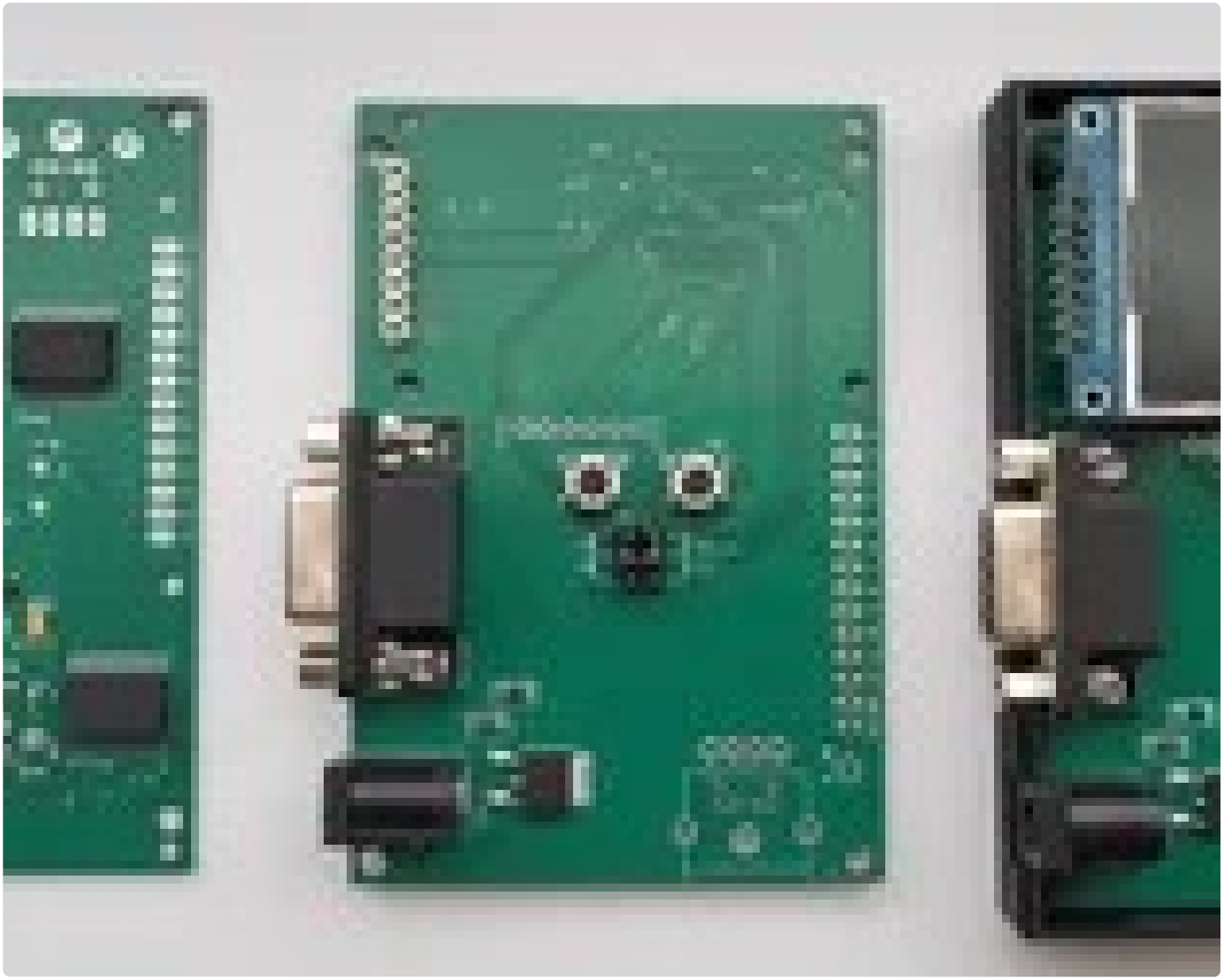
- Requires PCB design and soldering skills
- Less flexible for quick hardware changes

Additional required parts (common to both options)

- **RS-232 cable (DB9, straight-through)**
- A straight RS-232 cable is required.

    - Pin 2 → Pin 2
    - Pin 3 → Pin 3
    - ⚠️ A null-modem (crossed) cable will **not** work.
- **Antenna switch**
- In my setup:
    - All relay coils are connected to **+13.8 V**
    - The band decoder activates a relay by pulling the corresponding output to **GND**
    - This selects the active antenna.
    - *(antenna switch I made is here)*
- **TFT display – 1.8″ 128×160 RGB (ST7735)**
    - Two or more common display variants exist. One works without modification, the other requires a small firmware adjustment (color order / initialization)

Step 1: Hardware



Hardware overview

According to the schematic, the hardware consists of **three main functional blocks**:

1. **Microcontroller (Arduino Pro Mini compatible)**
2. **MAX3232 – RS-232 level converter**

3. **ULN2803 – relay driver transistor array** (for GND switched model only)

Each block has a clearly defined role.

Microcontroller (Arduino-compatible)

The microcontroller is wired as an **Arduino Pro Mini–compatible circuit**.

Its task is to handle communication, band detection, and output control.

Operation principle:

- The microcontroller periodically sends a **query command (IF command)** to the transceiver.
- It receives the response containing the **current operating frequency** and additional status information.
- Based on the frequency, the firmware determines the active amateur band.
- The corresponding output pin is activated to select the correct antenna.

Reason:

This approach ensures reliable and fully automatic band detection without relying on analog signals or external band data.

Limitation:

The method depends on correct CAT/COM communication with the transceiver.

MAX3232 – RS-232 level converter

The **MAX3232** is used to communicate with the Kenwood transceiver via the

COM (RS-232) connector.

Why it is needed:

- The transceiver uses RS-232 voltage levels (approximately **±5 V to ±15 V**).
- The microcontroller operates at **TTL/CMOS logic levels** (0–5 V or 0–3.3 V).
- These levels are **not compatible** directly.

The MAX3232 performs **bidirectional voltage level conversion**, allowing safe and reliable communication between the transceiver and the microcontroller.

ULN2803 – relay driver

The **ULN2803** is an 8-channel transistor array used to drive the relay coils in the antenna switch.

Purpose:

- Microcontroller pins cannot directly drive relay coils.
- The ULN2803 provides sufficient current capability and includes internal protection diodes.

Important schematic correction:

Although simplified block diagrams often show the ULN2803 input as a comparator or amplifier, in reality the inputs have **relatively low impedance**.

Because of this:

- A **2.2 kΩ resistor (R7)** was added
- The value of **R1 was changed to 510 Ω**

This modification ensures proper logic levels and reliable operation.

The internal pull-up alone is **not sufficient** in this application (see ULN2803 internal schematic).

PCB design and assembly

I designed a custom PCB and ordered it as **pre-assembled boards**, which greatly reduced manual soldering.

- Only a few components need to be soldered by hand
- The main downside is the **minimum order quantity** (usually 5 boards or more)

As a result, I currently have **unused assembled boards**.

If there is interest, I can offer fully assembled boards via eBay.

AnalogIN input (optional feature)

The schematic and PCB include an **AnalogIN** input.

Current status:

- Not used in this project

Future use:

- Allows the same hardware to be used with transceivers that indicate the selected band using **analog voltage levels**
- Requires **different firmware** and additional testing

This makes the hardware more flexible for future expansions.

Display notes (overview only)

The display is described in detail in a separate chapter, but one important note belongs here.

I use **1.8″ 128×160 TFT displays (ST7735)**.

Although they look identical, I encountered **two different internal variants**:

- Many low-cost displays from China have **RED and BLUE channels swapped**
- Some also show a **white or colored stripe** at the edge

Good news:

- These issues can be handled in **software**
- With proper initialization and color correction, the low-cost displays work just as well as the original ones

Limitation:

- Some functions from the Adafruit_ST7735 library may not work correctly
- The best approach is always to **test the display module you receive**

Step 2: Arduino Bootloader

⚠️ **If you are using a ready-made Arduino board, you can skip this step.**

This step is only required when you build a **custom Arduino-compatible clone** directly on your PCB.

Why a bootloader is needed

A blank microcontroller does not understand sketches uploaded from the Arduino IDE.

The **bootloader** is a small program that allows the microcontroller to:

- Communicate with the Arduino IDE
- Accept firmware uploads via a serial interface

Without it, the chip cannot be programmed in the usual Arduino way.

What you need

- **Arduino UNO** (used as a programmer)
- USB cable for the Arduino UNO
- Target board with an **ATmega328P** (or compatible)
- A few jumper wires

Reason:

The Arduino UNO can act as an **ISP (In-System Programmer)**.

Programming method

1. Connect the Arduino UNO to your PC.
2. In the Arduino IDE:
    - Open **File → Examples → ArduinoISP**
    - Upload this sketch to the Arduino UNO
3. Wire the Arduino UNO to the target microcontroller using the ISP signals
4. (MOSI, MISO, SCK, RESET, VCC, GND).

5. In **Tools** → **Board**, select:
6. **“Arduino Pro or Pro Mini”**
7. Select the correct processor and clock frequency for your design.
8. Click **“Burn Bootloader”**

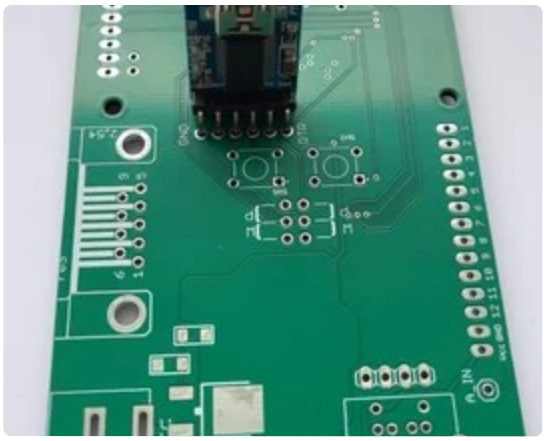
After this step, the microcontroller behaves like a standard Arduino Pro Mini and can be programmed normally via the serial interface.

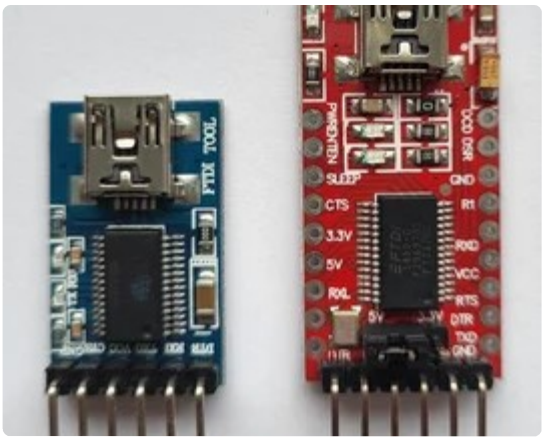
Notes and limitations

- Clock frequency and fuse settings must match your hardware
- (for example 16 MHz with external crystal)
- Wiring errors are the most common cause of failure
- This procedure is well documented, and many tutorials are available online

Once the bootloader is installed, you can proceed directly to uploading the firmware for the band decoder.

Step 3: The Code





I am not programmer just hobbies so I use Arduino IDE

Programming the microcontroller

You will need a **serial programmer** (USB-to-TTL adapter).

Any adapter can be used, **as long as the pinout matches the schematic and PCB**.

I use an older programmer with the following pin order:

DTR – RX – TX – VCC – CTS – GND

⚠️ **Important:**

- Always verify the pin order before connecting
- A wrong connection may prevent programming or damage the board

Firmware options

You have two choices:

- **Write your own firmware**
- The protocol is simple enough to implement if you are familiar with serial communication and string parsing.
- **Use my firmware**
- A professional programmer might smile at the structure, but:
  - The code is easy to read
  - The logic is straightforward
  - Most importantly: **it works reliably**

For now, I am publishing a **simplified version** of the code:

- No buttons
- No menu system
- No band groups
- Direct band-to-output mapping

Reason:

This makes the code much easier to understand, especially if you want to modify or extend it later.

I am still actively improving the firmware and I am almost fully satisfied with the current version.

More advanced versions (menu, buttons, antenna logic) can be published **on request**.

Core principle of operation

The entire band detection logic is based on the **CAT command IF**, sent from the microcontroller to the Kenwood transceiver via the COM port.

Important documentation note

In the document **ts890_pc_command_e.pdf**, the IF command is **not listed**.

However, it *is* documented in:

- **ts590_g_pc_command_e_rev2**

This command is compatible and works correctly with the TS-890.

IF command response format

After sending the IF command, the transceiver responds with a string similar to:

IF00014175000000000000000;

Where:

- 00014175000 = **14.175 MHz**
- The remaining fields contain status information

How the band decoder parses the response

The firmware processes the received data step by step:

1. **Detects the IF command**

2. Confirms that the received data belongs to an IF response
3. **Reads the frequency field**
4. Converts the numeric value into frequency
5. **Determines the band**
    - Valid amateur band
    - Or **out-of-band** condition
6. **Reads the P8 field**
7. Determines **RX / TX state**
8. **Waits for ;**
9. Identifies the end of the IF command

Only after the full command is received and validated does the decoder update the output pins.

Why this approach works well

- No analog measurements required
- No calibration needed
- Immune to voltage drift and noise
- Fully synchronized with the transceiver state

Limitation:

This method depends entirely on reliable CAT communication. If the COM link fails, band detection is not possible.

Note regarding the full firmware version

Developing the **full-featured firmware** (including buttons, menu system, antenna logic, and all safety features) took a **significant amount of time and testing**.

For this reason, the **complete version of the code is not published publicly by default**.

However, it is available **on request** for a **symbolic fee of 1 EUR / 1 USD (or an equivalent value)**.

Reason:

This is not intended as commercial software, but rather as a way to:

- value the time invested in development
- keep distribution manageable
- ensure that users requesting the full version are genuinely interested

The **simplified version** published in this article is fully functional and intended for:

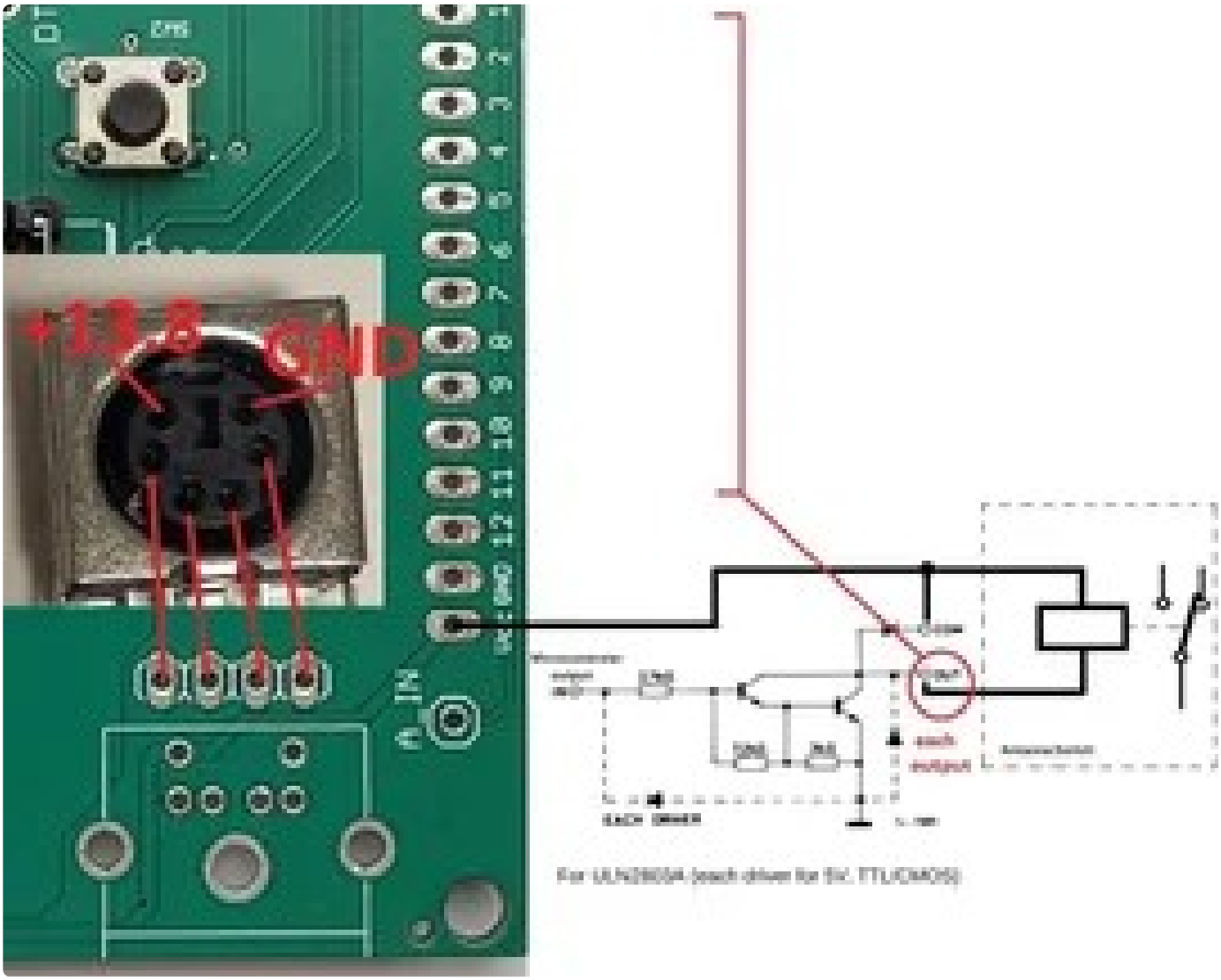
- learning
- understanding the protocol and logic
- creating your own customized implementation

Licensed radio amateurs who are interested in the **full firmware** can contact me directly.

Step 4: Enclosure

I made 3D model for my PCB.

Step 5: Outputs



Output structure overview

The band decoder provides:

- **12 independent “main” outputs**
- **One auxiliary 6-pin connector** (optional)

The 6-pin connector is **not required for operation**.

It is included purely to **simplify wiring** between the band decoder and a typical antenna switch.

The 6-pin **auxiliary** connector

The 6-pin connector already includes two fixed connections:

- **Ucc (+13.8 V)**
- **GND**

The remaining **four pins** are user-configurable.

Using simple **wire jumpers on the PCB**, each of these four pins can be connected to **any of the 12 main outputs**.

Reason:

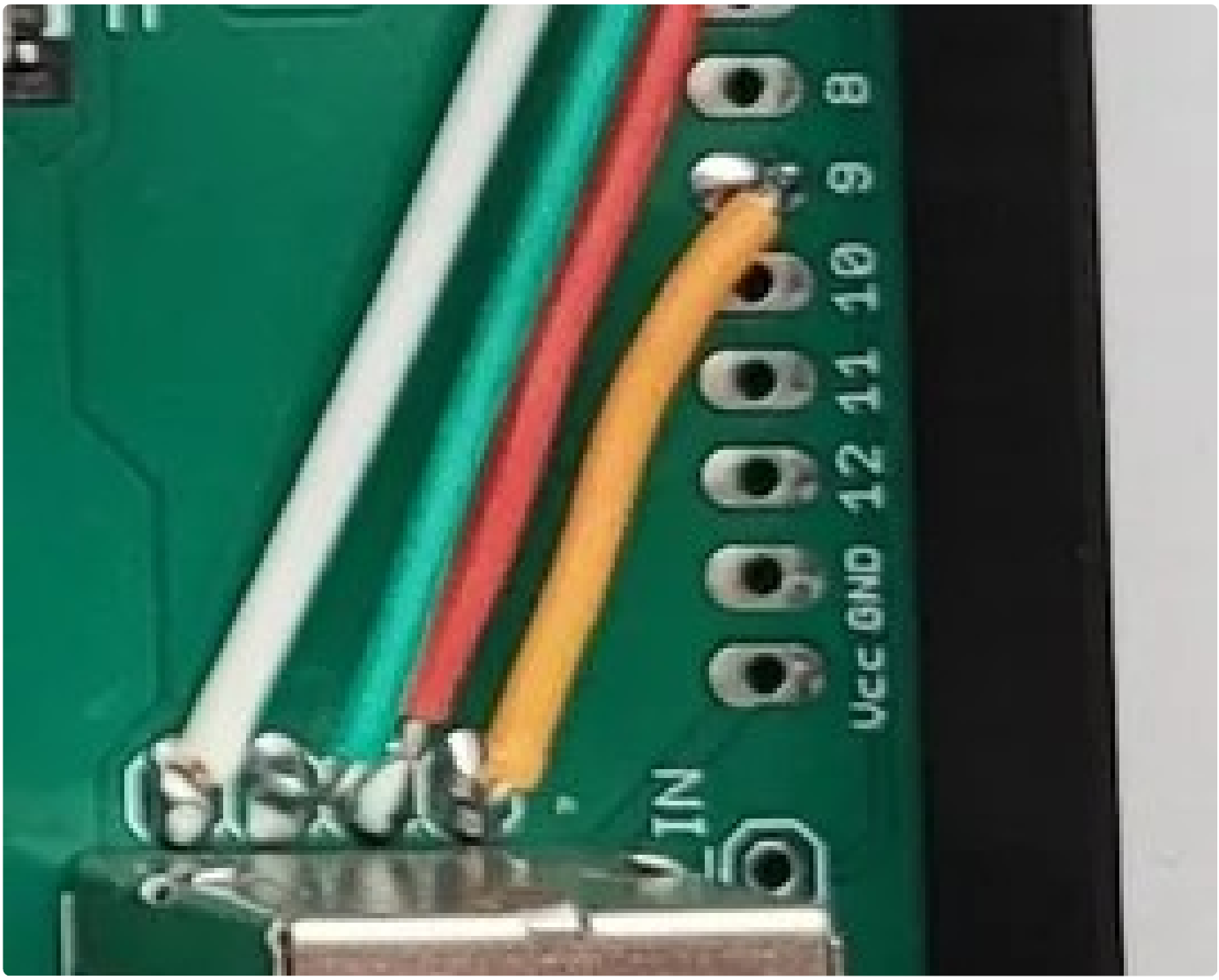
This allows easy connection to common **4-to-1 antenna switches** without running many individual wires.

Limitation:

Only four outputs can be routed to the connector at the same time.

If you need more outputs, you can always use the main output pins directly.

Step 6: Outputs Example



Example configuration

I use **four antenna outputs**, each driving one relay in the antenna switch.

Each wire has **two clearly defined ends**:

- **First end:** soldered directly to one of the **main outputs (OUT 1–OUT 12)** on the band decoder PCB
- **Second end:** soldered to a pin of the **6-pin connector**, which goes to the antenna switch

Assigned outputs and antennas

- **White wire**
  - **First end:** soldered to **Output 1** (ULN2803 output)
  - **Second end:** connected to the 6-pin connector
  - **Antenna A1:** assigned to all unused bands and connected to a **dummy load** via the antenna switch
- **Green wire**
  - **First end:** soldered to **Output 3**
  - **Second end:** connected to the 6-pin connector
  - **Antenna A2:** 40 m inverted-V dipole
- **Red wire**
  - **First end:** soldered to **Output 5**
  - **Second end:** connected to the 6-pin connector
  - **Antenna A3:** 3-element monoband 20 m Yagi-Uda
- **Yellow wire**
  - **First end:** soldered to **Output 9**
  - **Second end:** connected to the 6-pin connector
  - **Antenna A4:** 10 m / 11 m band antenna

Connector choice and reasoning

The **6-pin connector** is used only as a convenient interface between the band decoder and the antenna switch.

I reused this connector type from another project (Yaesu rotator LAN interface). Since my antenna switch has **only four relays**, the 6-pin connector is more than sufficient and keeps wiring clean and compact.

Alternative versions

- In an earlier **buttonless version**, I used an **8-pin Icom microphone connector**
- That version required a slightly larger enclosure
- A **3D enclosure model** is available on request

VCC-switched version note

In the **VCC-switched version**, up to **five outputs** can be routed to the connector, because only **GND is permanently wired**, leaving more pins available for signal outputs.

Step 7: Notes

This project page is **not yet fully finished**.

I will continue to expand it by adding:

- Additional description steps
- A **complete and final version of the firmware**

If there is interest, I can also **publish the schematic and PCB files**.

Please note that:

- The design was created in **Eagle**
- I currently use **Eagle only**, so the files are available in this format

Contact

- All **licensed radio amateurs**, for whom this article is intended, can find and contact me under the callsign **SA7KZA** on the **QRZ** website.

Step 8: New Version, Positive Output and Possibility for ICOM (voltage and CI-V)

During further development, I discovered an important practical detail:

Most **commercially available antenna switches** use **positive logic** to control their relays. In other words, a relay is activated by applying **+12 V (typically +13.8 V)** to its control input.

Positive-output (VCC-switched) version

To ensure compatibility with commercial antenna switches, I redesigned the output stage and **replaced the original output driver IC** with a device suitable for **positive-voltage switching**.

Result:

- The band decoder can directly drive **commercial antenna switches**
- No external interface circuitry is required
- The rest of the firmware logic remains unchanged

This modification makes the band decoder far more versatile in real-world stations.

ICOM compatibility (Voltage / CI-V)

While redesigning the hardware, another idea came up:

Why not make the band decoder compatible with **ICOM transceivers** as well?

To support this, I added a **CI-V interface** (see schematic image).

Key points:

- **Voltage-based band input** was already present on the board but is unused.
- **CI-V** is preferred because it allows **clear band identification and separation**

Testing status

- The **VCC-switched version** is already **tested** with **Kenwood TS-890** and **ICIM IC-7300MK2** transceivers
- Functionally, it uses the **same firmware** as the original version as only transistor array is different.
- ICOM testing is still pending. Now working well couple of days.