

HAOCS

Ham Antenna Open Control System

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slides at: <https://ka2c.com/haocs/>

KA2C QTH Antennas

- Optibeam OB7-3 Yagi on 20/15/10 at 45 feet
- Hy Tower modified for 160/80/40 at 200 feet from the shack – **controlled by HAOCS**
- SAL-20 RX directional loop antenna for 160/80/40 at 600 feet from the shack – Hamation Control Center
- 160/80/40 inverted vee at 40 feet in the center
- Custom 30/20/17/15/12/10 vertical with base at 8 feet and 100 feet from the shack – **controlled by HAOCS**
- Cushcraft A627013S Yagi on 6/2/70cm at 50 feet

KA2C Antenna Farm



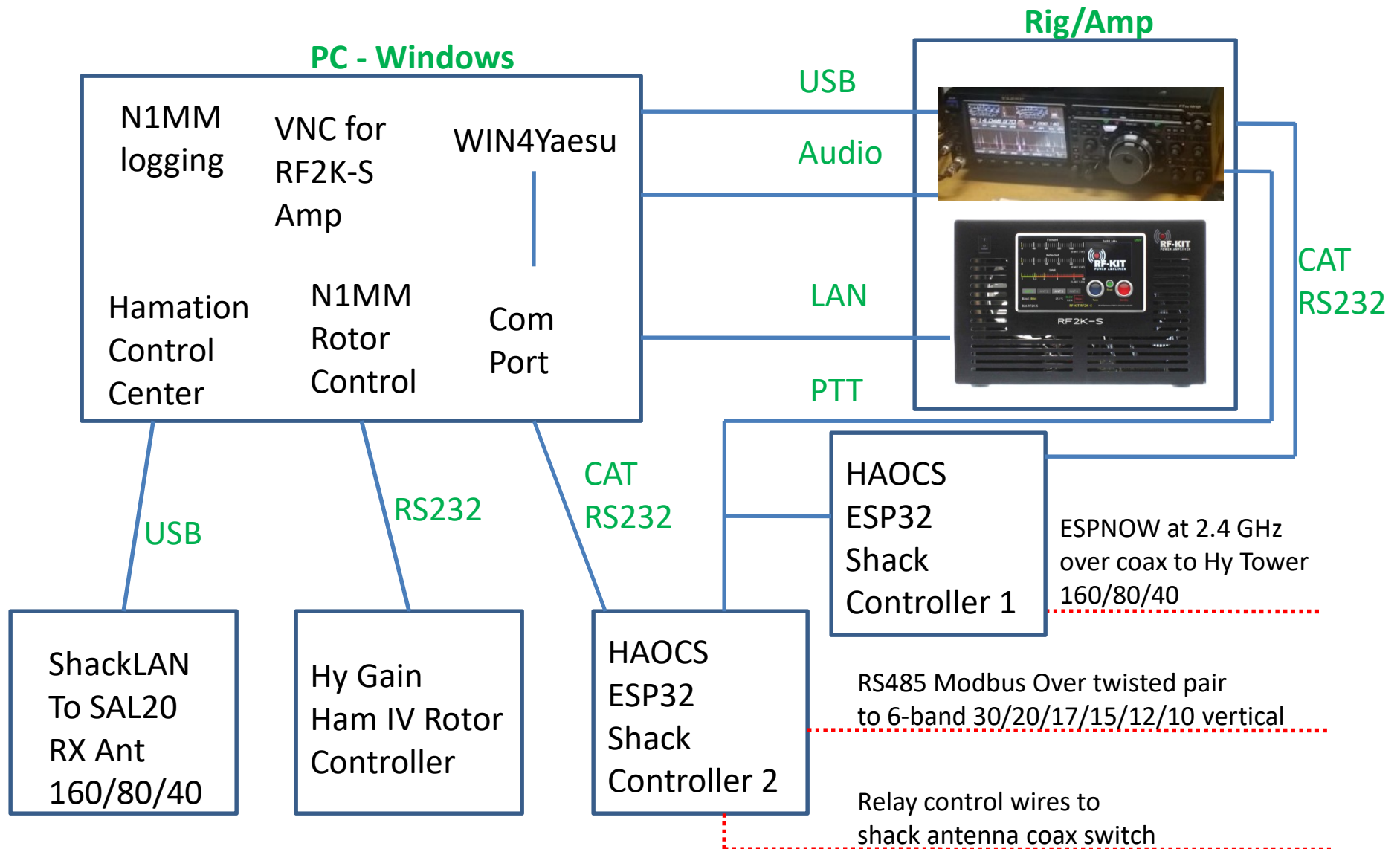
The Sunflowers at Peak



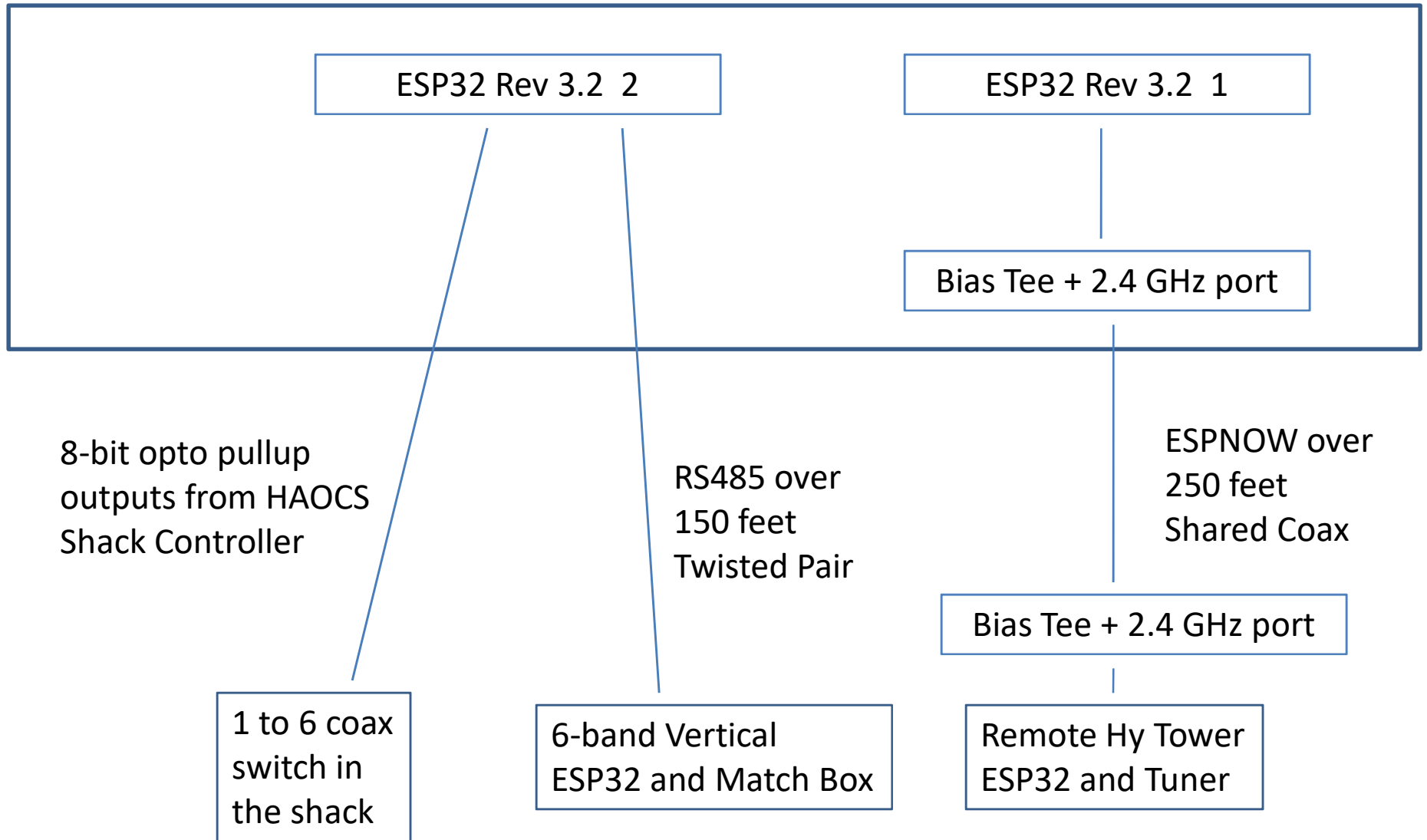
Shack Operating Position



HAOCS at KA2C QTH



KA2C HAOCS Shack Controllers & Remotes Block Diagram



Power for HAOCS and other Shack Devices



Off-the-shelf 8 output
Anderson Powerpole
Fusebox for +12 VDC

Individual fuses and
connections for each
HAOCS device

- HAOCS Controller 1 - direct cable to box on bench
- HAOCS Controller 2 - direct cable to box on bench
- Hy Tower Tuner Box – muxed over coax
- 6-band Vertical Tuner Box - over Ethernet cable

HAOCS

- Supports remote antenna system control relays based on rig frequency segment
- Fully open hardware, software, interfaces,.... allows custom implementation and added features
- Schematics, PCB, Gerber, BOM, Placement,... files – supports JLCPCB factory assembly
- ESP32 sketches and Windows files
- Flexible alternatives for remote links
 - Over the air
 - Muxed on coax
 - Twisted pair
 - Direct relay control wires

HAOCS Components

- Shack Controller & remote devices - ESP32DEVKITC
- 8-bit I/O expansion PCB's
- Bias Tee with a 2.4 GHz port
- Tuner & Match PCB's,....
- Remote control links
 - Direct control wire cable (wires go directly to relays)
 - RS-485 cable with HAOCS protocol – 115.2 kbps
 - ESPNow (over-the-air OR muxed-on-the-coax) – 1 Mbps
- Remote Devices
 - Direct control wire cables to relays
 - ESP32 devices

ESP NOW

- Expressif protocol
- Uses WiFi 1 Mbps physical layer
- 2.4 GHz
- Total link budget of about 120 dB
- Reliable protocol – error detection & repeat
- Very low delay – important to avoid hot switching
- Easily muxed onto coax for HF systems
- Driver libraries available
- Integrated with ESP32

RS485 + Modbus

- Well established and supported
- Twisted pair
- 100's of feet to 1000's of feet
- Low-cost IC's available for the physical layer with slew-rate limiting for low RFI
- 115.2 kbps is a good compromise on delay and distance
- UART RS232 TTL interface to the ESP32
- Modbus drivers available provide reliable transport – error detection and repeat
- Don't forget the termination and bias resistors on the twisted pair bus!

Future Possible Options

- Wireless

- WiFi
- BT
- Zigbee
- Z-Wave
- Lora

- Wired

- CAN bus
- Ethernet

Issues

- Frequency bands
- Bit rates
- Delay
- RFI
- Hardware
- Drivers

HAOCS ESP32 PCB Rev 3.2



Shack Controller and Remote Device Processor

- SMD PCB – 85 x 150 mm

-ESP32 WROOM ESP U – U.FL 2.4 GHZ ESPNOW connector

- USB connector for PC programming - interface

-8 relay driver outputs on 10-pin IDC ribbon cable connector – 100 ma 12V pullup

- I2C to 8-bit I/O IC, 8-bit opto pullups & IDC ribbon connector

-2x I2C connectors

-4 input 12-bit ADC

-RS232 TTL header for a CAT interface

-PTT input to prevent hot switching

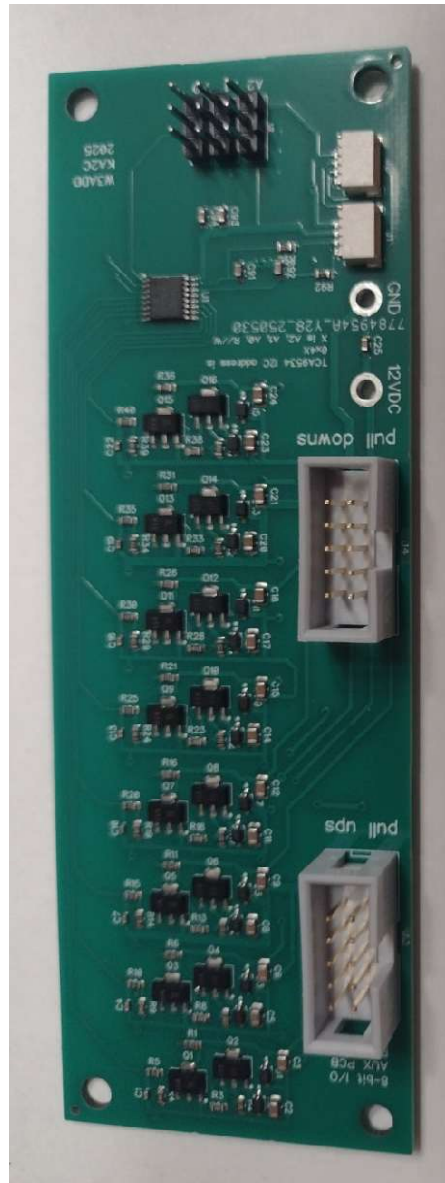
-MAX483 with slew-rate limiting RS485 driver LCD, user buttons, LED indicator

- Linear power supplies for low RFI

Almost all components factory installed

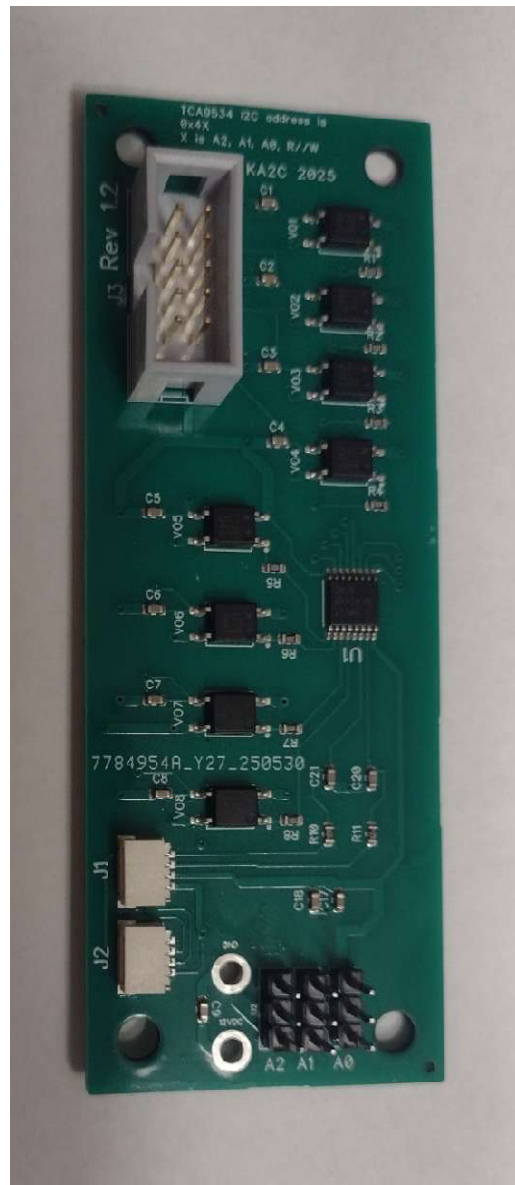
-Add ESP32, 5V regulator, heatsink, connectors

HAOCS Aux 8-bit Pullup/Pulldown I/O PCB



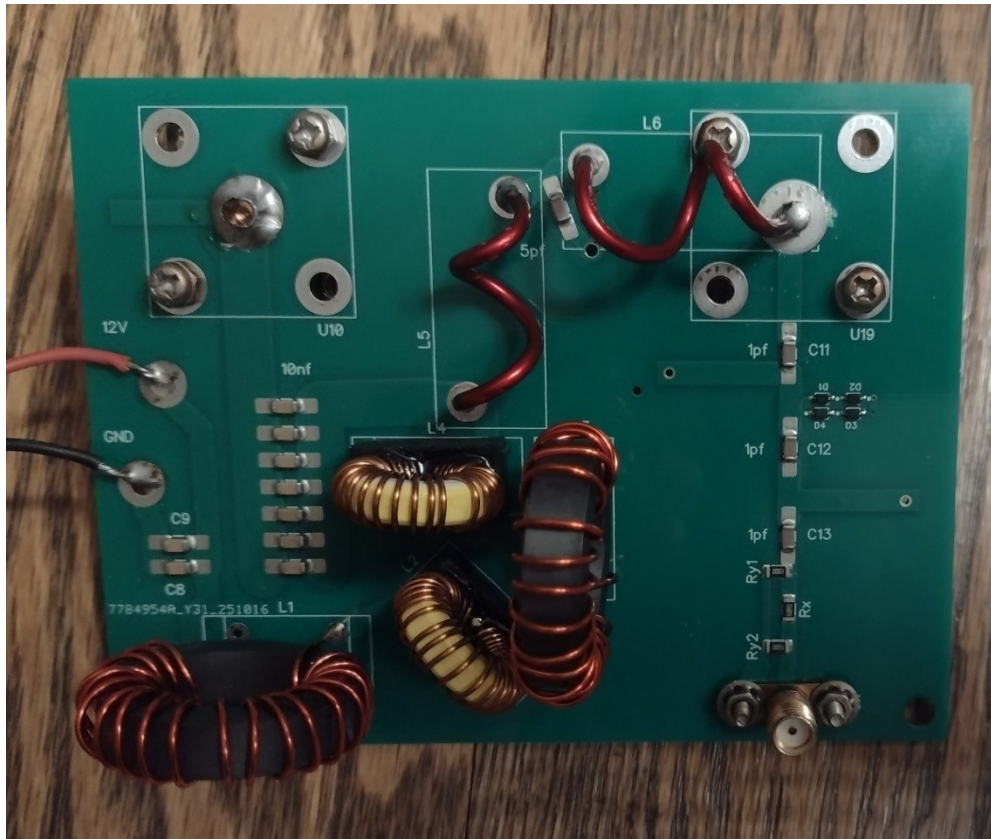
- Two 4-pin I2C connectors for bus chaining
- 3-bit address selection pin headers
- 10-pin IDC connector for pullups
- 10-pin IDC connector for pulldowns
- Discrete NPN/PNP transistor drivers
- Diode inductive flyback protection
- Up to 250 ma per output (max 1 A total)
- 135 x 45 mm
- Almost all components factory installed

HAOCS Aux 8-bit Opto PullUp I/O PCB



- Two 4-pin I2C connectors for bus chaining
- 3-bit address selection pin headers
- 10-pin IDC connector for pullups
- Opto-isolater pullups
- Diode inductive flyback protection
- Up to 100 ma per output (max 0.8 A total)
- 95 x 35 mm
- Almost all components factory installed

HAOCS Bias Tee with a 2.4 GHz Port



1.8 to 60 MHz

1500 watts

2.5 Amp DC power (12 VDC)

2.4 GHz port

> 80 dB isolation at 30MHz
surge protection diodes

Supports

ESPNOV

WiFi/BT

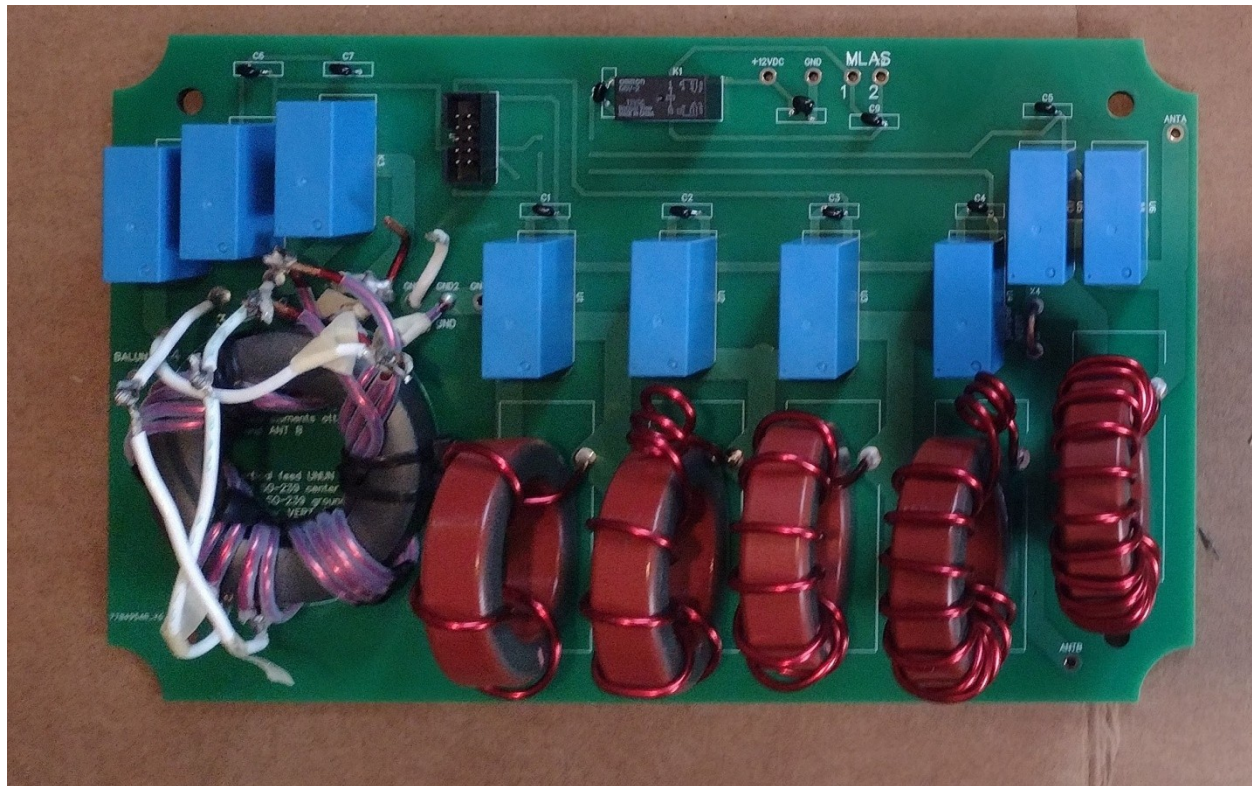
Zigbee

Units are placed in the shack
at the shack controller
and at the antenna device

Star architecture possible
using 2.4 GHz splitters

SMD parts factory assembled

HAOCS High Performance Tuner PCB



- Used to automatically pre-tune a Hy Gain vertical for 160/80/40 meters
- 5 binary arranged loading inductors
- Multimatch UNUN 50, 40, 28 and 12.5 Ohms
- Can be used on dipoles/inverted vees by reconfiguring the PCB
- 100% user assembled

PCB Manufacture JLCPCB

- Gerber files included in the HAOCs repository (BOM and part placement included for SMD's)
- Most parts installed at the factory including all SMD's – throughhole exceptions
 - 5V regulator, heatsink, ESP32 module, IDC connector,.....
- specific parts must be selected for resistor and cap values for JLCPCB manufacture submission
- Minimum of 5 PCB's by JLCPCB + shipping (can combine multiple PCB designs for shipping)

Repositories for HAOCS

- See www.KA2C.com/HAOCS
- GoogleDrive
 - <https://drive.google.com/drive/folders/1H7sNWx6dfMaDo38TYwMdHIII1klvpPk?usp=sharing>
- PCB tools using Diptrace
 - <https://diptrace.com/download/download-diptrace/>
 - Download the Freeware version
 - Use this to open and “see” all HAOCS schematics and PCB’s
- Baseline Boxes & PCB’s
 - HAOCS Shack Controller
 - HAOCS remote 8-bit I/O device (using the same PCB as the controller)
 - 8-bit remote control expansion PCB’s
 - High Performance Tuner – used in Vertical base tuner for 160/80/40 meters – Hy Tower
 - 6-band vertical matchbox
 - Bias Tee with a 2.4 GHz Port or Triplexer
- Baseline firmware/software
 - ESPNOW connected 8-bit remote control system (used for Hy Tower 160/80/40)
 - RS485 connected 8-bit remote control system (used for 6-band 30/20/17/15/12/10 vertical)

HAOCS Controller Functions

- Rig CAT interface obtains the operating frequency every 200 msec
- PTT from the rig goes to a priority interrupt to halt transmissions to remote devices and prevent hot switching
- Frequency segment based tables contain 8-bit data for remote devices – large number of frequency segments supported
- Drivers for links to remote devices and relay drivers
 - ESPNOW
 - MODBUS + RS485
 - I2C Serial to 8-bit I/O
- Driver for the 2x16 LCD display
- Driver for the RS232 CAT interface
- User pushbutton I/O & LED indicators

Frequency Segment 8-bit Relay Tables

- `const int lookupTable[][12] = {`
- `{160,1800000,1811999,1830,1,1,0,1,0,1,1,1},`
- `{160,1812000,1824999,1830,0,0,1,1,0,1,1,1},`
- `{160,1825000,1836999,1855,1,0,1,1,0,1,1,1},`
- `{160,1837000,1849999,1855,1,0,0,0,1,1,1,1},`
- `{160,1850000,1861999,1885,0,1,0,0,1,1,1,1},`
- `{160,1862000,1874999,1885,1,1,0,0,1,1,1,1},`
- `{160,1875000,1886999,1910,0,0,1,0,1,1,1,1},`
- `{160,1887000,1899999,1910,1,0,1,0,1,1,1,1},`
- `{160,1900000,1924999,1930,0,0,0,1,1,1,1,1},`
- `{160,1925000,1949999,1952,0,1,0,1,1,1,1,1},`
- `{160,1950000,1974999,1975,0,0,1,1,1,1,1,1},`
- `{160,1975000,2000000,1992,0,1,1,1,1,1,1,1},`
- `{80,3500000,3529999,3550,0,0,1,0,1,0,1,0},`
- `{80,3525000,3549999,3550,1,0,1,0,1,0,1,0},`
- `{80,3550000,3599999,3550,0,1,1,0,1,0,1,0},`
- `{80,3600000,3649999,3550,0,0,0,1,1,0,1,0},`
- `{80,3650000,3699999,3550,1,0,0,1,1,0,1,0},`
- `{80,3700000,3749999,3550,0,1,0,1,1,0,1,0},`
- `{80,3750000,3799999,3550,1,1,0,1,1,0,1,0},`
- `{80,3800000,3849999,3650,0,0,1,1,1,1,0,0},`
- `{80,3850000,3899999,3750,1,0,1,1,1,1,0,0},`
- `{80,3900000,3949999,3850,0,1,1,1,1,1,0,0},`
- `{80,3950000,4000000,3950,1,1,1,1,1,1,0,0},`
- `{40,7000000,7079999,7050,0,1,1,1,1,0,1,0},`
- `{40,7080000,7300000,7200,1,1,1,1,1,0,1,0}`
- `};`

Relay Tables are general purpose and can be used for any function that is frequency driven

12 segments on 160

11 segments on 80

2 segments on 40

Automatic pre-tuning

This is the table used for the Hy Tower At KA2C

HAOCS Remote Device Functions

- General purpose 8-bit parallel control output to drive groups of relays – dependent on frequency segments with existing software
- Link Drivers
 - ESPNOW
 - MODBUS + RS485
- I2C serial to 8-bit parallel drivers
- Optoisolator pullup outputs up to 100ma
- Bipolar outputs for Pullup or Pulldown up to 250 ma

Received data is immediately transferred to outputs

ESPNOW and Modbus are reliable protocols with error detection and packet repeat

Automatic detection of link failure
Displayed in the controllers

Possible Future - HAOCS – 2.0

- WINHAOCS
 - PC Windows Centric
 - UI is on the PC
 - Direct software interface to WIN4Yaesu, HRD, and other rig control platforms using virtual com ports
- HAOCS standalone
 - No PC required during operations
 - UI
 - 16x2 or 20x4 LCD
 - Pushbuttons and/or keypad
 - General purpose controller
- HAOCS standalone project centric
 - No PC required during operations
 - UI
 - 16X2 LCD
 - pushbuttons
 - Controller is remote link and project specific

Possible HAOCS 2.0 PCB's

- Limited fixes and enhancements
 - Integrated RS485 termination and bias resistor options
 - 5 VDC power pin fix on RS485 driver
 - 15V Zener diodes on +12 VDC for surge protection
 - JST SH I2C connectors aligned with Adafruit pinout
- RJ45 jacks in place of 10-pin IDC ribbon connectors to support using Ethernet cables for 8-bit I/O connections to groups of remote relays
- Integrated 8-bit SMD LED indicators for data or relay state
- Consider ESP32 S3 N16R8 module with USB OTG port to support USB based devices including nanoVNA's

Comments

- Option for Lora links may be attractive for longer range wireless – latency needs management
- Zigbee and others could be supported, but ESPNOW is built into the ESP32
- Automatic pre-tuned antennas are high performance and friendly for power amplifiers and operating
- HAOCs can work together with other control systems: Microham, Hamation, Green Heron Everywhere,...., to control different parts of a station – use multiple virtual or RS232 CAT ports on Win4Yaesu, HRD,....