Tode-RC

Hardware Development

Arduino-Mega Pro + Ebyte E32-433T30D [#AMPE32T30]

by TGit-Tech [http://www.tgit-tech.com]

Build Version: 212M / Last Updated: 2021-02-22

Table of Contents

1. Introduction $35

The Tode System

- Tode-RC = Handheld Remote Control Models
  - Model #AMP Arduino Mega Pro (No RF Module)
  - Model #AMPE32T30 Arduino Mega Pro + Ebyte E32-433T30D (1W/30dbm) RF module
  - Model #AMPE32T20 Arduino Mega Pro + Ebyte E32-433T20D (250mW/20dbm) RF module
  - Model #AMPXBEE Arduino Mega Pro + Digi XBee RF Module

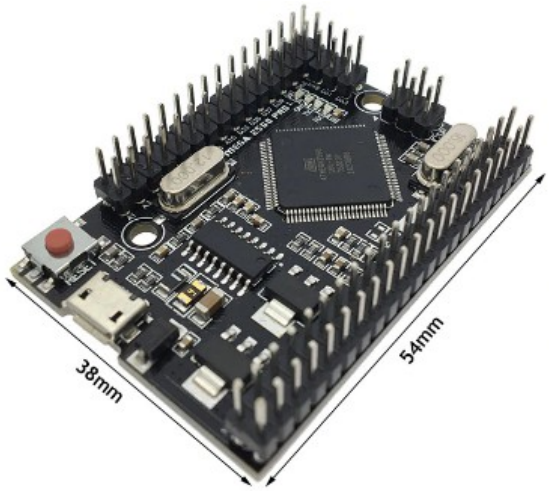
- Tode-SideIO = Input/Output Stations
  - Model #TSIOST Tode SideIO with Screw Terminals
  - Model #TSIOAP Tode SideIO with Aviation Plugs

Manuals

- User Manual Operator Instructions including Setup and Wiring
- Hardware Development How to build the hardware including detailed circuit diagrams
- Firmware Development How to adjust and create firmware for the Tode

2. Bill of Materials (BOM)

2.1 Parts $30

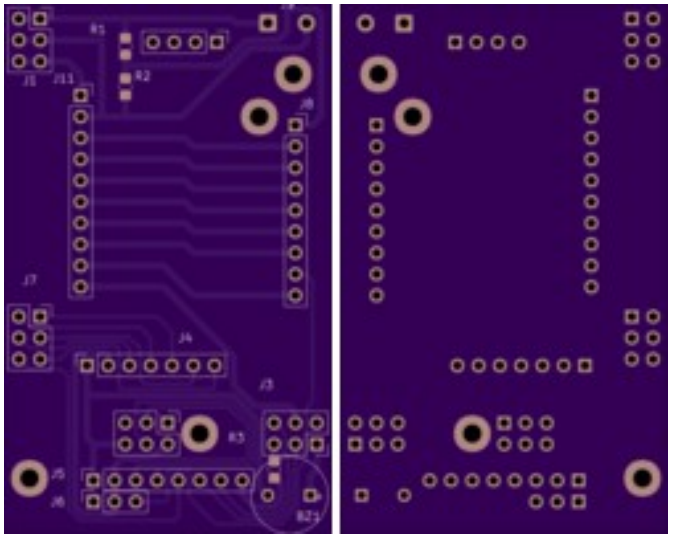


- ✔ Arduino Mega Pro Mini
  - Power In: 6Vdc to 9Vdc (Peek 18Vdc)
  - Power Out: 5Vdc @ 800mA + 3Vdc @ 800mA
  - Load Amps: 5Vdc @ 220mA
  - Dimensions: 38mm x 54mm
  - Controller: ATmega2560 @ 16MHz
  - IO-Pins: 54-Digital, 16-Analog
  - Memory: 256kb RAM, 4kb EEPROM
  - Temp Rng: -40C to 85C
  - Pricing: ~ $10/each
  - Web @ https://robotdyn.com/mega-2560-pro-embed-ch340g-atmega2560-16au.html

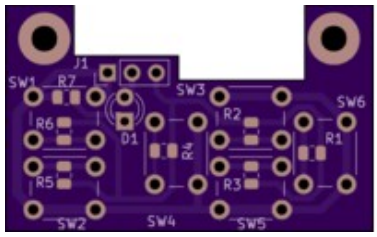
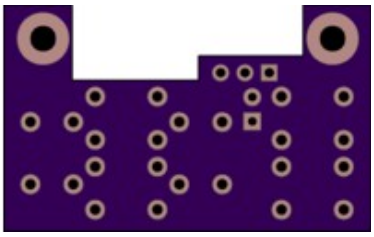
- ✔ Ebyte E32433T30D
  - Power In: 3.3Vdc to 5.2Vdc
  - Peek Power: 5.2Vdc (Damage)
  - Load Amps: Tx @ 106mA, Rx @ 15mA
  - Data Rate: 0.3Kbps to 19.2Kbps
  - Dimensions: 24mm x 43mm (w/o SMA)
  - Antenna Plg: SMA-K
  - Frequency: 410MHz to 441MHz
  - RF: Tx @ 30dBm, Rx @ -147dBm
  - Pricing: ~ $10/each
  - Web @ https://www.ebyte.com/en/index.aspx

https://www.ebyte.com/en/product-view-news.html?id=108

- ✔ 1.8 / 1.77 -Inch TFT LCD Display
  - Power-In: 5Vdc
  - Resolutions: 128 x 160dpi ST7735 RGB
  - Dimensions: 35mm x 56mm
  - Temp: -20C to 70C
  - (8)Pin-Order: GND,VCC,SCL,SDA,RES,DC,CS,BL
  - Pricing: ~ $4.75/each

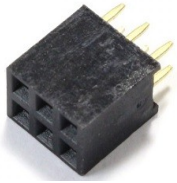
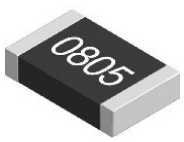


- ✔ Tode #EMPE32T30 PCB
  - Manufacturer: Oshpark.com
  - Pricing: $3.84
  - Batch Price: $115.20 per 30

  ✔ Tode Buttons PCB ○ Manufacturer: Oshpark.com ○ Pricing Each: $1.41 ○ Batch Price: $112.80 per 80	

2.2 Supplies $3

+3.5mm Drill Bit

	QTY: 1 @ $0.10/ea = $0.10 1x10P Female Pin Header Dupont 2.54mm-Pitch Used in Step#3 as a Relay Plug-in		QTY: 4 @ $0.10/ea = $0.40 1x2P Screw Terminal 5.08mm Pitch Step #4 and #5
	QTY: 1 @ $0.10/ea = $0.10 1x9P Female Pin Header Dupont 2.54mm-Pitch Used in Step #3 as Tode-IO Plug-in		QTY: 1 @ $0.10 = $0.10 1x3P LONG-Lead Female Pin Header Dupont 2.54mm-Pitch Used in Step #3 as Tode-IO Plug-in
	QTY: 1 1x4P @ $0.01/pin = $0.04 QTY: 1 1x3P @ $0.01/pin = $0.03 Male Pin Header (Cut from 40-Pin) Dupont 2.54mm-Pitch Used in Step #3 as Tode-IO Plug-in		QTY: 1 @ $0.10 = $0.10 1x8P LONG-Lead Female Pin Header Dupont 2.54mm-Pitch Used in Step #3 as Tode-IO Plug-in
	QTY: 1 @ $0.50 9x4.2mm [0942] Active Piezo Buzzer 2-Lead, 5Vdc, Ultra-Thin		QTY: 4” Red @ $0.10/ft = $0.05 QTY: 4” Black @ $0.10/ft = $0.05 22AWG Stranded Colored Wire
	QTY: 1 @ $0.20/ea 5.5x2.1mm DC Barrel Jack Female Panel Mount 2-Terminal with Nut		QTY: 6 @ $0.15/ea = $0.90 6x6x7mm DIP-4 Tactile Push Buttons Through-Hole leads
	QTY: 10 @ $0.01/ea = $0.10 0805 SMT Resistors #AMPE32T30 uses 910K, 470K, 39 #DispKB uses (2)1500, 1200 910, 680, 330, 10		QTY: 4 @ $0.10/screw-nut-pair = $0.40 (2) M2.5x0.45 x 8mm Screw + Nut for AMP (2) M2x0.4 x 8mm for Screw + Nut for DispKB

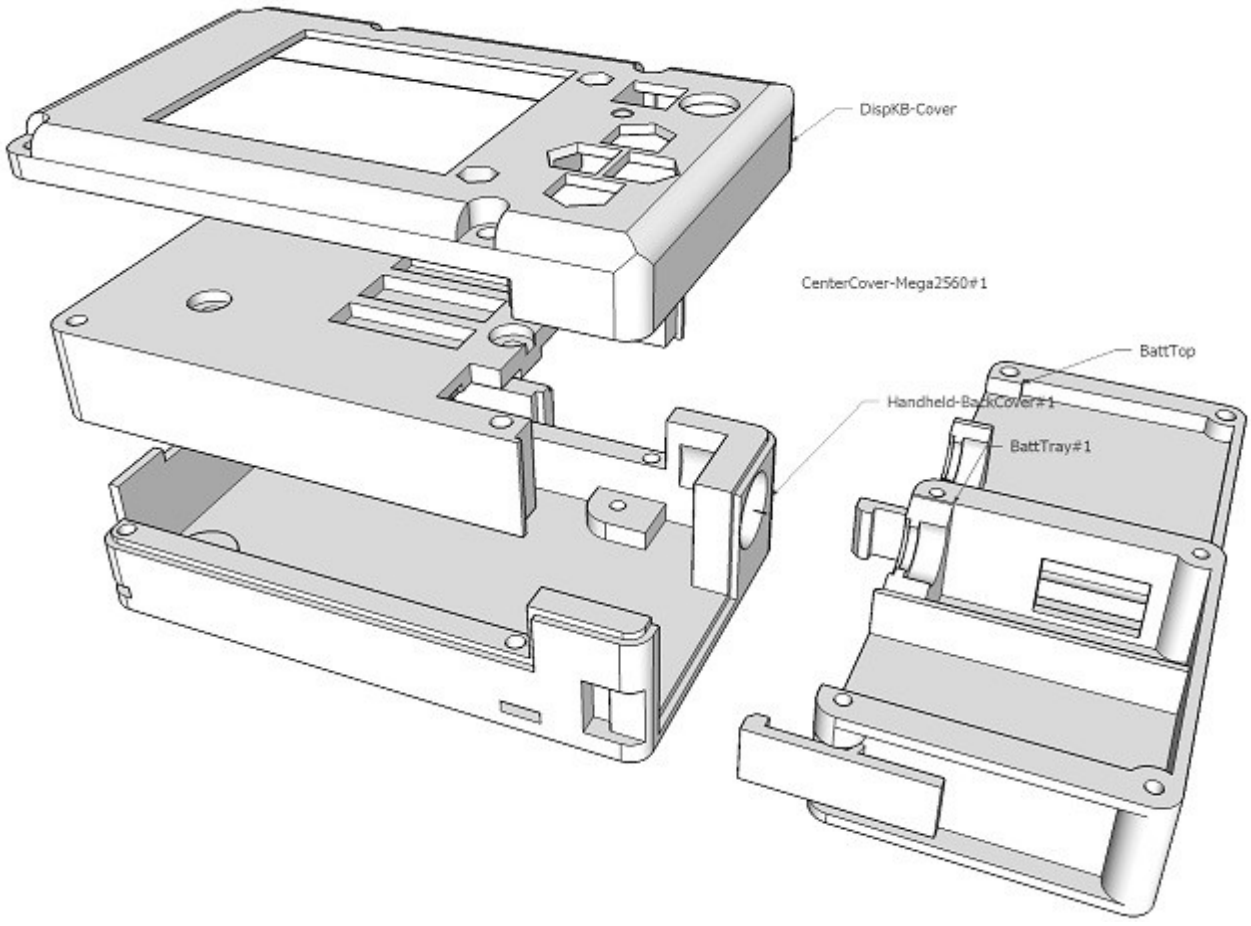
3. 3D-Prints $2

✔ 3D Print the Following Casing Files in Folder: /3DPrints/

File Name	Grams	Cost	Time
Tode-Handheld-AMPE32T30.stl	23grams	$0.41	2:19m
Tode-Handheld-AMPCenter.stl	18grams	$0.31	2:15m
Tode-DispKB-Cover.stl	13grams	$0.22	1:17m
Tode-DispKB-Buttons.stl	1gram	$0.02	0:31m

- Pricing Determined by --
  - (5)Kg Rolls of 3D Solutech White PLA
  - Total Price with Tax & Shipping: $84.75 / 5000-grams = $0.01695/gram

Assembly Diagram



3.1 Tode-Handheld-AMPE32T30

The Casing for the AMPE32T30 PCB

4. Printed Circuit Boards (PCB's)

Printed Circuit Boards can be either ordered from a Custom PCB Manufacturer or created with a CNC Router.

- ✔ Custom Manufactured PCB
  - Benefits - Custom PCB manufacturing is by far the better approach.
    - Copper through holes provide better connection
    - A Silk Sscreen for better corrosion resistance
    - Far easier to solder

  - Common Custom Manufacturing Businesses
    - https://oshpark.com/
    - https://jlcpcb.com/
    - https://www.pcbway.com/orderonline.aspx
    - https://www.customcircuitboards.com/
    - https://custompcb.com/

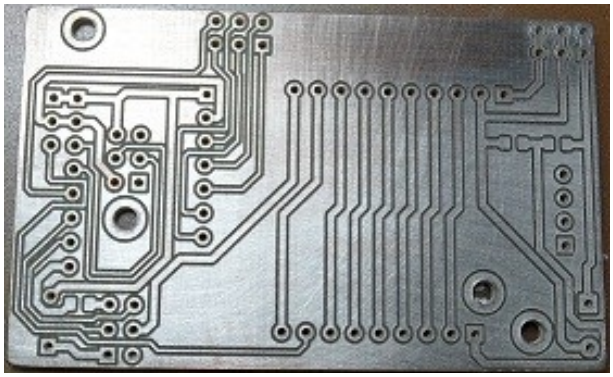
- ✔ CNC Routed PCB
  - Benefits
    - Generally cheaper by a couple dollars
    - Instant product (No shipping/manufacturing wait time)
    - Good for designing phases; not good for finished design production.

4.1 Arduino Mega Pro & Casing

4.2 Handheld Backplane PCB #AMPE32T30

4.2.1 Steps

STEP #1 – Obtain (Purchase/Make) the AMPE32T30 – PCB



- ✔ Design File
  - FOLDER = /kicad/AMPE32T30/output/
  - GERBER FILE = AMPE32T30-F_Cu.gbr
- ✔ CNC Routing
  - CNC File = AMPE32T30-F_Cu.gbr.nc
  - CNC Settings: Z-Down: -0.045, Speed: 45mm/s
  - CNC Isolation Bit = Pyramid 0.2mm Tip 45-deg
  - Hole Sizes = 0.8mm, 2.7mm

STEP #2 – Attach SMT Resistors

- ✔ Using Schematic & Layout Solder-Paste SMT Resistors
  - R1 = 910KΩ SMT 0805 Resistor
  - R2 = 470KΩ SMT 0805 Resistor
  - R3 = 39Ω SMT 0805 Resistor
- ✔ Bake the PCB in Reflow Oven

STEP #3 – Attach & Solder AMP Female Headers

- ✔ Refer to Schematic & Layout to insert & solder Pin-Headers
  - J1 [PWR] = 2x3P Female Header
  - J2 [ICSP] = 2x3P Female Header
  - J3 [D44...] = 2x3P Female Header
  - J7 [D18...] = 2x3P Female Header
  - J8 [A1...] = 1x9P Female Header
- ✔ Plug in the Arduino Mega Pro for proper alignment (as shown)

WARNING: Never solder-on E32 Radio before STEP #4.

STEP #4 – Attach & Solder **J11** 1x10P [SideIO] Female Header

- ✔ Refer to Schematic & Layout to insert **J11** as shown
  - Unplug the Arduino Mega Pro from PCB
  - Press header pins on flat surface; bend to 90-deg
  - **J11** [IO] = 1x10P Female Header w/bent pins

STEP #5 – (**CNC ONLY**) Run In-Circuit Shorts Test

- ✔ Using DMM ensure Power Rows are Isolated on J1.
  - Plug the Arduino Mega Pro back into the PCB
  - Run In-Circuit Test #1 to check for shorts
    - FOLDER: \firmware\test\ICT_Test_-_AMPE32T30\
    - FILE: ICT_Test_-_AMPE32T30.ino

STEP #5 – Attach Piezo Buzzer
- ✔ Insert Ultra-Thin 5Vdc Piezo Buzzer into Bottom-Left
- ✔ Solder the Piezo Buzzer leads and snip to board level.

STEP #6 – Solder the Ebyte E32 Radio to the PCB

- ✔ Cut a 4P Male Header and Insert at the top for alignment
- ✔ Insert Ebyte E32 RF Module into the AMPE32T30 PCB (as shown)
- ✔ Solder Pin that attach to the PCB

STEP #7 – Solder Power Wires to the Board

- ✔ Using Black and Red 22AWG stranded wire
  - ○ Cut 4-Inches of Black wire and 4-Inches of Red wire
  - ○ Wire Strip one end of both wires
  - ○ Insert stripped end into PCB and solder (as shown)
    - ▪ Black (GND) on Closest to closest Outer-Side-Edge
    - ▪ Red (VIN) on Further to closest Outer-Side-Edge

STEP #8 – Attach AMPE32T30 PCB into Casing

- ✔ Slide PCB from bottom to top and E32 Antenna plug through hole
- ✔ Using (2) #2-56 x 1/4" Machine Screws and Nuts fasten the PCB
  - ○ Use the hole in the very Bottom-Right (as shown)
  - ○ Use the hole in the very Top-Left (next to wires)

STEP #9 – Insert and Wire Up DC-Barrel Plug

- ✔ DO-FIRST - SLIDE the DC-Barrel Plug NUT over both wires

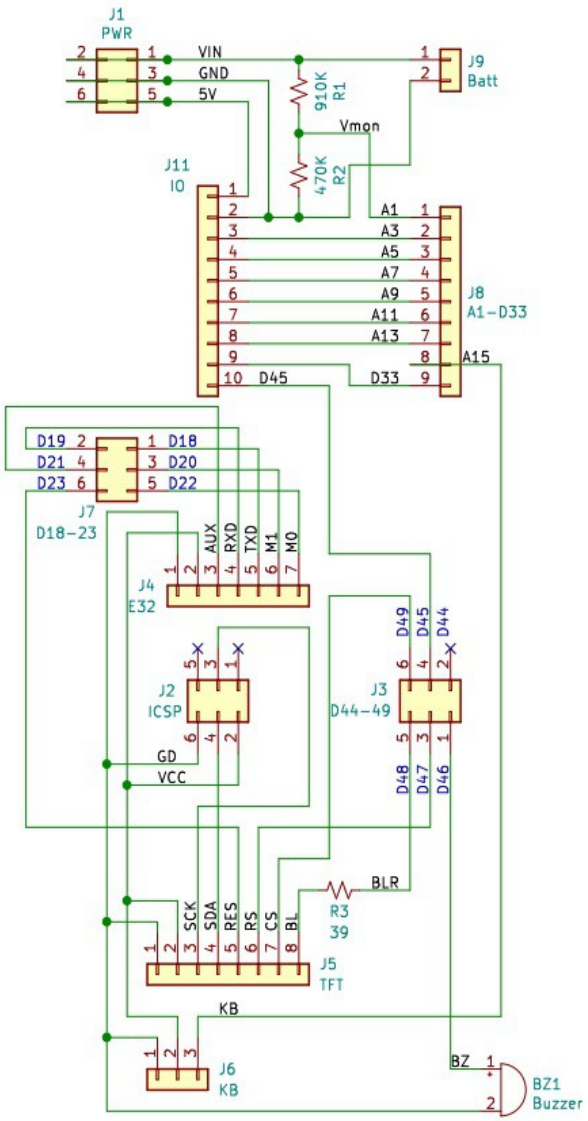
- ✔ Insert the DC-Barrel Plug into the Casing hole (where shown)

- ✔ Strip the wire ends
  - ○ Solder the Red Wire to the shorter DC-Barrel Plug Lead
  - ○ Solder the Black Wire to the longer DC-Barrel Plug Lead

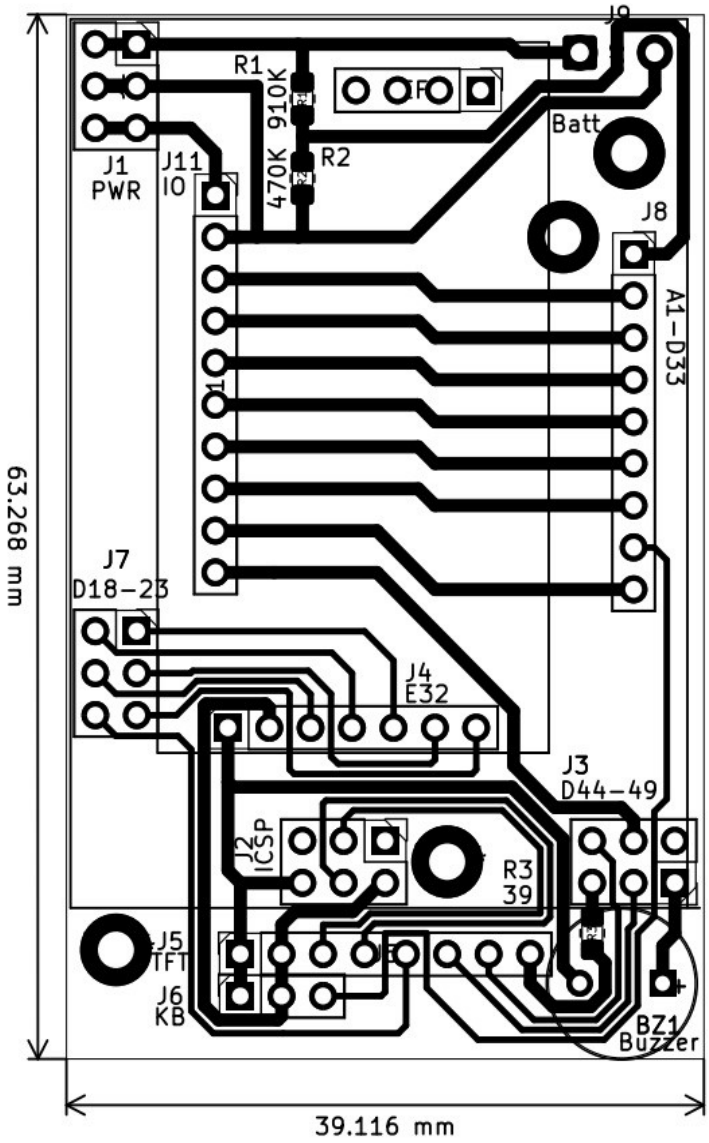
- ✔ After Soldering slide Nut up and tighten w/needle nose pliers

4.2.2 Schematic & Layout

SCHEMATIC



LAYOUT



- ✔ Female Dupont 2.54mm pitch Connectors

J1	PWR	2x3P Female Header
J2	ICSP	2x3P Female Header
J3	D44-	2x3P Female Header
J4	E32	E32 Radio Module (Direct Solder)
J5	TFT	1x8P Female Header (TFT) Display
J6	KB	Keypad PCB
J7	D18	2x3P Female Header
J8	A1-10	1x9P Female Header
J10	SideIO	1x10P Female Header

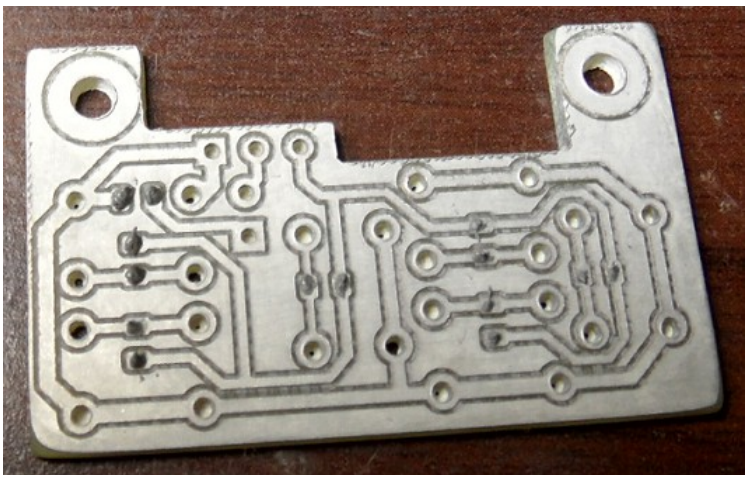
- ✔ Resistors
  - R1 – 910Kohm 0805 SMD
  - R2 – 470Kohm 0805 SMD
  - R3 – 39ohm 0805 SMD
- ✔ J4(E32) Direct Solder
- ✔ BZ1 Direct Solder

4.3 DispKB PCB

4.3.1 Steps

STEP #1 – Obtain (Purchase/Make) the BUTTONS – PCB

- ✔ Design File
  - FOLDER = /kicad/Buttons/output/
  - GERBER FILE = Buttons-F_Cu.gbr
- ✔ CNC Routing
  - CNC File = Buttons-F_Cu.45S045D.gbr.nc
  - Hole Sizes = 0.8mm, 2.7mm

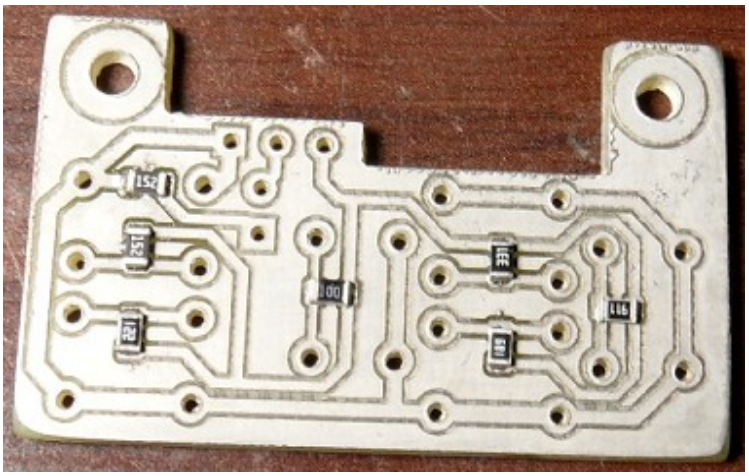


STEP #2 – Attach SMT Resistors

- ✔ Use Schematic & Layout to determine Resistor Locations
- ✔ Apply solder paste at all Resistor locations (as shown)
- ✔ Place SMT Resistors at correct Locations

STEP #3 – Use Reflow Oven to solder SMT Resistors

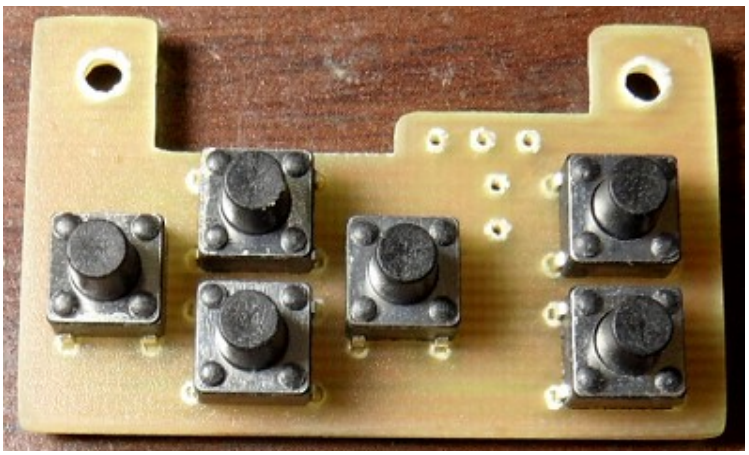
- ✔ Place Board w/Resistors & Paste in Reflow Oven T-962
  Select Wave #3 and Start the Reflow Oven



STEP #4 - Install and Solder Buttons

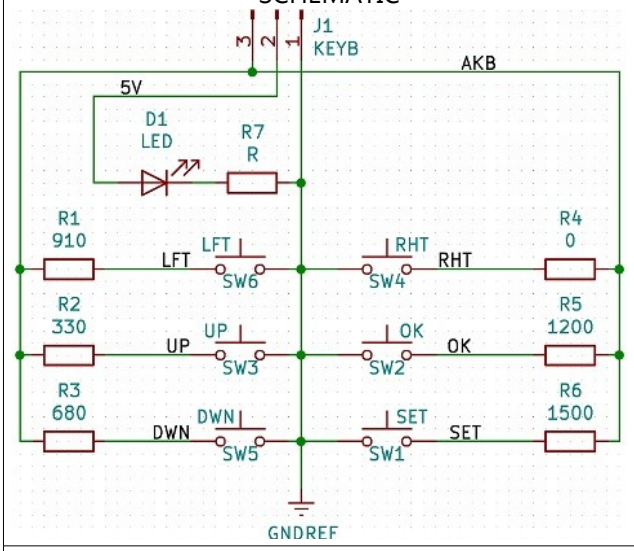
Set the board asside and proceed to Assembly Instructions.

NOTICE: The 3P Male Header and Power LED will be installed to fit during assembly.

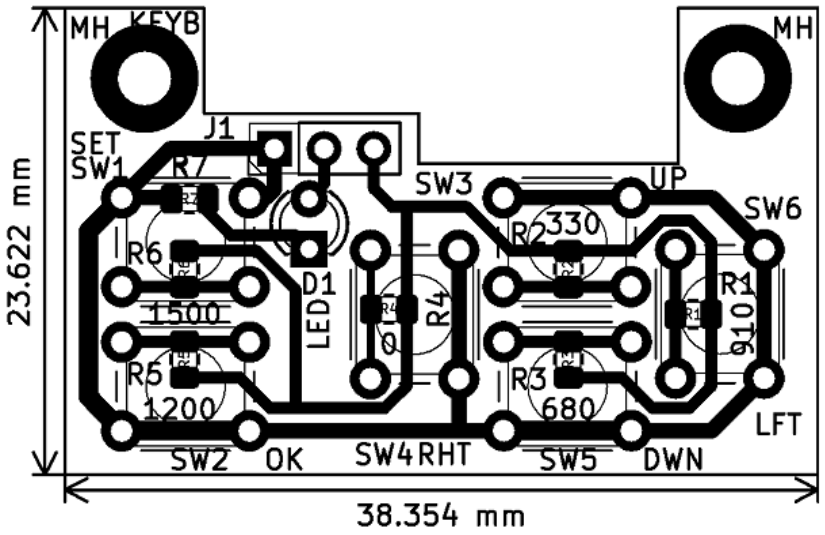


4.3.2 Schematic & Layout

SCHEMATIC



LAYOUT



- ✔ Surface Mount (SMT) 0805 Resistors
  - LFT – R1(SW6) = 910-ohm
  - UP – R2(SW3) = 330-ohm
  - DWN – R3(SW5) = 680-ohm
  - RHT – R4(SW4) = 10-ohm or less
  - OK – R5(SW2) = 1200-ohm
  - SET – R6(SW1) = 1500-ohm
  - LED – R7 = 1500-ohm

- ✔ D1(LED) = 3mm Round LED
  - J1(KEYB) Pin #2 is 5V / R7(1500) = 3.3mA through LED
  - Polarity = +/Long-Lead to J1 Side, -/Short-Lead to Bottom
- ✔ SW1 to SW6 are ALL 7mm Tactical Switches

4.4 CNC Routing a PCB (Settings & Process)

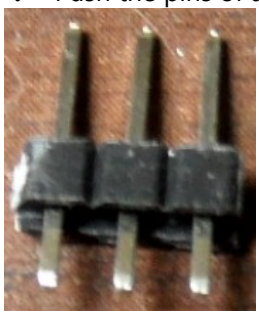
1. Using the CNC machine shown in Workstation::Equipment
2. Using the 3D Printed 3" x 4" Cu-Clad PCB Holder
3. Using Isolation Bit 45-deg, 0.2mm tip, Diamond Shape
4. Using Flatcam Settings
   a) Speed: 45 mm/s
   b) Depth: -0.045mm
5. Using bCNC
6. Load PCB onto CNC1610 using PCB holder
7. Load the Trace Isolation Bit (Suggest 45-deg 0.2mm Tip Diamond Shape)
8. Open bCNC
9. Home the CNC
10. Enter Command G01 X22Y17 F300
11. Zero Coordinates
12. Manually move bit close but not touching PCB
13. Zero Z Coordinate
14. Probe
15. Open File
16. Set Autolevel margins
17. Scan for Autolevel
18. Probe again and Autolevel Zero
19. Remove Autolevel Probe Wire
20. Start Isolation Routing
21. Preform Isolation Routing
22. Preform Hole Drilling

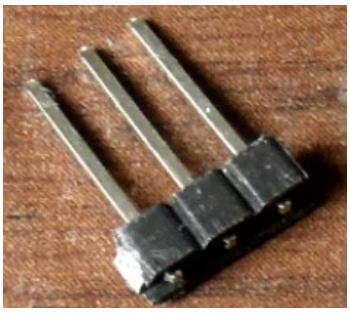
23. Preform Edge-Cuts
24. Sand & Treat with Liquid Tin

5. Assembly

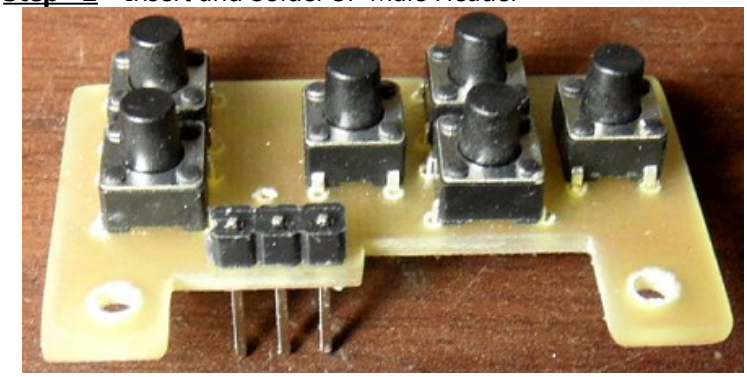
Step #1 – Keyb Connection

✔ Push the pins of a 3P Male Header flush with Top

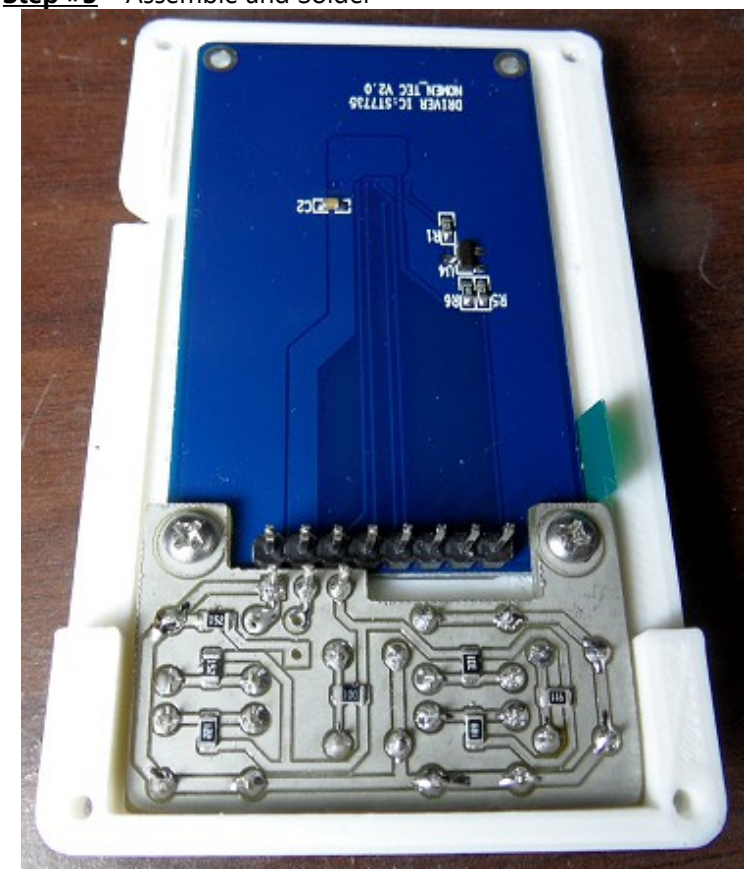




Step #2 – Insert and Solder 3P Male Header

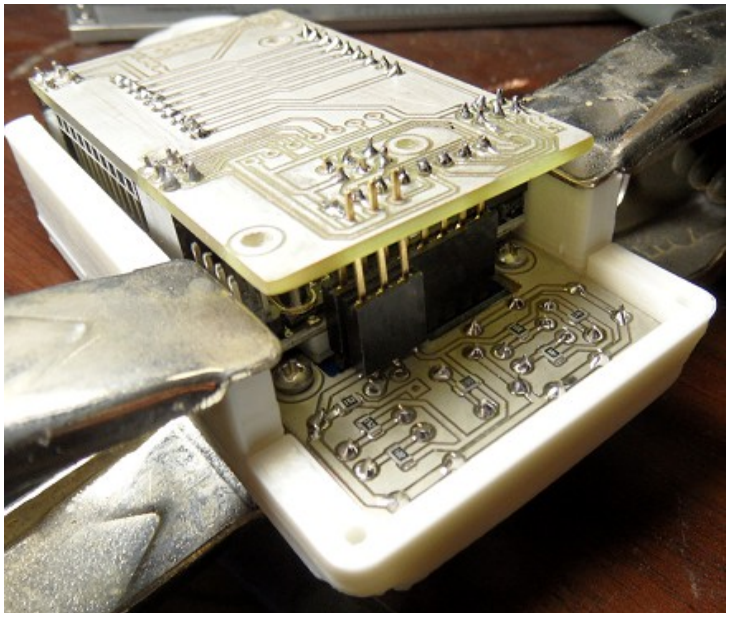


Step #3 – Assemble and Solder



Screws = M2x0.4 x 8mm

Step #4 – Insert AMPE32T30
1x3P Long-Lead Female Header for Buttons
1x8P Long-Lead Female Header for Display



Step #5 – Test operation of Buttons and Display

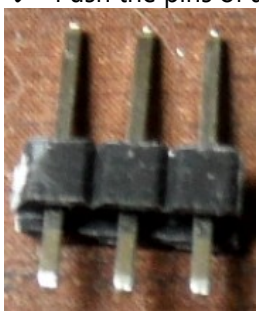
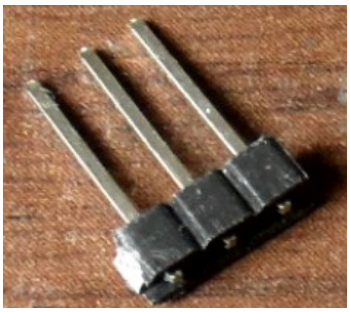
Upload Firmware and check that display and buttons work.

Step #6 – Upload Tode Firmware and Test Button Operation	Step #6 -
25. Fasten KEYS-PCB and LCD Display into Casing	Install 3mm Round LED into PCB -- POLARITY --? Bit Size 3.58mm Drill out Buttons
Install 2mmx0.4mm x 10mm Screw to Pull Down nuts into plastic. Replace the 10mm long screws with 8mm screws for flush fit	Push LED up as far as possible and solder into place Clip leads Long Leg is Positive and goes to the Top Side

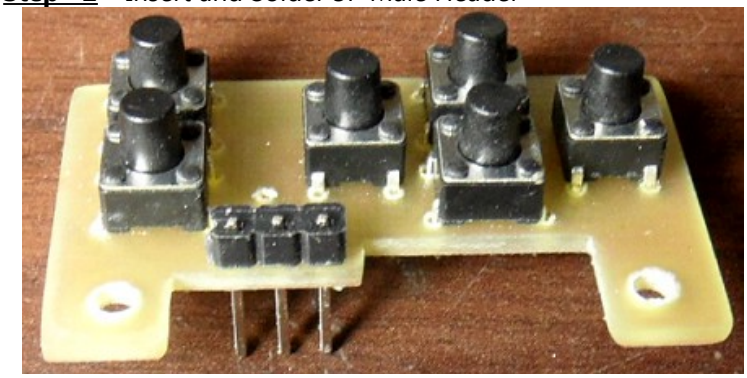
5.1.1 DispKB Plugs

Step #1 – Insert Arduino Mega Pro into Casing
Using M2.5x8mm and Nuts

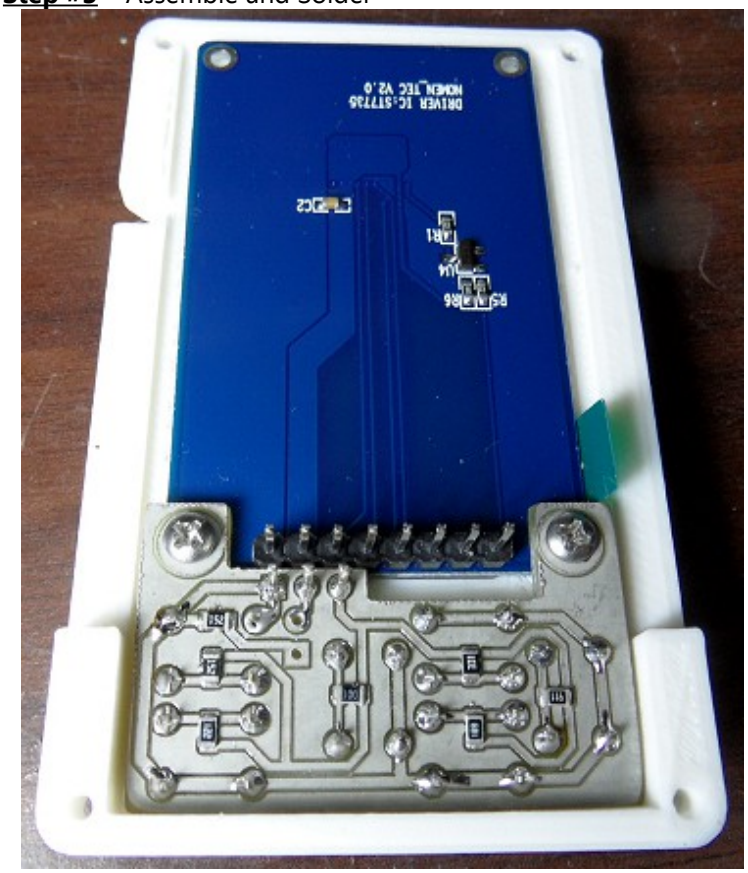
✔ Push the pins of a 3P Male Header flush with Top

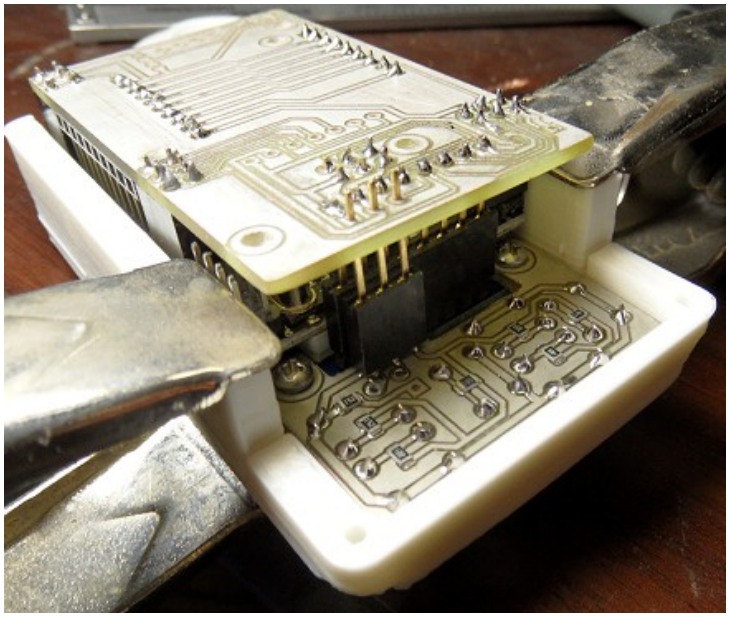
Step #2 – Insert and Solder 3P Male Header



Step #3 – Assemble and Solder



Screws = M2x0.4 x 8mm

Step #4 – Insert AMPE32T30 1x3P Long-Lead Female Header for Buttons 1x8P Long-Lead Female Header for Display 	**Step #5** – Test operation of Buttons and Display Upload Firmware and check that display and buttons work.
Step #6 – Upload Tode Firmware and Test Button Operation	Step #6 -
26. Fasten KEYS-PCB and LCD Display into Casing	Install 3mm Round LED into PCB -- POLARITY --? Bit Size 3.58mm Drill out Buttons
Install 2mmx0.4mm x 10mm Screw to Pull Down nuts into plastic. Replace the 10mm long screws with 8mm screws for flush fit	Push LED up as far as possible and solder into place Clip leads Long Leg is Positive and goes to the Top Side