

Tode-RC

Hardware Development

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

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

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1. Introduction

The Tode System

- Tode-RC = Handheld Remote Control Models <https://github.com/TGit-Tech/Tode-RC>
 - 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 <https://github.com/TGit-Tech/Tode-SIOST>
 - Model #SIOST Tode SideIO with Screw Terminals
 - Model #SIOAP 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

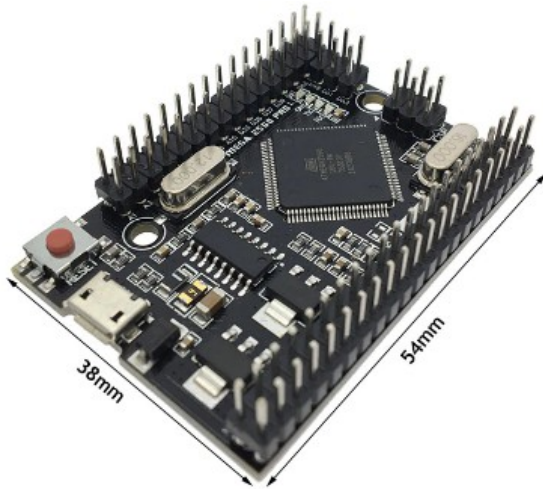
The Tode System is licensed under the MIT License.

2. Tode-RC

2.1 Bill of Materials (BOM) \$40

- ✓ See the "Tode General Hardware Development" document for required tools
 - Note: A 3.5mm Drill bit is required as well as general tools described in that document.

2.1.1 Parts \$34



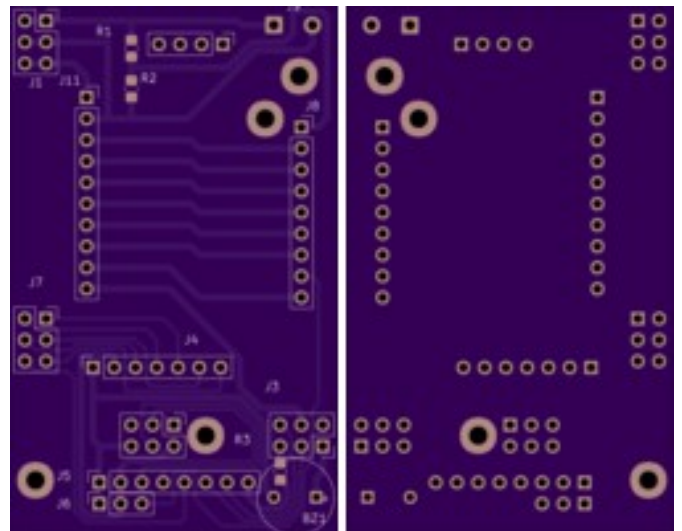
- ✓ Arduino Mega Pro Mini [ATmega2560 @ 16MHz]
 - Power In: 6Vdc to 9Vdc (Peek 18Vdc)
 - Power Out: 5Vdc @ 800mA + 3Vdc @ 800mA
 - Load Amps: 5Vdc @ 220mA
 - IO-Pins: 54-Digital, 16-Analog
 - Memory: 256kb RAM, 4kb EEPROM
 - Temp Rng: -40C to 85C
 - Pricing: ~ \$10/each
 - Web @ <https://robotdyn.com/mega-2560-pro-embed-ch340g-atmega2560-16au.html>



- ✓ Ebyte E32433T30D
 - Power In: 3.3Vdc to 5.2Vdc (+ = Damage)
 - Load Amps: Tx @ 106mA, Rx @ 15mA
 - Data Rate: 0.3Kbps to 19.2Kbps
 - 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>



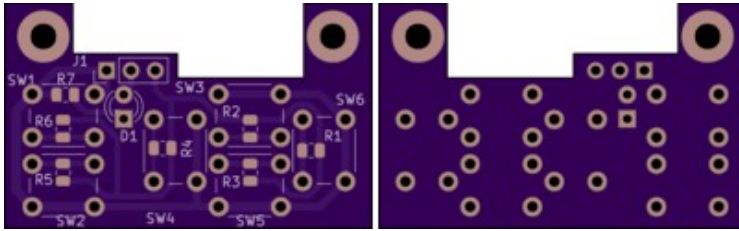
- ✓ 1.8 / 1.77 -Inch TFT LCD Display
 - Power-In: 5Vdc
 - Resolutions: 128 x 160dpi ST7735 RGB



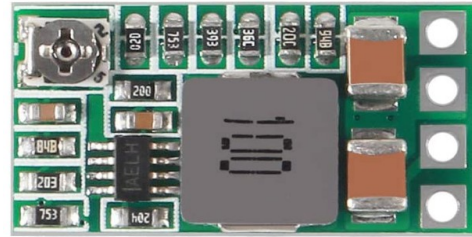
- ✓ Tode #EMPE32T30 PCB
 - Manufacturer: Oshpark.com
 - Pricing: \$3.84

- Dimensions: 35mm x 56mm
- Temp: -20C to 70C
- (8)Pin-Order: GND,VCC,SCL,SDA,RES,DC,CS,BL
- Pricing: ~ \$4.75/each

- Batch Price: \$115.20 per 30



- ✓ Tode Buttons PCB
 - Manufacturer: Oshpark.com
 - Pricing Each: \$1.41
 - Batch Price: \$112.80 per 80



10mm/0.39in

20mm/0.78in

- ✓ Dorhea 5V @ 3A Buck Power Supply Module
 - Input Voltage: 4.5Vdc to 24Vdc
 - Output Voltage: 0.8-17V (Fixed Voltage by Trace-Cut)
 - Max Output: 3A
 - Nominal Output: 1.5A
 - Pricing: \$1/ea
 - Web @ <https://www.amazon.com/dp/B08Y674Z6F>



- ✓ 433M SMA Aerial Antenna
- ✓ Various Models may be used ranging from \$1 to \$5/ea
- ✓ Price estimate at \$3/ea

2.1.2 Supplies \$4

	QTY: 1 @ \$0.10/ea = \$0.10 1x9P Female Pin Header Dupont 2.54mm-Pitch (J8) On AMPE32T30		QTY: 4 @ \$0.10/ea = \$0.40 2x3P Female Pin Header Dupont 2.54mm Pitch (J1-PWR)(J2-ISCP)(J3)(J7) on AMPE32T30
	QTY: 1 @ \$0.10/ea = \$0.10 1x10P Female Pin Header Dupont 2.54mm-Pitch (J11) On AMPE32T30 for Side-IO		QTY: 1 @ \$0.10 = \$0.10 1x3P LONG-Lead Female Pin Header Dupont 2.54mm-Pitch (J6-Keypad) on AMPE32T30
	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 E32 Align & Keypad		QTY: 1 @ \$0.10 = \$0.10 1x8P LONG-Lead Female Pin Header Dupont 2.54mm-Pitch (J5-Display) on AMPE32T30
	QTY: 1 @ \$0.50 (OPTIONAL) 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 = \$0.20 5.5x2.1mm DC Barrel Jack + Nut Female Panel Mount 2-Terminal		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: 2 @ \$0.10/pair = \$0.20 M2.5x0.45 x 6mm Machine Screw & Nut To fasten Mega-Pro to AMPCenter 2.4 AMPE32T30 Final Assembly Step #1
	QTY: 1 @ \$0.05/ea = \$0.05 3mm Green LED		QTY: 2 @ \$0.10/pair = \$0.20 M2x0.4 - 8mm Machine Screw & Nut (Keypad & Disp) 2.2.2 Display Hardware Assembly Step #1,3 QTY: 1 @ \$0.10/ea = \$0.10 M2x0.04 - 20mm Machine Screw Only (Heat stem) 2.2.2 Display Hardware Assembly Step #1
	QTY: 4 @ \$0.10/ea = \$0.40 #2 - 3/8" Pan Sheet Metal Screws Used to Attach DispKB to AMPCenter 2.4 Final Assembly Step #7		QTY: 2 @ \$0.10/pair = \$0.20 #2-56 x 1/4" Machine Screw & Nut (AMP PCB) QTY: 1 @ \$0.10/ea = \$0.10 #2-56 x 3/8" Machine Screw Only (Pull Stem)
	QTY: 4 @ \$0.10/ea = \$0.40 #2 - 5/8" Pan Sheet Metal Screws AMPE32T30 Casing to AMPCenter 2.4 Final Assembly Step #7		

2.1.3 3D-Prints \$2

- ✓ 3D Print the Following Casing (Order according to Assembly Needed)

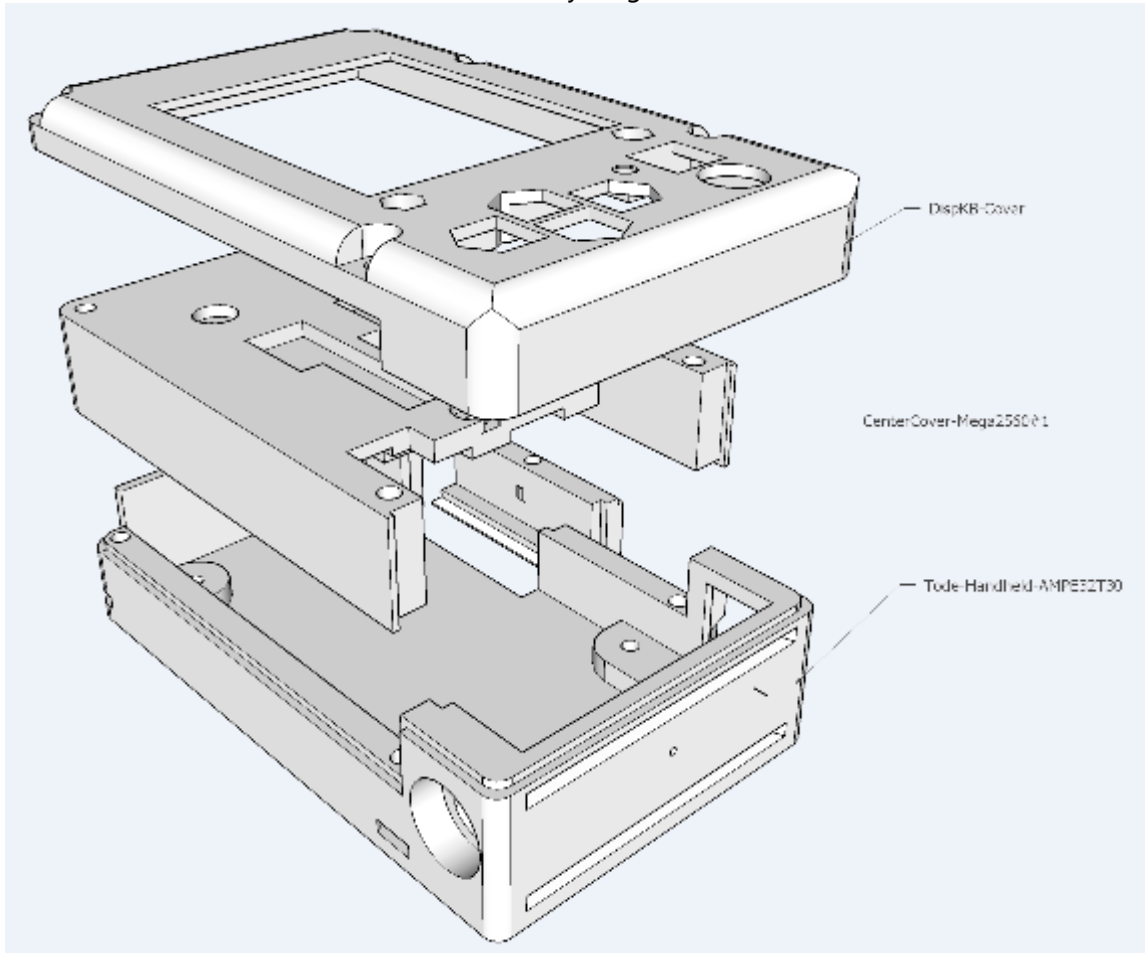
- Files in Folder: /3DPrints/

File Name	Grams	Plastic Cost \$0.02/g	Time	Power + Machine Use \$0.01/hr	Total Cost	Supports
Tode-DispKB-Cover.stl	13-grams	\$0.26	2h 31m	\$0.03	\$0.29	YES
Tode-Handheld-AMPE32T30.stl	24-grams	\$0.48	4h 50m	\$0.05	\$0.53	NO
Tode-Handheld-AMPCenter.stl	17-grams	\$0.34	3h 25m	\$0.04	\$0.38	NO
Tode-DispKB-Buttons.stl	1-gram	\$0.02	0:16m	\$0.01	\$0.03	NO

- Pricing at \$20/per 1KG Roll
 - 0.15 Layer Height

- ✓ See separate Section [#3.Battery Tray|outline](#) for the Battery Tray Extension

Assembly Diagram



2.2 Display Assembly

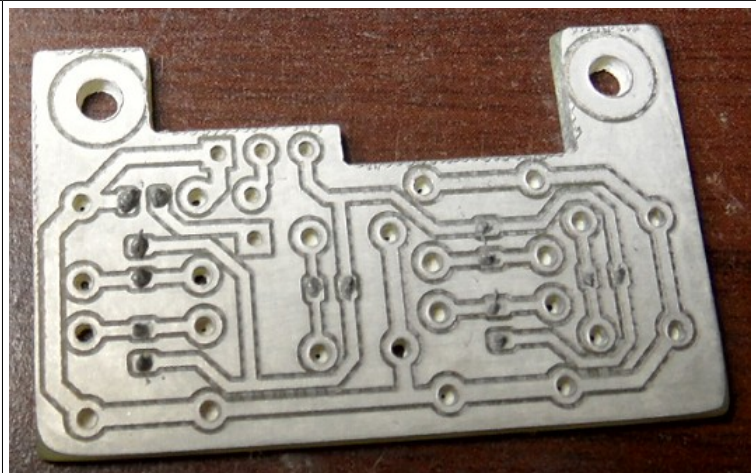
2.2.1 PCB Assembly

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.

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

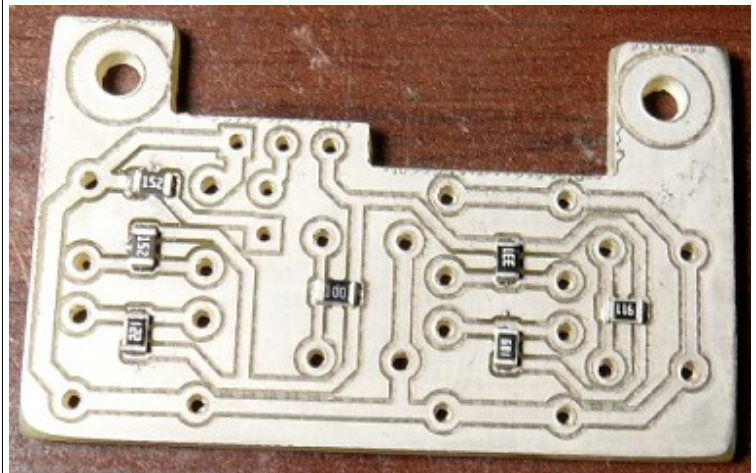


STEP #2 – Attach SMT Resistors

- ✓ 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

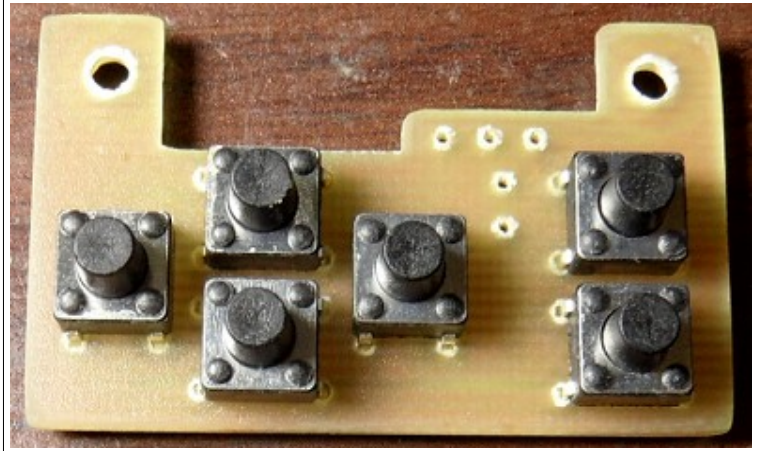
- ✓ Place Board w/Resistors & Paste in Reflow Oven T-962
Select Wave #3 and Start the Reflow Oven



STEP #4 - Install and Solder Buttons

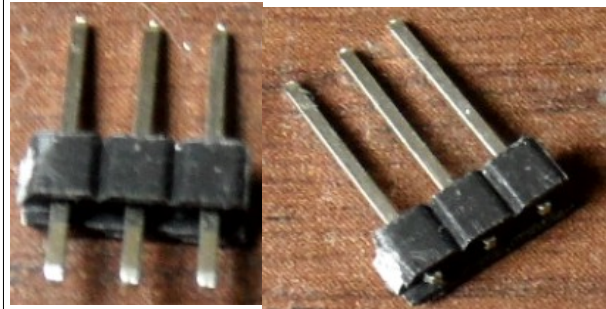
Set the board asside and proceed to Assembly Instructions.

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



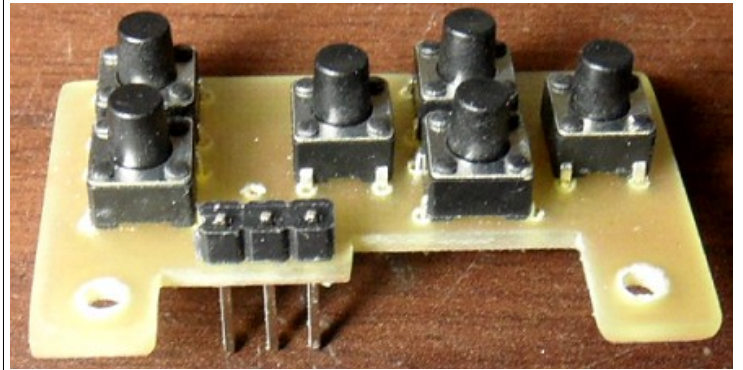
STEP #5 – Keypad Connection

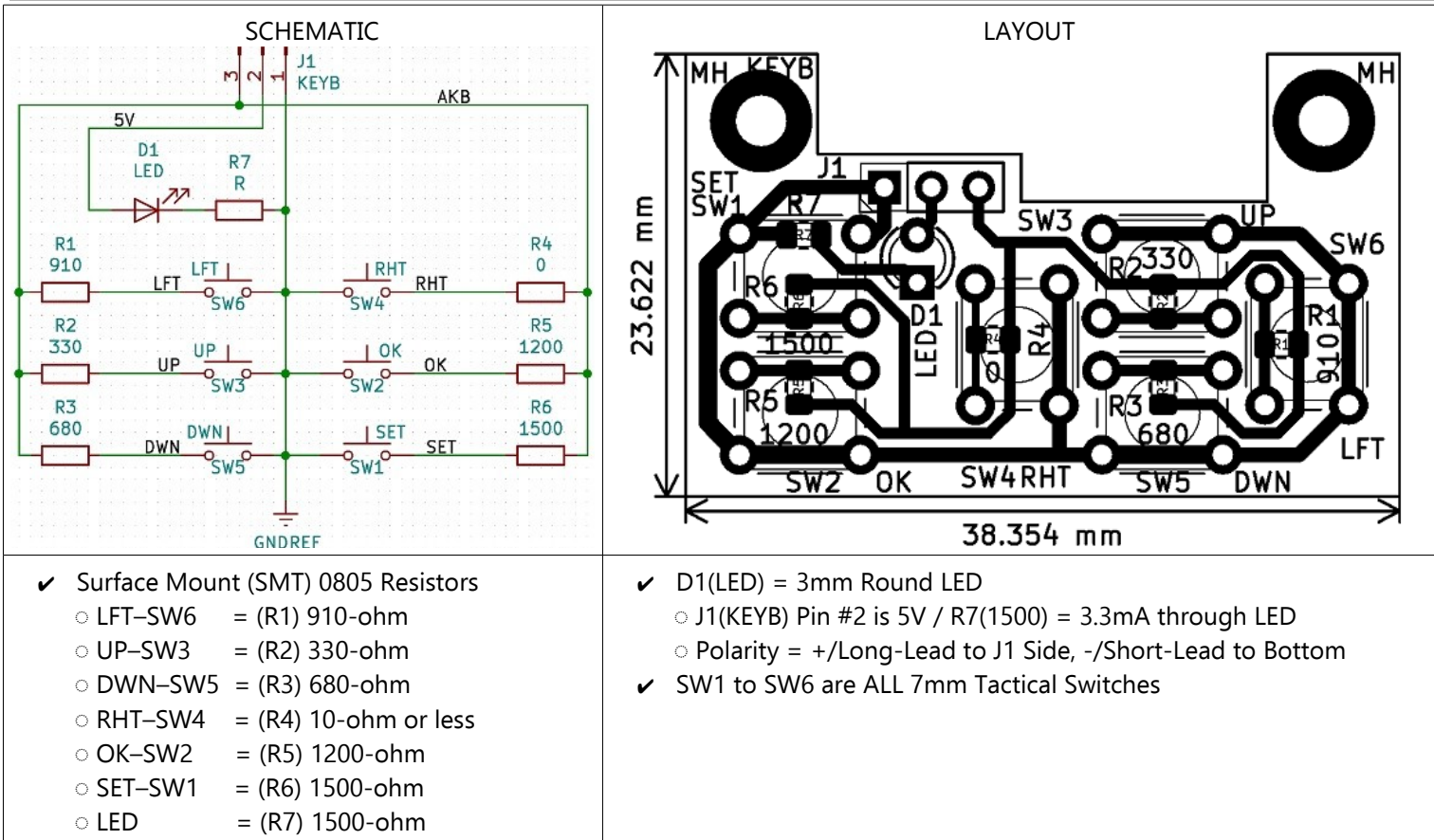
- ✓ Push the pins of a 3P Male Header flush with Top



Step #6 – Insert and Solder 3P Male Header

- ✓ Solder from the bottom-side instead of top

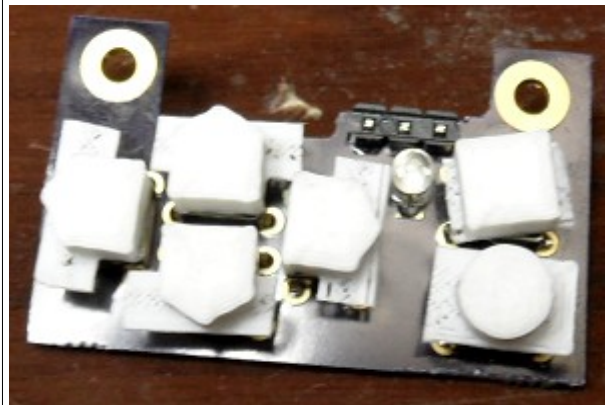


A. Schematic & Layout**2.2.2 Hardware Assembly****STEP #1** – Install Nuts to [Tode-DispKB-Cover.stl](#)

- ✓ Melt-in two M2 Nuts
 - Hold Nut with a long M2 screw and pliers as shown
 - Heat the Nut using a heat gun
 - Press the nut, edges lined up to shell & flush with top

**STEP #2** – Prepare and Insert [Tode-DispKB-Buttons.stl](#)

- ✓ Place Buttons on Keypad Switches
 - Use Scissors to cut Buttons apart at the center
 - Skinny legged arrow belongs on top
 - If button don't push-on use 3.5mm bit to drill-out
- ✓ Place 3mm LED light into PCB
 - Square-Pad is Negative (short-lead)
 - Do not solder the LED at this point



STEP #1 – Install Stickers to Face of [Tode-DispKB-Cover.stl](#)**STEP #3** – Fasten Display & Keypad and Solder LED

- ✓ Place 1.8/1.77-Inch TFT Display in [Tode-DispKB-Cover.stl](#)
 - Solder the 8P Male Header to Screen if separate
- ✓ Place the Keypad in Shell over the LCD as shown
 - Fasten with Screw Size: M2x0.4 – 8mm long
 - Suggest using Phillips flat head but Pan-head okay.
- ✓ Use LED pins to position LED in Shell Hole for LED
 - Solder and cut LED pins to PCB
- ✓ On Manufactured Keypad PCBs a proper fit may require cutting, sanding above the 3P Connection Header.

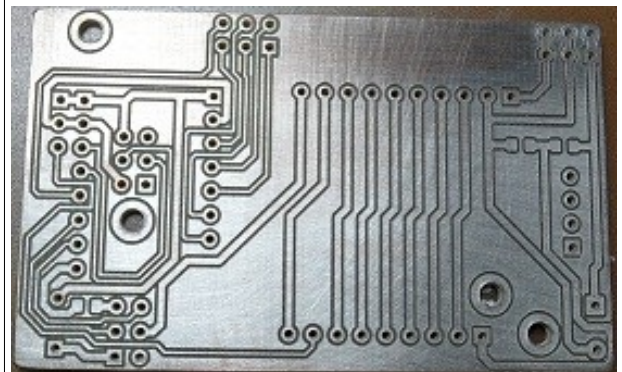


2.3 Backplane AMPE32T30

2.3.1 PCB Assembly

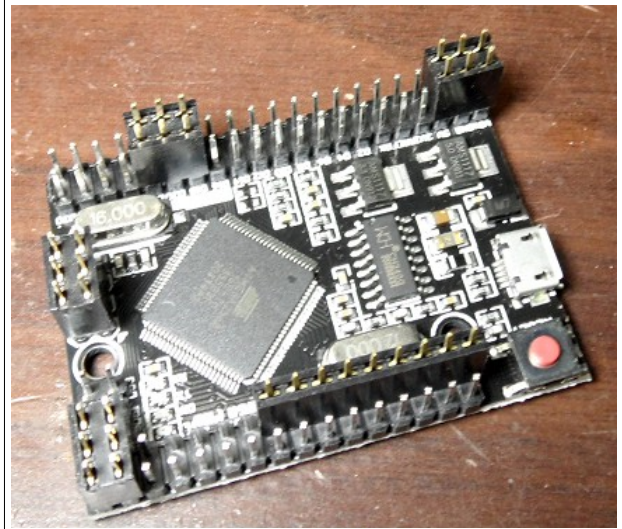
STEP #1 – Obtain (Purchase/Make) the AMPE32T30 – PCB

- ✓ 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

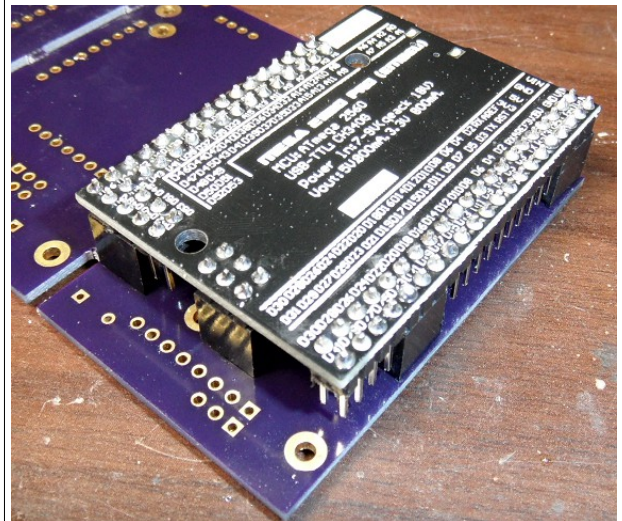


STEP #2 – Attach Female Dupont Headers

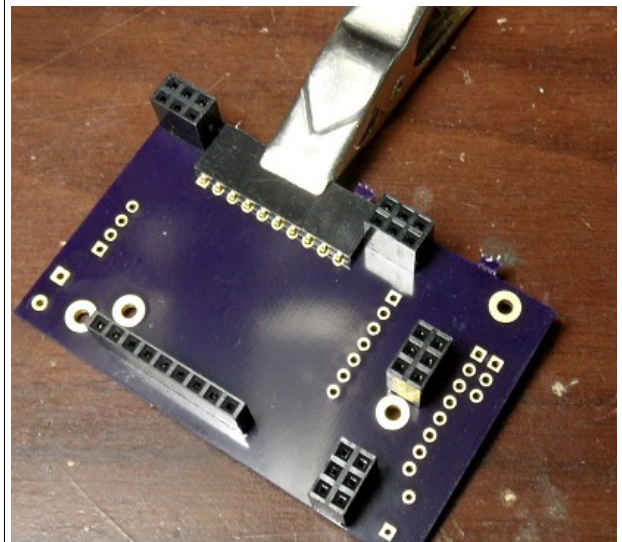
- ✓ Plug the following Female Headers onto the Mega-Pro Pins
 - J1 [PWR] = 2x3P Female Header (Very Top left)
 - J2 [ICSP] = 2x3P Female Header (ICSP 6-Pin Port)
 - J3 [D44...] = 2x3P Female Header (Bottom-Right Corner)
 - J7 [D18...] = 2x3P Female Header (4-Pin Rows Up on Left)
 - J8 [A1...] = 1x9P Female Header (Top Inner on Right)
- ✓ Refer to [Schematic & Layout](#) to place Pin-Headers

**STEP #3** – Solder Female Headers to the PCB

- ✓ Place the Arduino Mega Pro and Headers into proper place on PCB
- ✓ Solder the Female Pin-Headers from Step #3 to the PCB board.

**WARNING: Never solder-on E32 Radio before STEP #4.****STEP #4** – Attach & Solder **J11** 1x10P [SideIO] Female Header

1. Unplug the Arduino Mega Pro from PCB
 2. Press header pins on a flat surface; bend to 90-deg
 3. **J11** [IO] = 1x10P Female Header w/bent pins
 4. Insert as shown. Be sure face is parallel with edge of board
 5. Use a Clip to hold in place while soldering the pins to the PCB.
- ✓ Refer to [Schematic & Layout](#)

**STEP #5A** – **BUZZER OPTION** (OPTIONAL) Buzzer Resistor

- ✓ 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

SKIP THIS STEP – The battery monitor is no longer relevant due to the required external 3A Power Supply.

If a Buzzer Feature is desired – Manually solder the R3 = 39Ω SMT Resistor.

STEP #5B – BUZZER OPTION (OPTIONAL) Attach Buzzer

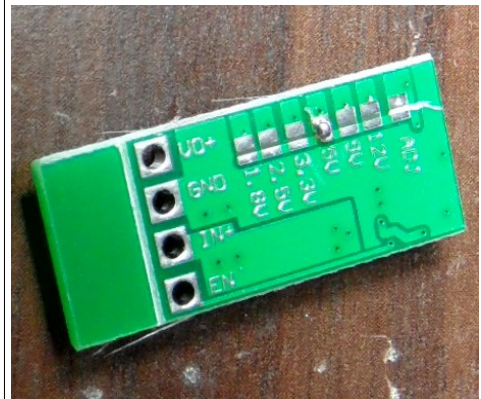
- ✓ Insert Ultra-Thin 5Vdc Piezo Buzzer into Bottom-Left
- ✓ Solder the Piezo Buzzer leads and snip to board level.

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

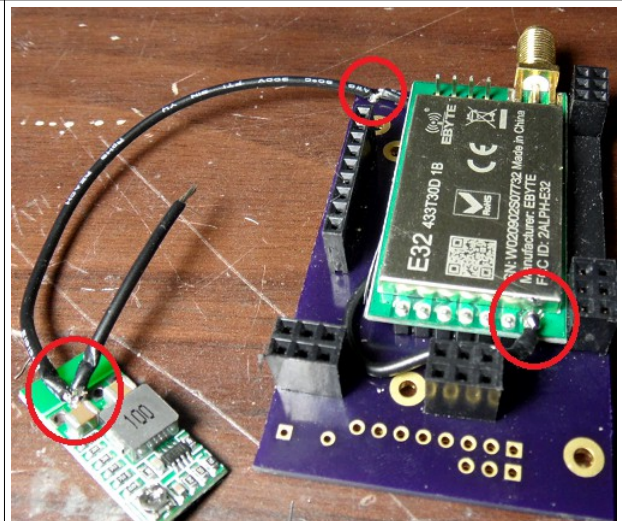
1. Cut a 4P Male Header and Insert at the top for alignment
 - a) The red circle in the picture
2. Insert Ebyte E32 RF Module into the AMPE32T30 PCB (as shown)
3. Solder Pins that attach to the PCB
 - a) No need to solder the 4P top alignment pins to E32 Module

**STEP #7 – Prepare 5V 3A Power Module**

- ✓ Using Razor Knife cut the Top Trace (label ADJ)
- ✓ Jump a Solder bridge where 5V is labeled
- ✓ Do a Continuity Test verifying changes

**STEP #8 – Wire 5V 3A Power Supply(GND) Ground**

- ✓ With 22awg **Black** stranded wire
 - Solder GND hole of **P.S.** by twisted together the ends of...
 - 4" long piece
 - 1-1/2" long piece
 - Solder GND hole of **PCB** board by twisting together the ends of...
 - The other end of the 4"-long wire above from P.S.
 - 3-1/2" long piece
- ✓ NOTE – *It was found that the Mega-Pro on board power regulator couldn't feed the radio while set to high-power (30dbm) and would cause the Mega-Pro to reset during transmission.*
 - The Solution is an external 3A Power Module feeding directly into the Radio but GND must also feed to PCB/Mega.

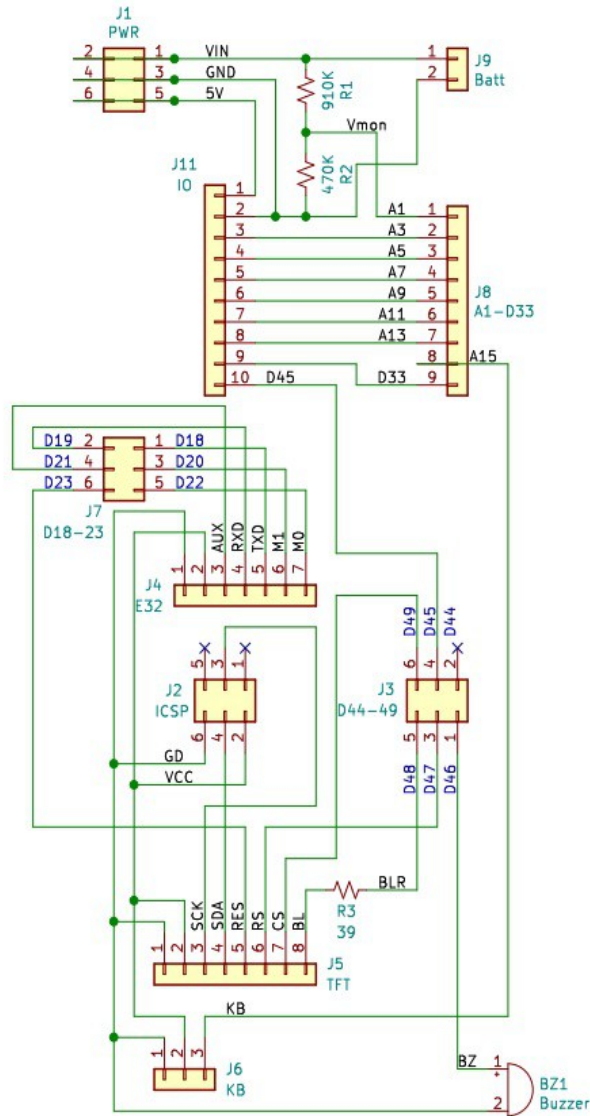
**STEP #9 – Wire 5V 3A Power Supply Power**

- ✓ With 22awg **Red** stranded wire
 - Solder 1-1/2" long piece
 - Power Supply VO+(5Vdc) → E32-VCC Pin
 - Solder 1-1/2" long piece in P.S. VI+ (In) hole.

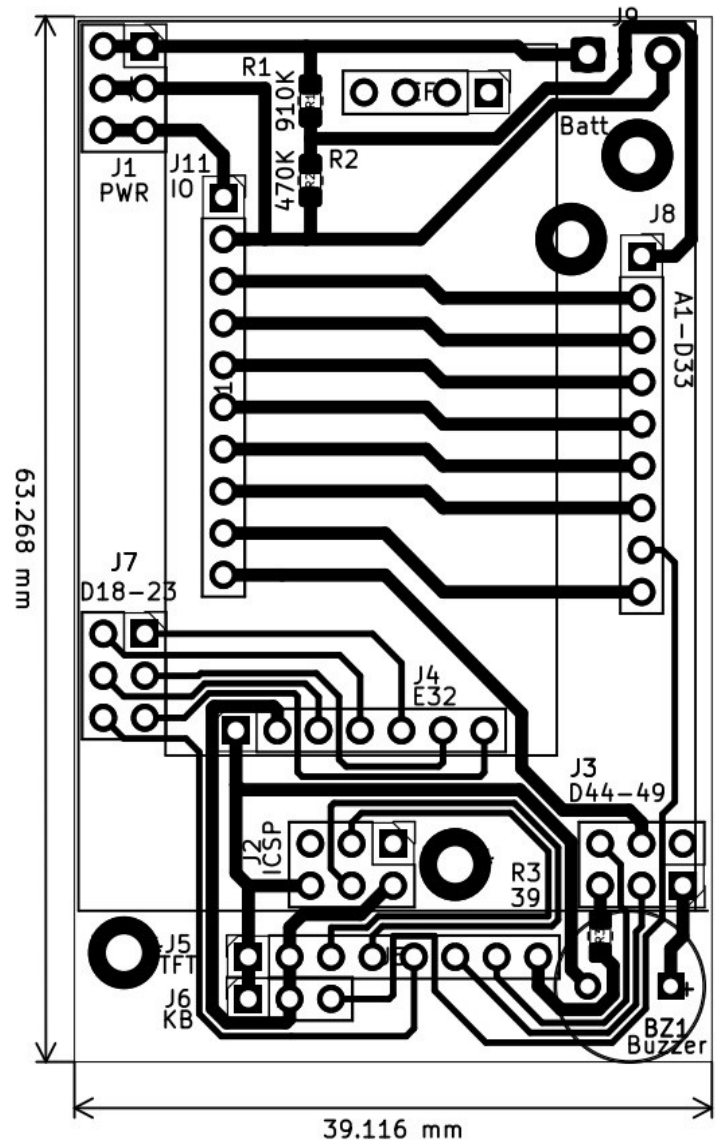


A. Schematic & Layout

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

✓ J4(E32) Direct Solder

✓ Battery Monitor Resistors

- R1 – 910Kohm 0805 SMD (No longer used)
- R2 – 470Kohm 0805 SMD (No longer used)
- **Due to the external 3A power regulator the battery monitor feature design is no longer used.**

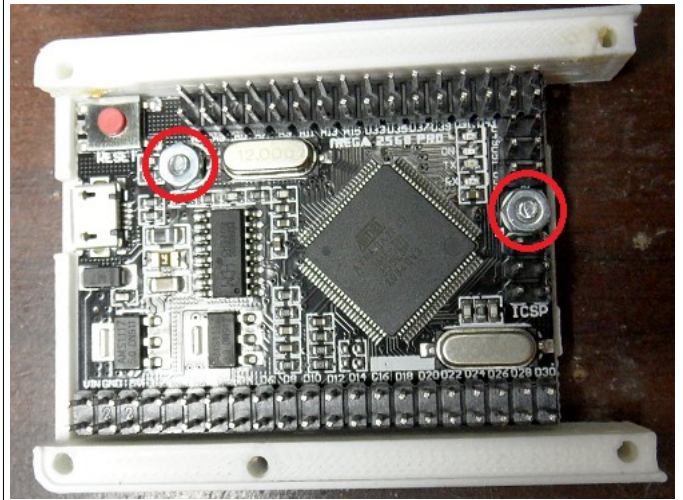
✓ Buzzer Feature (If a buzzer feature is desired)

- R3 – 39ohm 0805 SMD
- BZ1 Direct Solder

2.4 Final Assembly

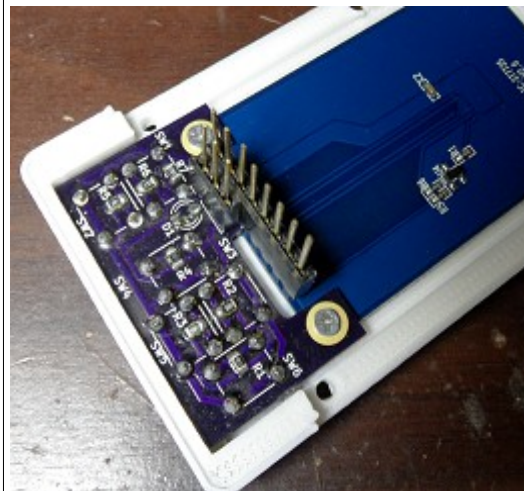
STEP #1 – Fasten Mega 2560-Pro Board to AMPCenter

- ✓ 3D-Print File: Tode-Handheld-AMPCenter.stl
- ✓ Pan-head Screw Size: M2.5x0.45 – 6mm long



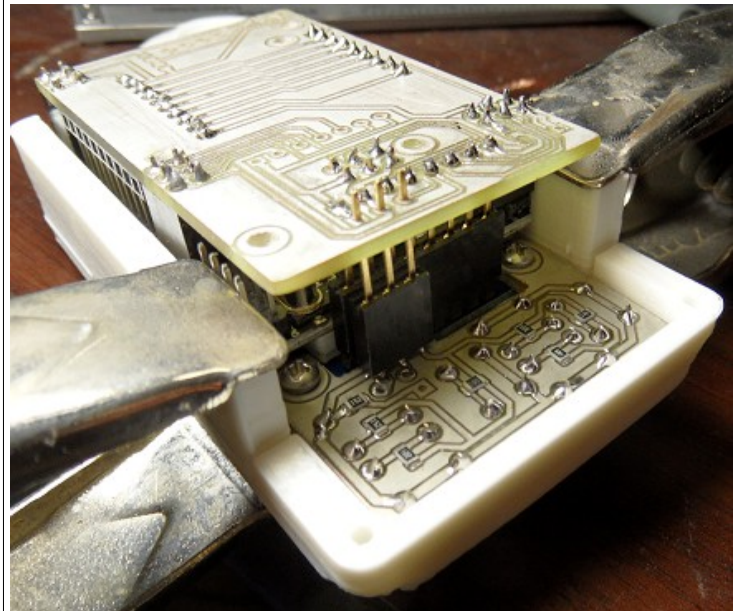
STEP #2 – Plug on Long-Leg 3P Female and 8P Female

- ✓ On the Display Assembly
 - Plug in a Long-Legged 8P Female Header to Screen
 - Plug in a Long-Legged 3P Female Header on Keypad



Step #3 – Plug on Back-plane Assembly with Screen

- ✓ Carefully Align the Mega-Pro Pins [from Step#1] with the AMPE32T30 back-plane PCB as well as the Screen and Keypad pins
- ✓ Compress the assembly verifying all plugs are seated.
 - Lift Plugs on Display & Keypad just a hair.
- ✓ Solder the Display and Keypad Plug Pins to the PCB.
 - Cut off excessive leads

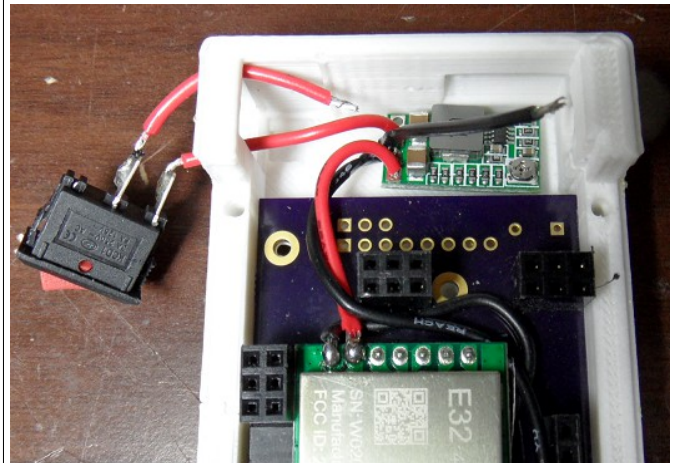


Step #4 – Insert and Fasten the AMPE32T30 Back-plane PCB.

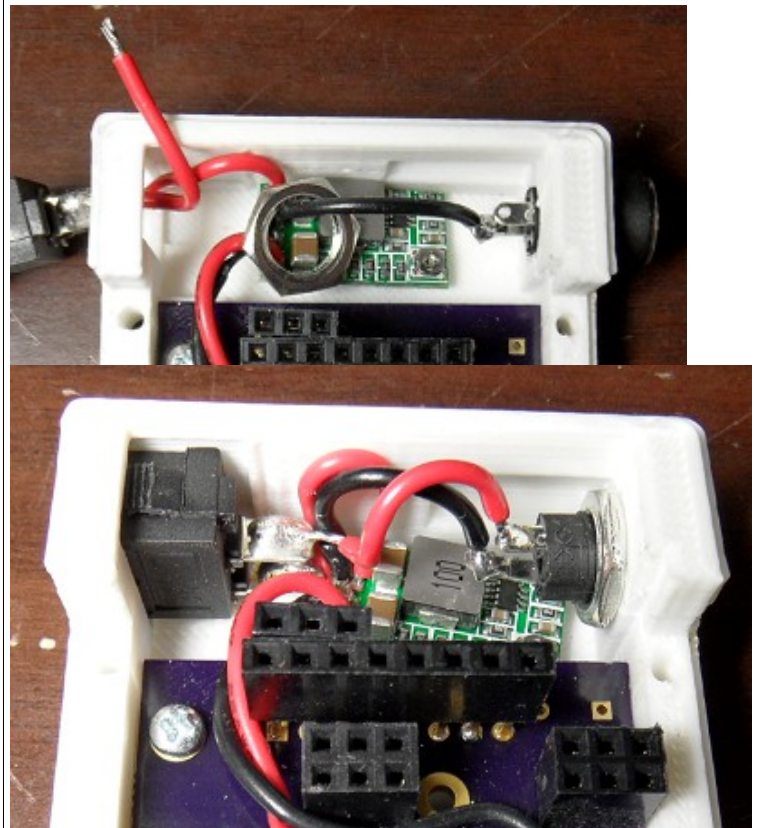
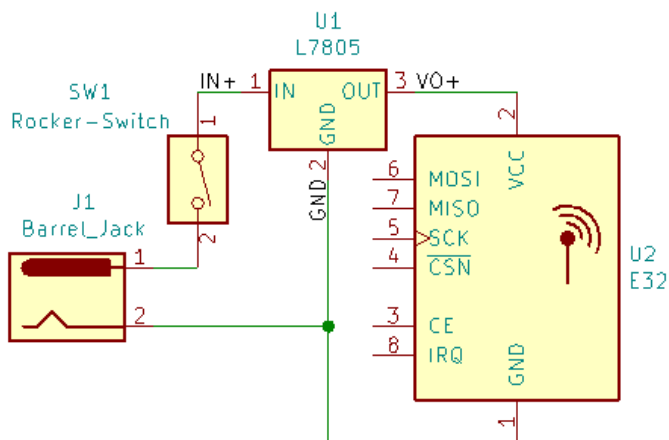
- ✓ Slide PCB from bottom to top and E32 Antenna plug through hole
- ✓ Using (2) #2-56 x 1/4" Machine Screws and Nuts fasten the PCB
 - Use the hole in the very Bottom-Right (as shown)
 - Use the hole in the very Top-Left (next to wires)
 - Use a longer screw to pull nuts into the plastic

**Step #5** – Solder Switch

- ✓ Thread the 1-1/2" long piece in P.S. VI+ (In) hole ([from Step #9](#)) through the switch hole and solder to the bottom leg of the switch as shown.
- ✓ Cut 1-1/2" long piece and solder to switch top leg and thread it through the switch hole as shown.

**Step #6** – Finish Wiring

- ✓ Wire Power Supply GND to Barrel Plug (long-leg)
 - Thread wire through Barrel NUT BEFORE soldering.
- ✓ Tighten barrel jack with Nut
- ✓ Wire Switch top-leg to Barrel Plug (short-leg)
- ✓ Insert Switch fully and arrange wires



STEP #7 – Final Assembly and Functional Test

- ✓ Plug the Mega-Pro Into the AMPE32T30 Backplane
- ✓ Plug the DiskKB on top.
 - Fasten using (4) #2 x 3/8" long pan-head SMS.
- ✓ Fasten from the backside
 - Use (4) #2 – 5/8" long Pan-head Sheet Metal Screws
- ✓ Side-IO Cover Install
 - Insert a #2-56 nut into side of cover
 - Use #2-56 x 3/4" long screw to tighten
- ✓ Plug the Tode-RC into Computer via Top-USB
- ✓ Upload the firmware and test button/screen operation

NOTICE – E32 Radio's must be configured in 'Fixed' Mode for the Tode to Work. See the Users Guide for more info.



3. Battery Tray

3.1 Bill of Materials (BOM) \$4

3.1.1 Supplies \$3

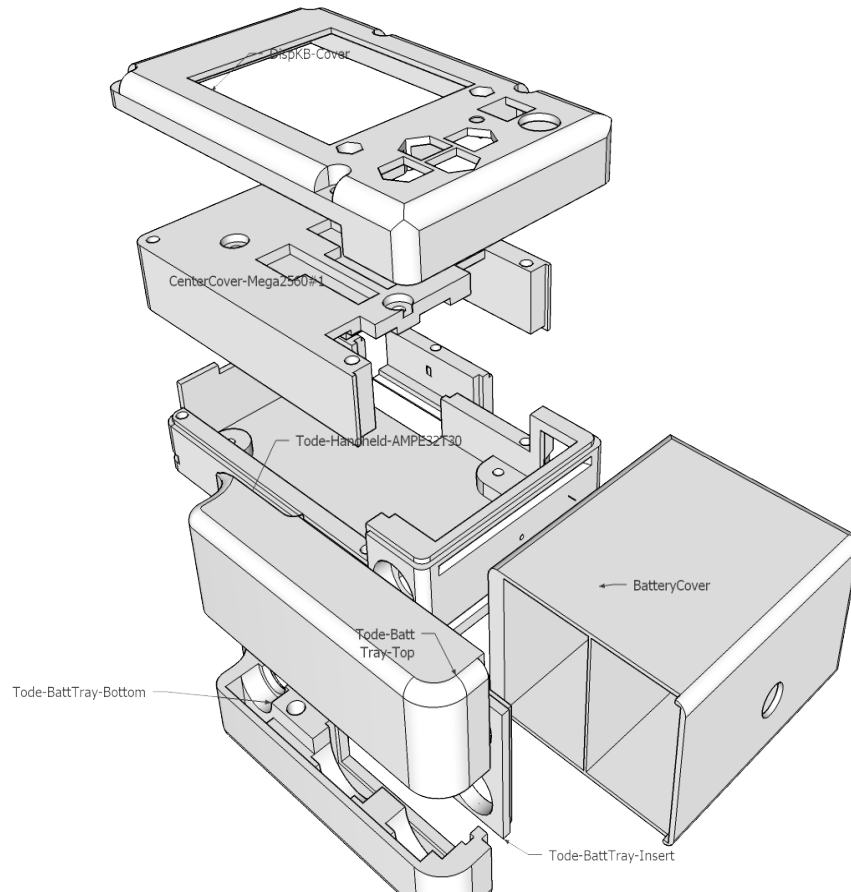
	<p>QTY: 1 @ \$1.75/ea 5.5x2.1mm DC Barrel Plug Female Panel Mount 2-Terminal with Nut</p>		<p>QTY: 2 @ \$0.35/ea = \$0.90 Hard Plastic Side-Exit Wires 9V Battery Connector Clip *Wires must exit from a side / must be hard plastic.</p>
	<p>Pan-Head Screws @ \$0.10/ea (1) #2 x 1/4" Long. (1) #4 x 3/4" Long.</p>		

3.1.2 3D-Prints \$1

- ✓ 3D Print the Following Casing (Order according to Assembly Needed)
 - Files in Folder: /3DPrints/

File Name	Grams	Plastic Cost \$0.02/g	Time	Power + Machine Use \$0.01/hr	Total Cost	Supports
Tode-BattTray-Top.stl	7-grams	\$0.14	1h 43m	\$0.02	\$0.16	NO
Tode-BattTray-Bottom.stl	4-grams	\$0.08	1h 0m	\$0.01	\$0.09	NO
Tode-BattTray-Insert.stl	2-grams	\$0.04	0h 20m	\$0.01	\$0.05	NO
Tode-BattTray-Cover.stl	14-gram	\$0.28	2h 54m	\$0.03	\$0.31	NO

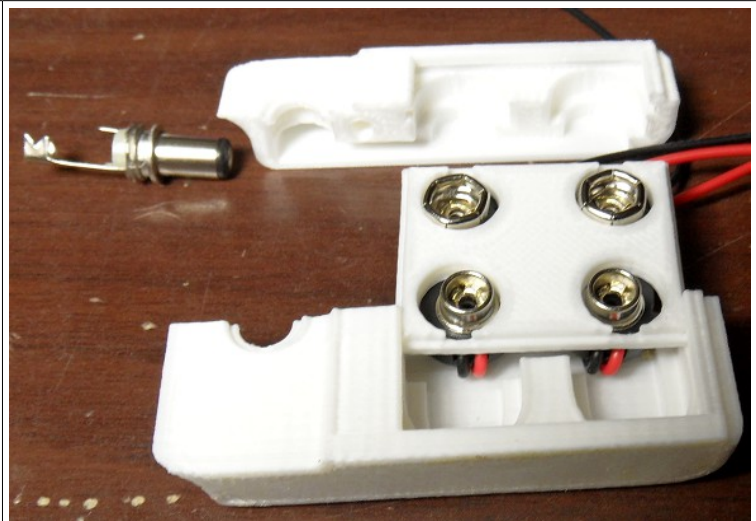
- Pricing at \$20/per 1KG Roll
- 0.15 Layer Height



3.2 Assembly

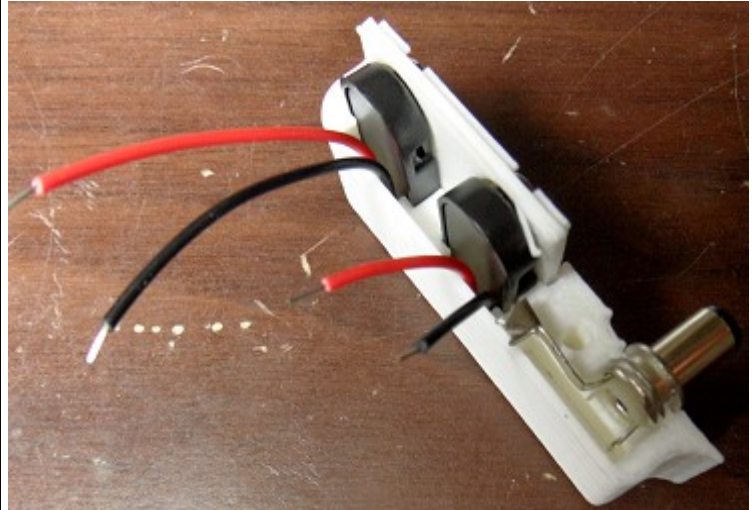
STEP #1 – Place Insert and Plugs

- ✓ Place (2) 9V Clips in [Tode-BattTray-Insert.stl](#)
- ✓ Bend wires back behind the clip as shown
- ✓ Slide the Insert w/Plugs into the [Tode-BattTray-Top.stl](#)



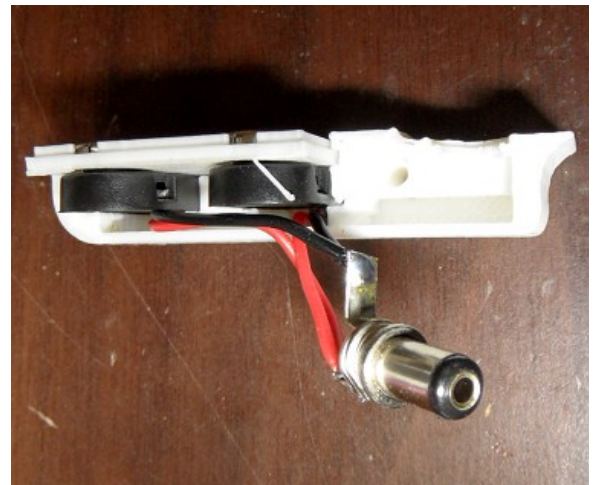
STEP #2 – Cut-to-fit wires and strip

- ✓ Pull the wires together to the edge of the model
- ✓ Snip the wires and strip their ends
- ✓ Bend the long DC-Barrel Plug Lead over to fit in model
- ✓ Cut the wire holding part off with dikes



STEP #3 – Solder wires to DC-Barrel Plug

- ✓ Twist the two red wires together and solder to short lead on DC-Barrel plug
- ✓ Twist the two black wires together and solder them to the longer (cut-off & bent) lead.



STEP #4 – Assemble the [Tode-BattTray-Bottom.stl](#)

- ✓ Slide the Bottom down over the top
- ✓ Make sure wires don't get trapped in the joint
- ✓ Use #4 – 3/4" long screw to tighten/hold assembly



STEP #5 – Attach [Tode-BattTray-Cover.stl](#) to Tode-RC Unit

- ✓ Place a #2 – 1/4" Long Screw on a screwdriver
- ✓ Run the screw up through the holes in the Tray Cover
- ✓ Hold the screw up and place Tode-RC on top
 - Where the Grooves mesh together
- ✓ Tighten the Screw with the screwdriver



STEP #6 – Loading / Replacing Batteries

- ✓ Plug (2) 9V Batteries onto battery clips
- ✓ Slide the assembly right into battery cover
- ✓ The DC-Barrel jack will align correctly with Tode-RC

