Tode-RC

Hardware Development

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

by TGit-Tech [http://www.TGit-Tech.com]
Build Version: 21C9 / Last Updated: 2021-12-09

This guide covers everything needed to build the Left and/or Middle Units in the below picture.

Table of Contents

1. Introduction

✔ The Tode Project is a Universal Platform of...
  ○ Face - UI Options
  ○ Tode – Backplane with optional Radio & Arduino Micro-Controller
  ○ Extensions - IO Interfaces, Battery Trays

Face Options (User Interface)		
Model	**Components**	**Resources**
#TFT18KB6	1.8" TFT LCD Color Screen (6) Key keypad	Design Files https://github.com/TGit-Tech/Tode-RC
#COVER	A Cover Only	*Not available at this time*

Tode Models *(post-fix RC=Remote/Radio Control equipped)*		
Model	**Components**	**Resources**
Tode #AMP	Arduino Mega Pro (AtMega2560)	*Not available at this time*
Tode-RC #AMPE32T30	Arduino Mega Pro (AtMega2560) Ebyte E32-433T30D Radio (1W/30dbm)	Design Files https://github.com/TGit-Tech/Tode-RC Firmware https://github.com/TGit-Tech/Tode-RC-Firmware
Tode-RC #AMPE32T20	Arduino Mega Pro (AtMega2560) Ebyte E32-433T20D Radio (250mW/20dbm)	*Not available at this time*
Tode-RC #AMPXBEE	Arduino Mega Pro (AtMega2560) Digi Xbee Radio	*Not available at this time*

SIO Stations (*Input/Output by Todes Side-IO [SIO] plug*)		
Model	**Components**	**Resources**
#SIOST	Screw Terminals	Design Files https://github.com/TGit-Tech/Tode-SIOST
#SIOAP	Aviation Plugs	*Not available at this time*

The Tode System is licensed under the MIT License. It's hosted on Github.com at:
https://github.com/TGit-Tech/Tode-RC

✔ See the "Tode General Hardware Development" document for required tools

2. KB-Display #TFT18KB6

2.1 Bill of Materials (BOM) $8

2.1.1 Parts $6.16

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

✔ 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
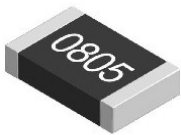 ○ (8)Pin-Order: GND,VCC,SCL,SDA,RES,DC,CS,BL
  ○ Pricing: ~ $4.75/each

2.1.2 Supplies $1.48

QTY: 1 @ $0.01/pin = $0.03
1x3P Male Pin Header (Cut from 40-Pin)
Dupont 2.54mm-Pitch
Keypad Connector

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
(2)1500, 1200, 910, 680, 330, 10

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

2.1.3 3D-Prints $0.32

✔ 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-DispKB-Buttons.stl	1-gram	$0.02	0:16m	$0.01	$0.03	NO

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

2.2 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.

2.2.1 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
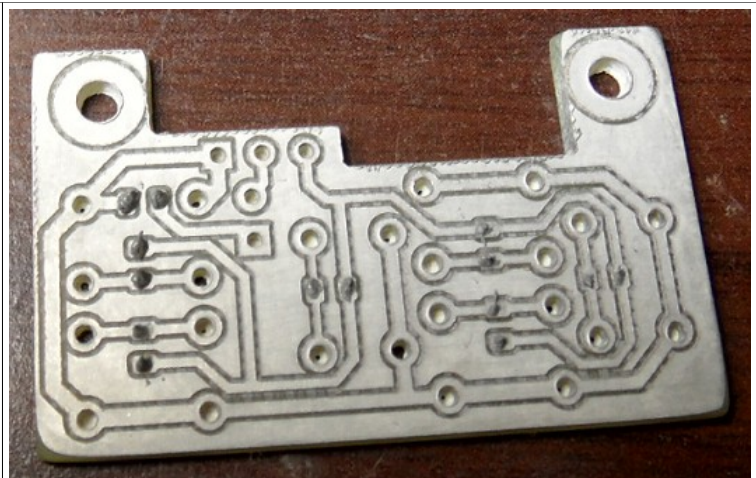
2.2.2 Attach SMT Resistors

1. Use Schematic & Layout to determine Resistor Locations

2. Apply solder paste at all Resistor locations (as shown)

3. Place SMT Resistors at correct Locations

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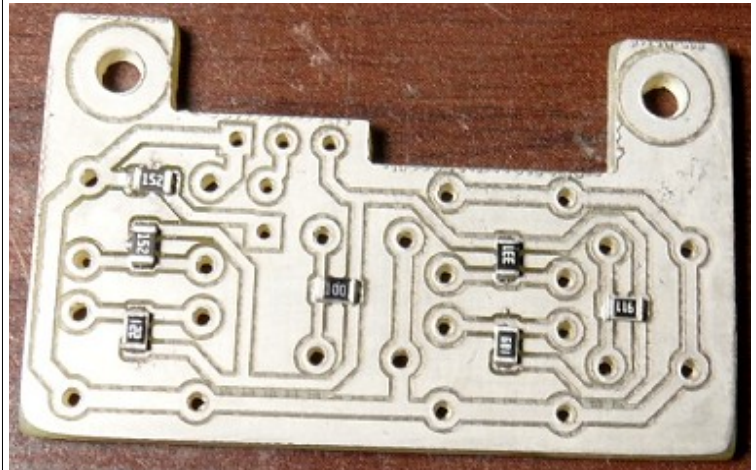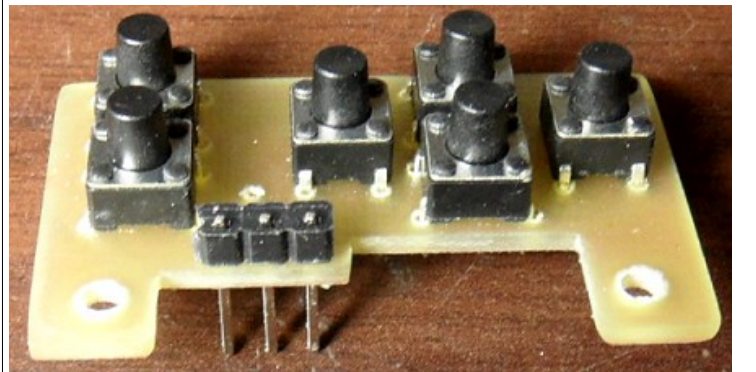

2.2.3 Install and Solder Buttons

5. Push (6) 6x6x7mm Tacticle Push buttons into place
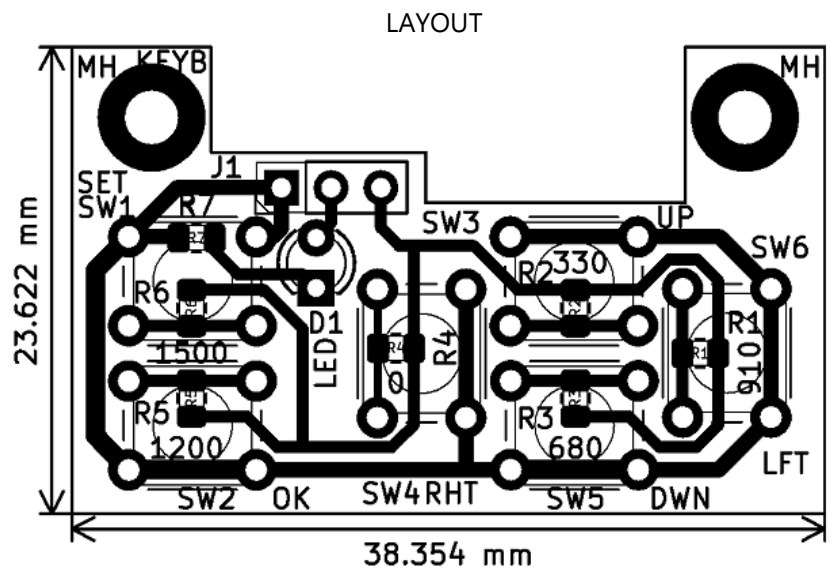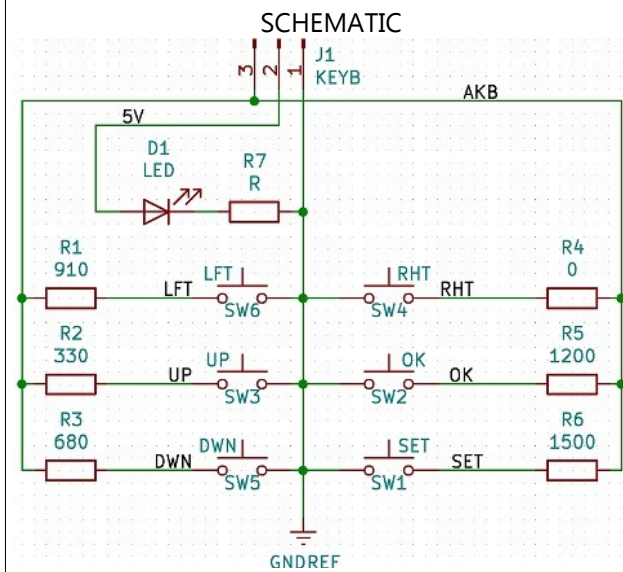
6. Solder the buttons to the board
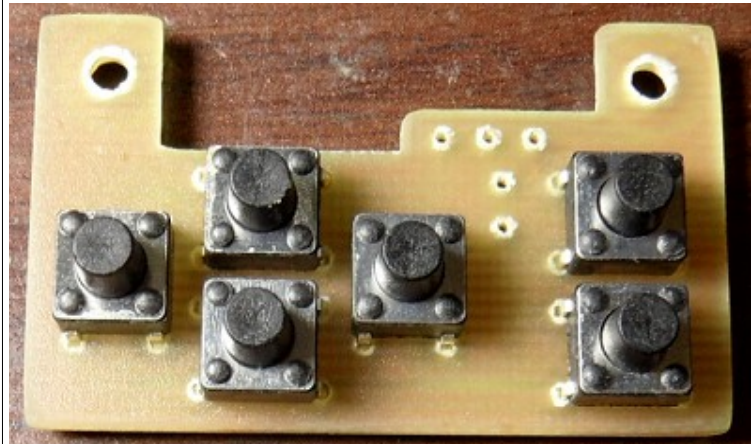
2.2.4 Keypad Plug

7. Insert a 3P Male Header as shown

8. Push pins down flush with the top.

9. Solder from the bottom-side instead of top

2.2.5 Schematic & Layout

SCHEMATIC

LAYOUT

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

2.3 Display Assembly

2.3.1 Install Nuts to Tode-DispKB-Cover.stl

10. Thread a M2 nut to a long M2 Machine Screw

11. Heat the Nut with a heat gun

12. Press the heated nut into the plastic as shown.

13. Repeat for both nut locations under display opening


2.3.2 Install Stickers to Face

This step requires a cutting machine and special materials and design files.

Contact Tgit-Tech if you'd like to purchase face stickers. DIY hobbyists can skip this step to create a unit without custom face stickers.

2.3.3 Attach Tode-DispKB-Buttons.stl

14. Use Scissors to cut Buttons apart at the center

15. Push Buttons onto tactile switches as shown
    a) Skinny legged arrow belongs on top
    b) If button don't push-on use 3.5mm bit to drill-out

16. Place 3mm LED light into PCB but do not solder yet.
    a) Square-Pad is Negative (short-lead)
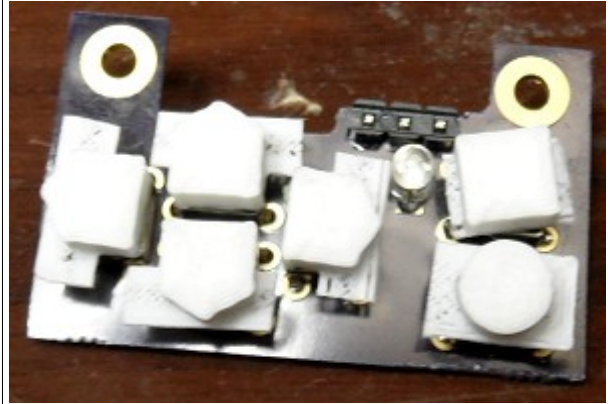
2.3.4 Fasten Display & Keypad and Solder LED

17. Place 1.8/1.77-Inch TFT Display in opening
    a) Solder the 8P Male Header to Screen if separate

18. Place the Keypad in Shell over the LCD as shown
    a) Fasten with **M2x0.4 – 8mm** machine screw

19. Use LED pins to position LED in Shell Hole for LED
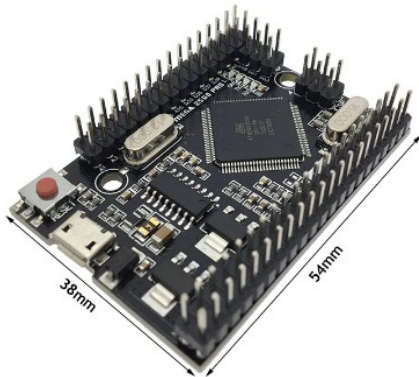20. Solder and cut LED pins to PCB

NOTE: *On Manufactured Keypad PCBs a proper fit may require cutting, sanding above the 3P Connection Header.*

3．Tode-RC #AMPE32T30
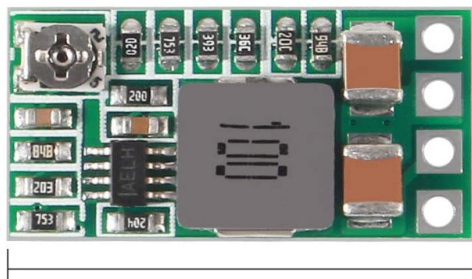
## 3.1 Bill of Materials (BOM) $31

3.1.1 Parts $27.84

✔ 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

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
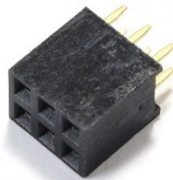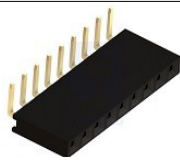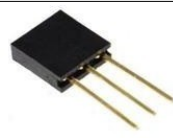- Nominal Output: 1.5A
- Pricing: $1/ea
- Web @ https://www.amazon.com/dp/B08Y674Z6F
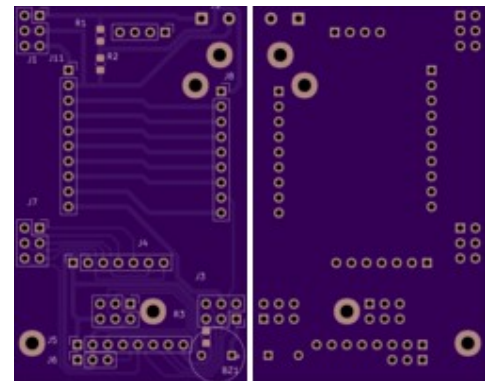
✔ Tode #EMPE32T30 PCB
- Manufacturer: Oshpark.com
- Pricing: $3.84
- Batch Price: $115.20 per 30

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

3.1.2 Supplies $1.94

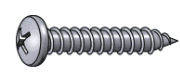|			
	QTY: 1 @ $0.10/ea = $0.10 1x9P Female Pin Header Dupont 2.54mm-Pitch *(J8) On AMPE32T30*		**QTY**: 4 @ $0.10/ea = $0.40 2x3P Female Pin Header Dupont 2.54mm Pitch *(J1-PWR)(J2-ISCP)(J3)(J7) on AMPE32T30*
	QTY: 1 @ $0.10/ea = $0.10 1x10P Female Pin Header Dupont 2.54mm-Pitch *(J11) On AMPE32T30 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 Male Pin Header (Cut from 40-Pin) Dupont 2.54mm-Pitch *E32 Align*		**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**: 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: 4 @ $0.10/ea = $0.40 #2 – 5/8" Pan Sheet Metal Screws *AMPE32T30 Casing 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*)

3.1.3 3D-Prints $0.91

✔ 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-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

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

✔ See separate Section #3.Battery Tray|outline for the Battery Tray Extension

Assembly Diagram
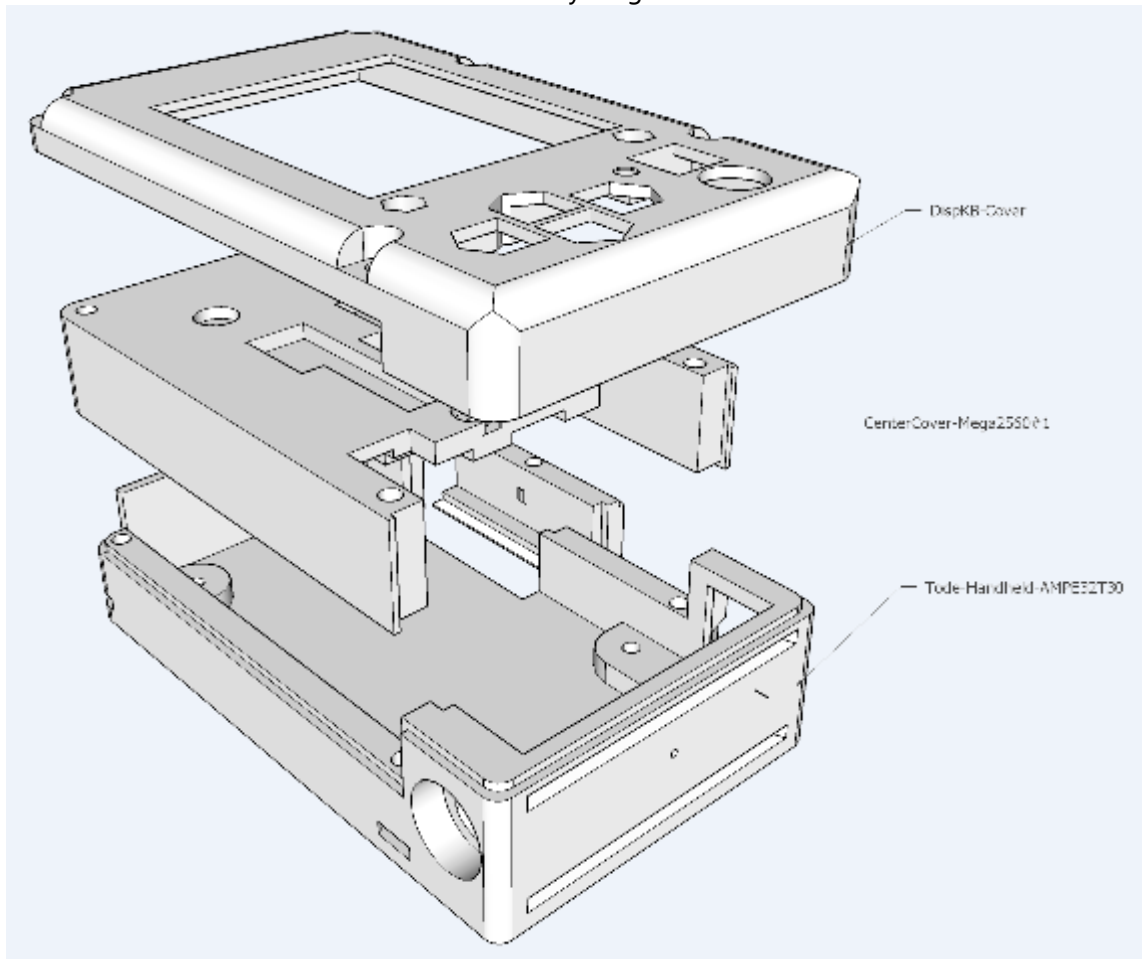
3.2 PCB Assembly

3.2.1 Obtain (Purchase/Make) the **AMPE32T30 – PCB**

✔ Design File
  ○ FOLDER = /kicad/AMPE32T30/output/
  ○ GERBER FILE = AMPE32T30-F_Cu.gbr

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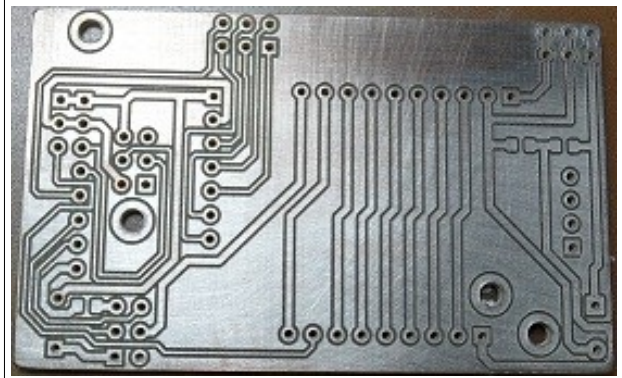 ○ CNC File = AMPE32T30-F_Cu.gbr.nc
  ○ CNC Settings: Z-Down: -0.045, Speed: 45mm/s
  ○ CNC Isolation Bit = Pyramid 0.2mm Tip 45-deg
  ○ Hole Sizes = 0.8mm, 2.7mm

3.2.2 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
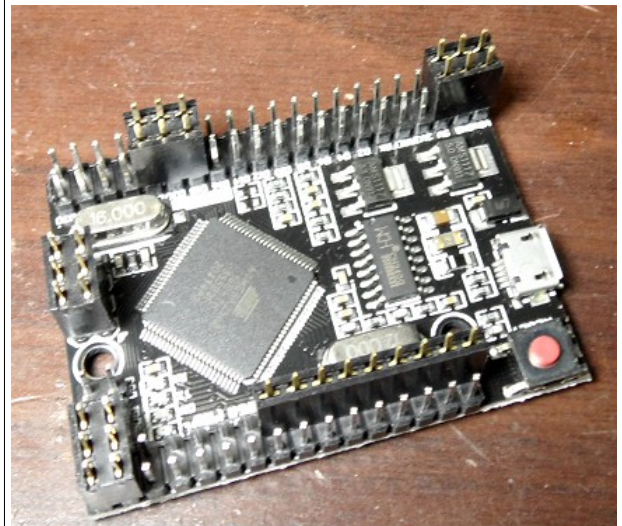
3.2.3 Solder Female Headers to the PCB

✔ Place the Arduino Mega Pro and Headers into proper place on PCB
✔ Solder the Female Pin-Headers from Step #3 to the PCB board.
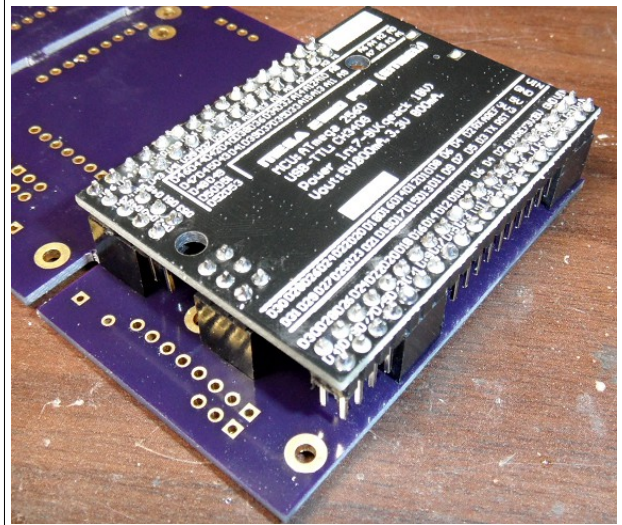
3.2.4 Attach & Solder J11 1x10P [SideIO] Female Header

WARNING: **Never solder-on E32 Radio before STEP #4.**
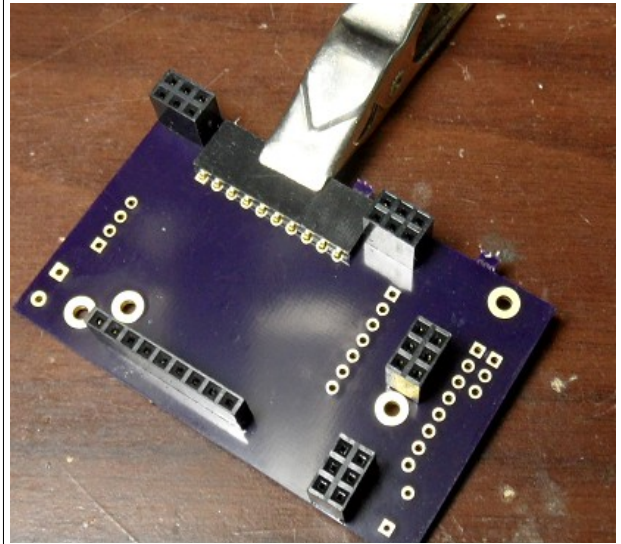1. Unplug the Arduino Mega Pro from PCB
2. Press header pins on a flat surface; bend to 90-deg
3. J11 [IO] = 1x10P Female Header w/bent pins
4. Insert as shown. Be sure face is parallel with edge of board
5. Use a Clip to hold in place while soldering the pins to the PCB.

✔ Refer to Schematic & Layout

3.2.5 *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
✔ Insert Ultra-Thin 5Vdc Piezo Buzzer into Bottom-Left
✔ Solder the Piezo Buzzer leads and snip to board level.

SKIP THIS STEP – The battery monitor is no longer relevant due to the required external 3A Power Supply.
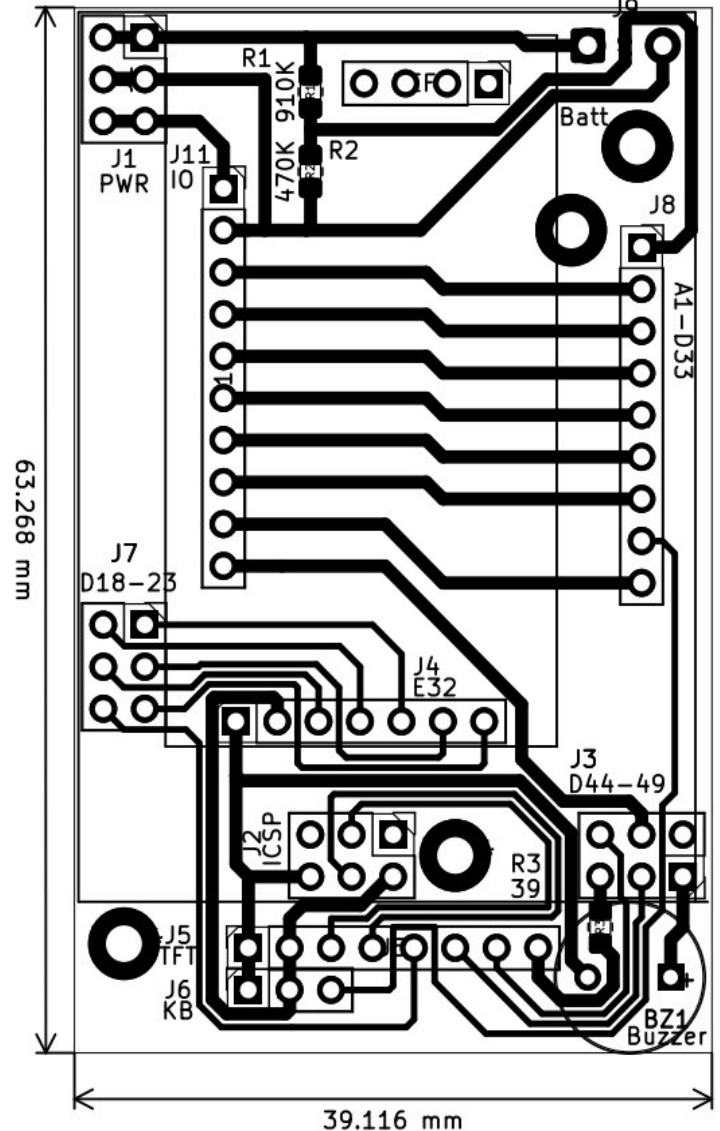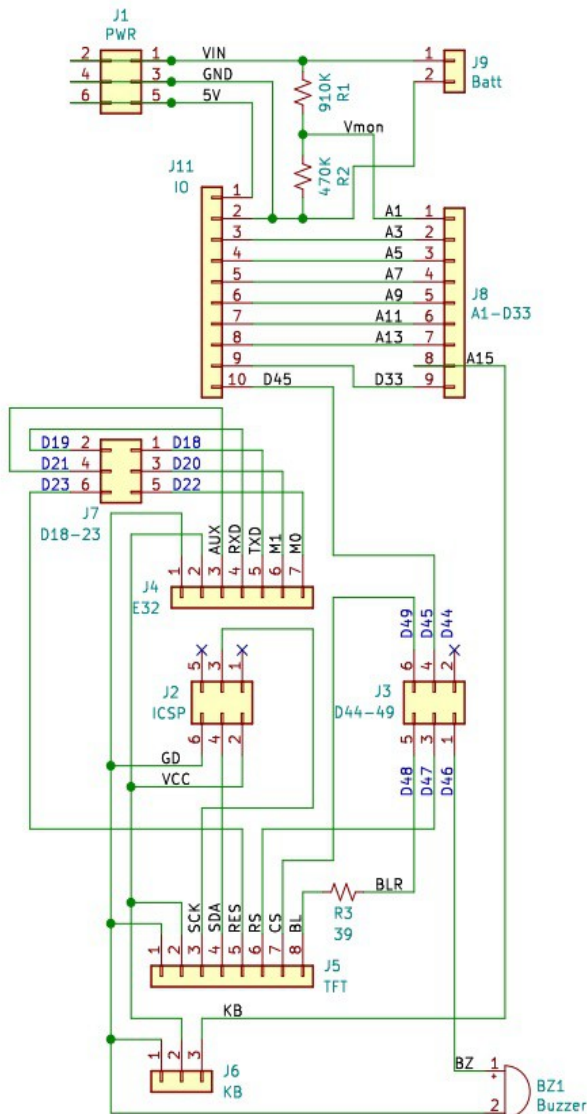
If a Buzzer Feature is desired - Manually solder the R3 = 39Ω SMT Resistor.

3.2.6 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

3.2.7 Solder Ground Wire Junction

4. Using 22awg Black Solder together a junction as shown
   a) 1" Stem Wire to...
      - 1-1/2" Tied Split
      - 2-1/2" Tied Split
      - 3" Tied Split
   b) Slide and attach Heat Shrink tubing

5. Solder the Junction Stem-Wire to the left-top circle pin on PCB

A. Schematic & Layout

SCHEMATIC

LAYOUT
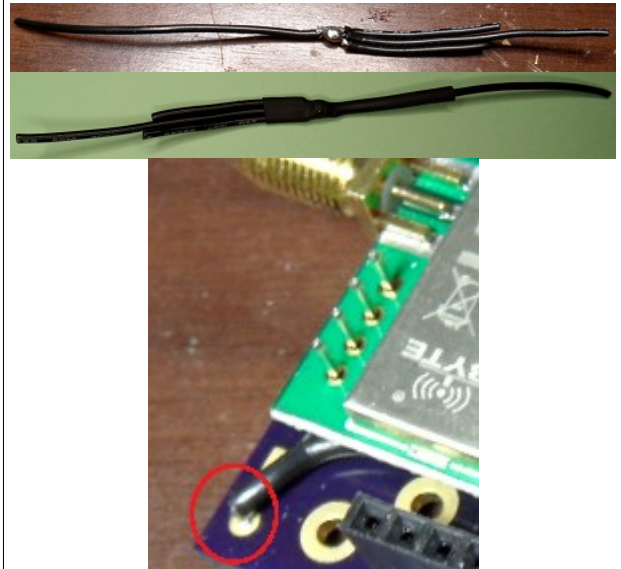
✔ Female Dupont 2.54mm pitch Connectors

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

3.3 Final Assembly

3.3.1 Fasten Mega 2560-Pro Board to AMPCenter

1. Install a Mega-Pro 2560 Micro-Controller into the Tode-Handheld-AMPCenter.stl Model as shown.

2. Fasten with **M2.5x0.45 – 6mm** long machine screws and nuts.
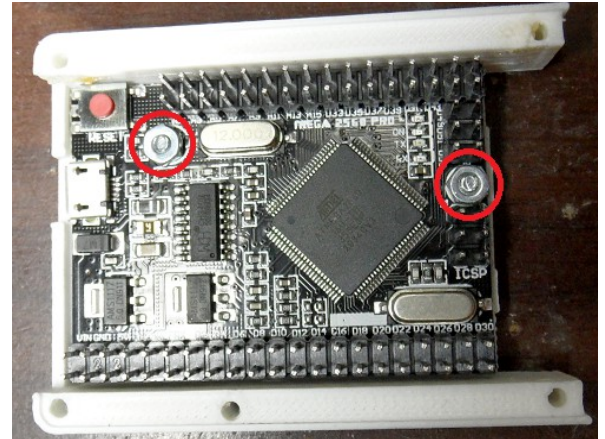
3.3.2 Prepare KB-Display Plug

3. With an Assmbled KB-Display #TFT18KB6
   a) Plug a Long-Leg 3P Female Header to keypad
   b) Plug a Long-Leg 8P Female Header to Display
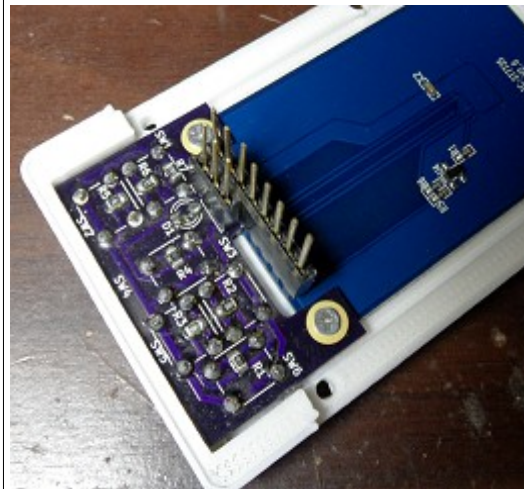
3.3.3 Align and Solder KB-Display Plugs

4. Carefully Align the Mega-Pro Pins [from Step#1] with the AMPE32T30 back-plane PCB as well as the Screen and Keypad pins

5. Compress the assembly verifying all plugs are seated.
   a) Lift Plugs on Display & Keypad just a hair.

6. Solder the Display and Keypad Plug Pins to the PCB.
   a) Cut off excessive leads
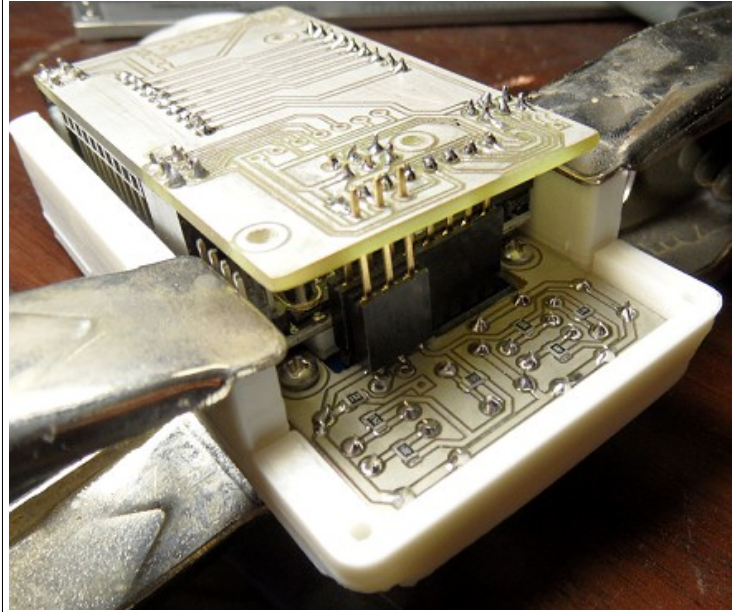
3.3.4 Prepare 5V 3A Power Module

7. Using Razor Knife cut the Top Trace (label ADJ)

8. Jump a Solder bridge where 5V is labeled

9. Do a Continuity Test verifying changes
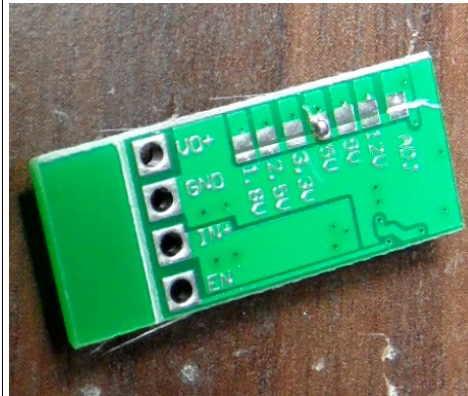
3.3.5 Solder Ground Wire Junction Wires

10. Solder the shortest 1-1/2" GND Junction Wire to the GND pin of the E32 Radio Module

11. Solder the middle-length 2-1/2" GND Junction Wire to the GND Pin of the 5V 3A Power Module. (*Ignore the extra black wire in picture on PS module – incorrect*)

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.
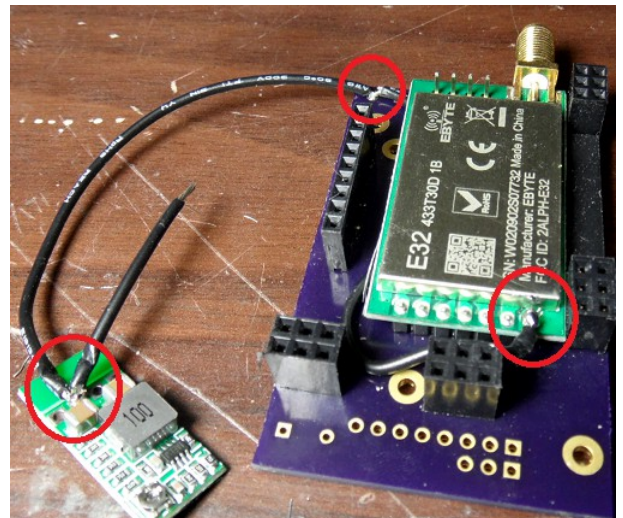
3.3.6 Wire 5V 3A Power Supply Power to E32 Radio

12. Solder a 1-1/2" long 22awg Red Wire
    a) PS Module VO+ → E32 Radio VCC

13. Solder a 1-1/2" long 22awg Red Wire
    a) PS Module VI+ Pin (later will go to switch)


3.3.7 Attach AMPE32T30 PCB to Housing

14. Slide PCB from bottom to top and E32 Antenna plug
    through hole

15. Pull #2 nuts into plastic using a long #2 screw.

16. Fasten using (2) #2-56 x 1/4" Machine Screws

3.3.8 Solder Switch

17. Thread the 1-1/2" red wire from PS VI+ [Step #13]
    through the switch hole and solder to the bottom leg
    of the switch as shown.

18. Solder a 1-1/2" long red wire to switch top leg and
    thread it through the switch hole as shown.
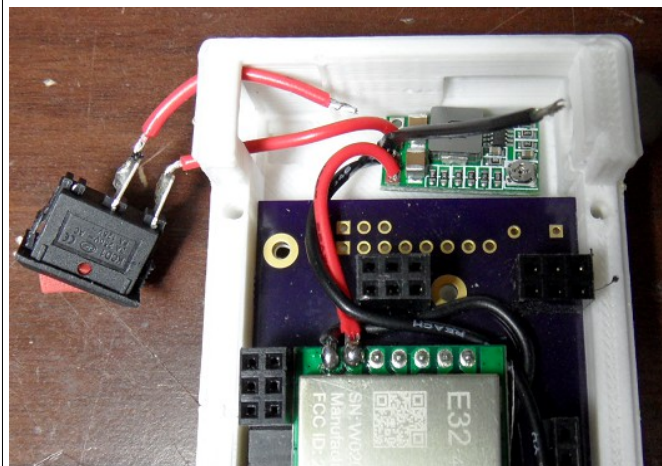
3.3.9 Finish Wiring

19. Route DC Barrel Nut over 3" GND Junction wire.

20. Insert DC Barrel Plug and solder the 3" GND Junction Wire to the DC Barrel Plug (long-leg)

21. Tighten barrel jack with Nut

22. Wire Switch top-leg to Barrel Plug (short-leg)

23. Insert Switch fully and arrange wires
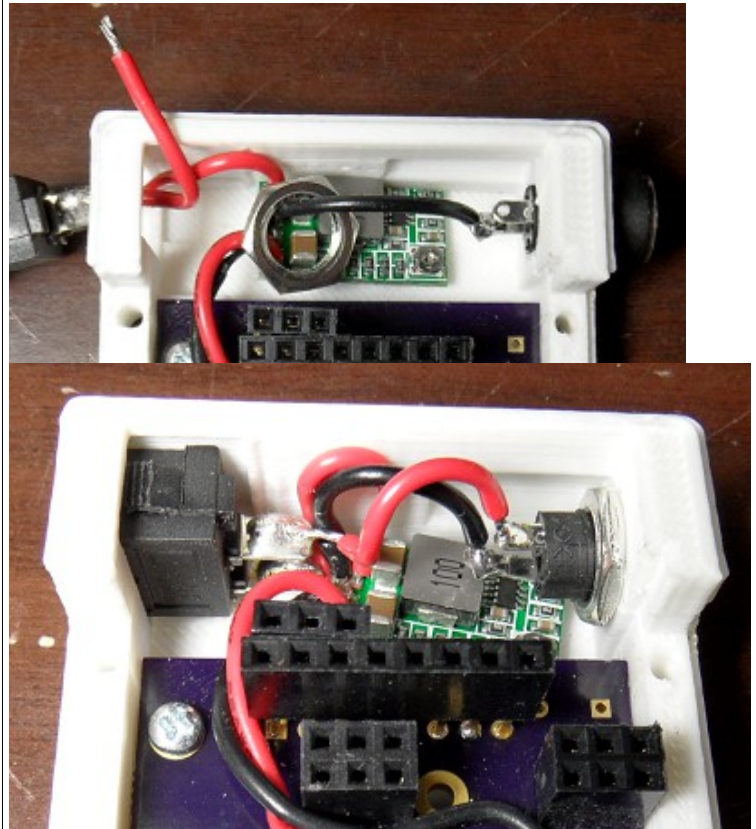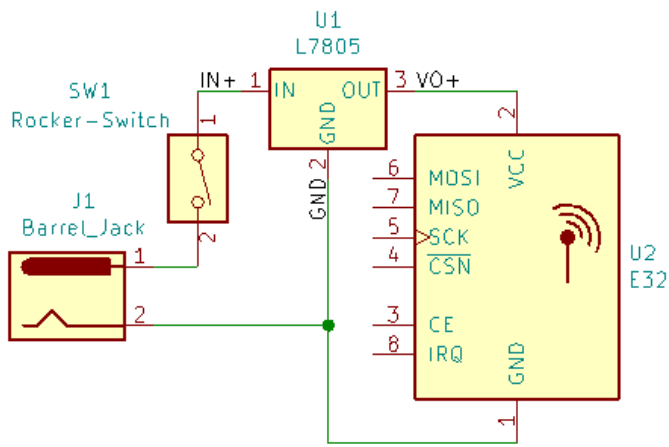
3.3.10 Final Assembly and Functional Test

24. Plug the Mega-Pro Into the AMPE32T30 Backplane

25. Plug & Fasten the DiskKB using **(4) #2 x 3/8"** SMS.

26. Fasten Back to Center using **(4) #2 x 5/8"** SMS.

27. Insert a **#2-56** nut in slot of Side-IO Plug Cover

28. Fasten with **#2-56 x 3/4"** Machine Screw.

29. Plug the Tode-RC into Computer via Top-USB

30. 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.

4. Battery Tray

4.1 Bill of Materials (BOM) $4

4.1.1 Supplies $3

|	
QTY: 1 @ $1.75/ea 5.5x2.1mm DC Barrel Plug Female Panel Mount 2-Terminal with Nut	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.
Pan-Head Screws @ $0.10/ea (1) #2 x 1/4" Long. (1) #4 x 3/4" Long.	

4.1.2 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
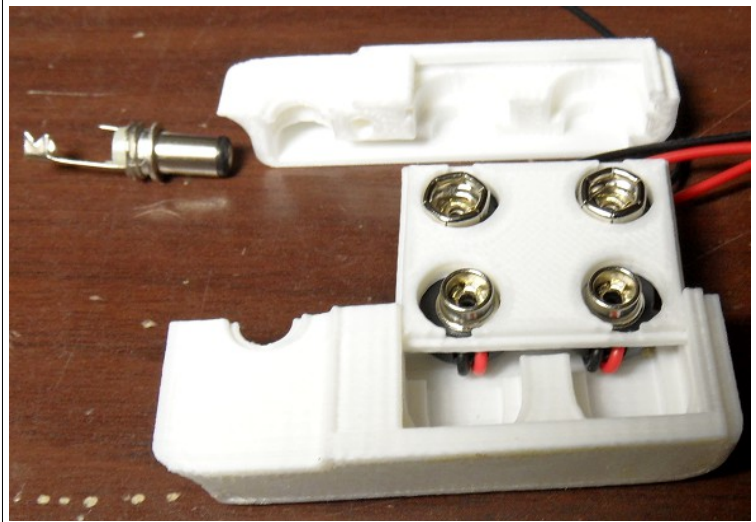 ○ 0.15 Layer Height
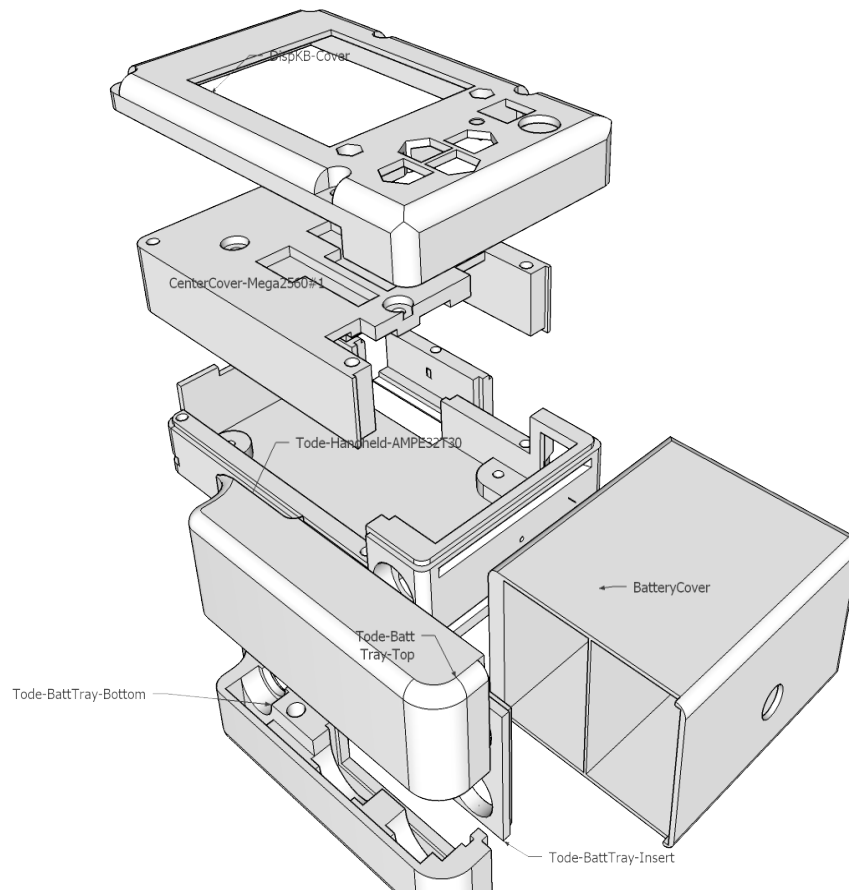
4.2 Assembly

### 4.2.1 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

4.2.2 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
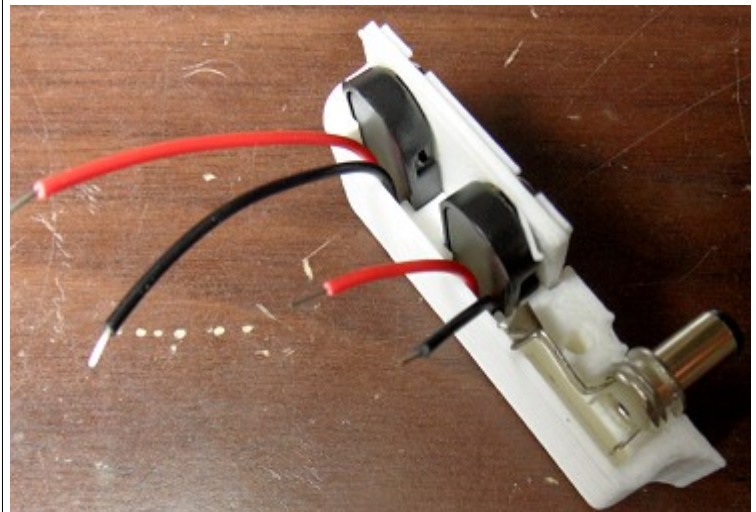
4.2.3 Solder wires to DC-Barrel Plug

✔ 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.
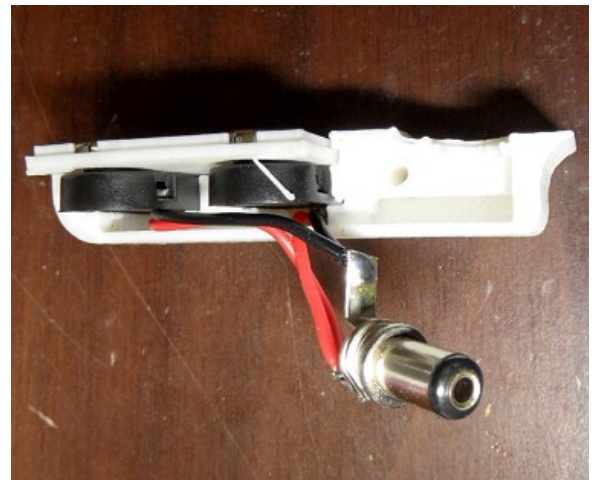
4.2.4 Assemble the Tode-BattTray-Bottom.stl

✔ 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

4.2.5 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

4.3 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