MOD-SIX_7971 GEN-II V9 Clock PCB assembly notes.
Version 2.6 January-2018, HCO.

Revision list.
2.6 Minor typos fixed.
2.5 Update CPU to rev 7.6. Update PSU to 7.6. Update RPTR reference. Misc fixes.
2.4 Updated RPTR references.
2.3 Remove MEZZ and RPTR 2.0 references.
2.2 Updates for Gen-II-V7 added. Various typos corrected and clarifications added.
2.1 Added RF-LINK Mezzanine board assembly notes.
2.0 Initial release

This document incorporates feedback from individuals who have assembled kit versions of the first and second generations of the MOD-SIX. Their input is very much appreciated, and you can benefit greatly from their contributed experiences.

Please pay special attention to all **BOLD RED** notices. They are of particular importance.

WARNING: This clock utilizes hazardous **High Voltages** to power the Nixie tubes. This voltage is generated from an offline switching power supply, but proper caution should always be exercised when physically interacting with the clock's circuitry. A proper enclosure should also be used at all times to shield and protect the user and any innocent bystanders from the **high voltages** present within this clock.

These are supplemental notes on assembling the MOD-SIX_7971 clock kit PCB assemblies. It's assumed you are experienced and comfortable with assembling electronic circuitry and SMD components in particular. Please seek assistance if you are unsure of your soldering ability with fine pitch SMD or lack the proper tools.

Primarily you'll be working from the schematics and parts placement drawings, these notes are just additional hints and techniques to hopefully make the whole assembly process easier.

NOTE: If you wish to have the mill-max tube socket pins raised above the PCB it is **VERY** important to solder the pins in before any other components. Please see **separate** document that shows in detail how to install the Nixie socket pins and how to fabricate the copper towers for the colon dots and the am/pm indicator.

Some Terminology:

PSU - Power Supply Unit.
Converts 12 VDC input to intermediate 8 volts, also generates high voltage for the Nixie tubes and neon bulbs..

TDU - Tube Driver Unit.
Converts logic level signals from CPU to drive the nixie tubes and neon indicators.

CPU - Central Processing Unit.
Contains microprocessor and battery backed Real Time Clock functions.

Supports the wireless RF-LINK circuitry.

RPTR - Standalone GPS repeater unit.
Receives time and location data from an integrated GPS receiver. Rebroadcasts the time data to all compatible receivers. Additionally, the RPTR broadcasts temperature, relative humidity, barometric pressure, and random words from a built in lexicon to populate the MOD-SIX clock's random word display feature. The MCU on the original MOD-SIX did not have enough memory to store all the words, so the lexicon was moved to the RPTR. User instructions for the RPTR are available in a separate document.

Some General Notes:
Discrete SMD parts are inexpensive, and we included some extras in case one goes flying. So don't worry if you have any leftover parts.

You can take advantage of the modular nature of the design to assist in assembling and debugging any problems encountered while constructing the MOD-SIX clock. It's best to assemble and test the **PSU first**, then the **CPU** before proceeding onto constructing the **TDU** boards. The CPU had test features to assist in debugging the TDUs.

After assembling the **PSU** and verifying proper voltages, you can then plug it directly into the **CPU** and test for proper voltages on the **CPU** board.

Please Disable the HV output for these preliminary tests by removing the HVEN strap.

You can then assemble a TDU board and test it in circuit before continuing onto the rest of the clock construction. Each additional completed TDU can be added one at a time, or tested individually.

PSU specific construction notes:
It's easiest to insert and solder the HV-PSU last.

D2-D3 LEDs. The cathode (K) indicator notch on the included LEDs should be towards the rear of the clock. Different color PLCC-2 LEDs can be substituted or you can choose not to install the LEDs entirely.

After assembling the PSU, apply 12 volts to DC input, and check for +8 volts at J2.

The Neon bulb should illuminate when the HV is present. Check for HV DC at J3. Voltage should be in the 180-190 volt range.

Removing the HVEN strap disables the HV module for testing purposes.

NOTE. Be sure the SMD capacitor at C4 is the high voltage part. It'll be the largest SMD capacitor.

NOTE. The Neon lamp NE1 is installed as an HV live indicator, but will only illuminate if the

high voltage level is above approximately 90volts.

NOTE. The manufacturer's label may be removed from the HV module for a cleaner finished look. The label residue can be removed with Isopropyl alcohol or "goo-gone". Some physical effort will be necessary to remove all the residue. You may wish to do this before part placement and soldering.

NOTE. Acetone based solvents will remove the paint from the HV module. Be careful if you use acetone to remove solder flux residue. If you wish, you can remove all the paint from the HV module easily with some acetone and either repaint a different color or leave the natural copper exposed for that steam punk look.

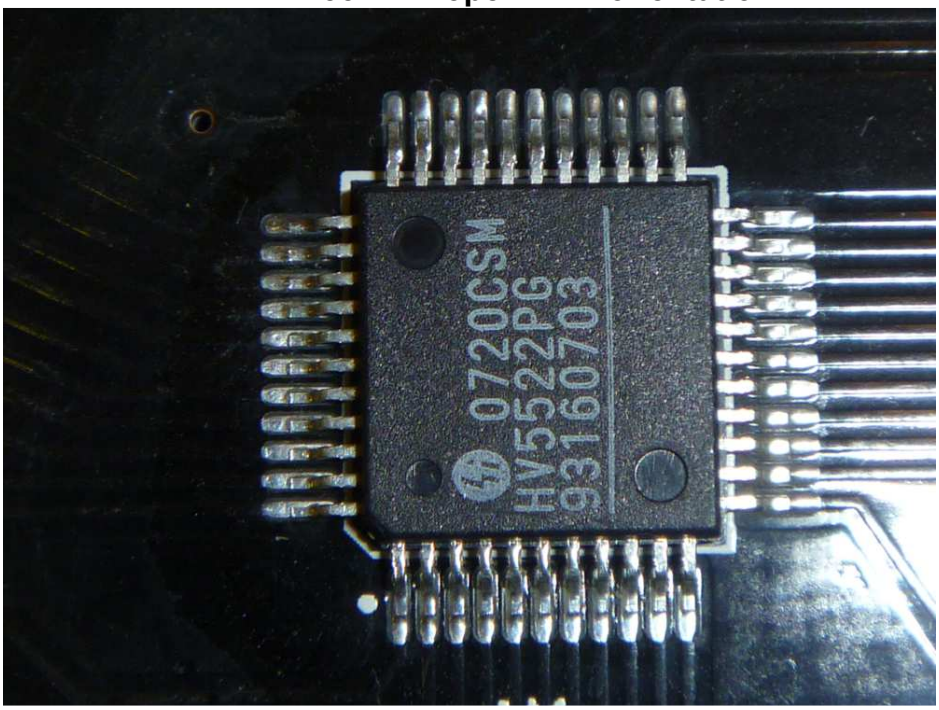
TDU specific notes:
NOTE: If you wish to have the mill-max pins raised above the PCB it is **VERY** important to solder the pins in before any other components.

Please see the separate document provided for detailed instructions on installing the mil-max nixie tube socket pins and the construction of the copper neon colon & AM/PM towers. These can be tricky steps and the separate document will walk you through the process.

Also note that the pins are elevated off the PCB primarily for aesthetic reasons. There is the idea that the extended pins may have more spring and stress the tubes less, but it's just a theory. You could certainly mount the pins flush with the PCB, but then you may have to adjust the colon tower tube lengths to maintain alignment.

NOTE: **U1** Pin 1 location. The **HV5522** plastic package has some possibly confusing molding indents. Please take care in properly determining Pin 1 prior to soldering.

HV5522 Proper Pin 1 orientation.



TDU cathode resistors.
The “A B C D” designators on the TDU PCB silkscreen correspond to the 4 different cathode resistor values for the B7971 tubes. Different length cathodes within the nixie tube require different current limiting resistors so that the brightness of each segment will match properly. The letters themselves are just an assembly aid to speed up locating the SMD resistors on the PCB. This seemed less error prone than working with the individual resister values. The actual resistor values are on the schematic and in the BOM, but are provided here again:

A = 22k B = 24k C = 27k D = 33k

CPU specific construction notes:

J1 - HV. High voltage is not used on the CPU board. A location is provided for a matching header to provide for a more symmetric build. Please take proper precautions around high voltages.

RF1 - 2.4ghz RF-MODULE. **NOTE** Solder the 2x4 header to the CPU PCB, and then plug the RF module into the header when CPU construction is finished. The RF module is oriented with the gold PIFA squiggle antenna towards the front of the clock,

J4 – ISP. Used to reprogram / upgrade the firmware of the AVR ATMEGA168 MCU. An external compatible AVR programmer or a vendor provided FW upgrade “dongle” is required.

U3 - Voltage regulator**.** Be sure to properly solder the ground tab of the 78M05.

Q1- Photo-transistor**.** The long lead of the photo-transistor is the Emitter. It should be installed towards the front of the clock. **NOTE** that on the GIIV7 and later version clocks the ROHM photo-transistor has been replaced with a **VISHAY** TEPT4400 photo-transistor. **R4** has been changed to 120K to provide a better match to the sensitivity. The TEPT4400’s lead detail requires it to be installed at a minimum height above the PCB.

D1- LED. The long lead of the included green LED is the Anode. It should be installed towards the rear of the clock. You may substitute a different color if desired. **AESTHETIC NOTE** You may wish to install the LED D1 after installing photo-transistor Q1 to align the heights of the two components.

MOD-SIX Diagnostic notes:

CPU
On Power up the green CPU led should light and then extinguish after a couple of seconds. If there are any problems with the RTC subsystem (the RTC chip is not present or the I2C bus is open/shorted) the CPU led will blink rapidly and the clock will not function.

NOTE If the rotary encoder is depressed and held while power is applied to the clock, a tube segment bit test pattern will be displayed on the Nixie tubes. It will run continuously until the power is cycled. You can use this to test, and help find possible soldering issues on the **TDU**

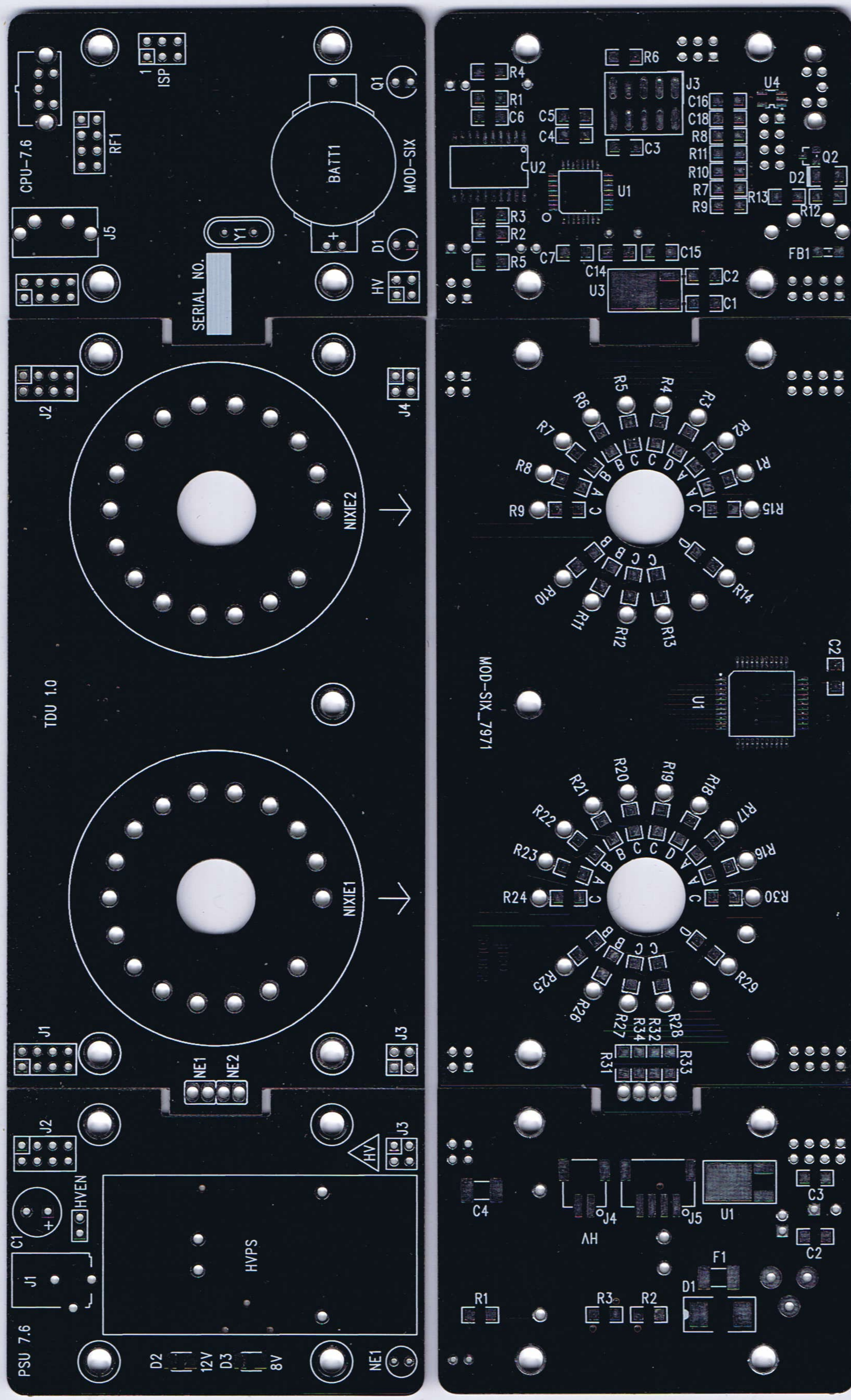
boards. There is an additional segment test function in the clock's main configuration menu than can be accessed when the clock is running normally..

TDU

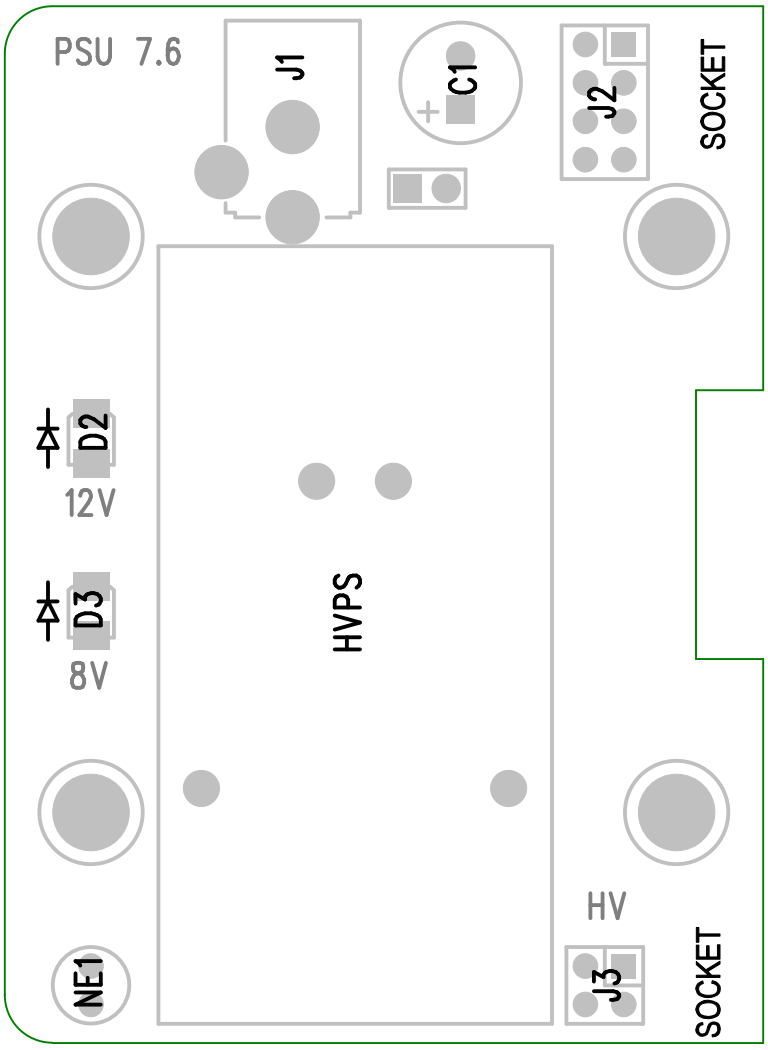
The segment test feature on the **CPU** can be very helpful**.** Individual **TDU** boards may be tested with just the **CPU** and a **PSU**.

Attached Images and diagrams list:

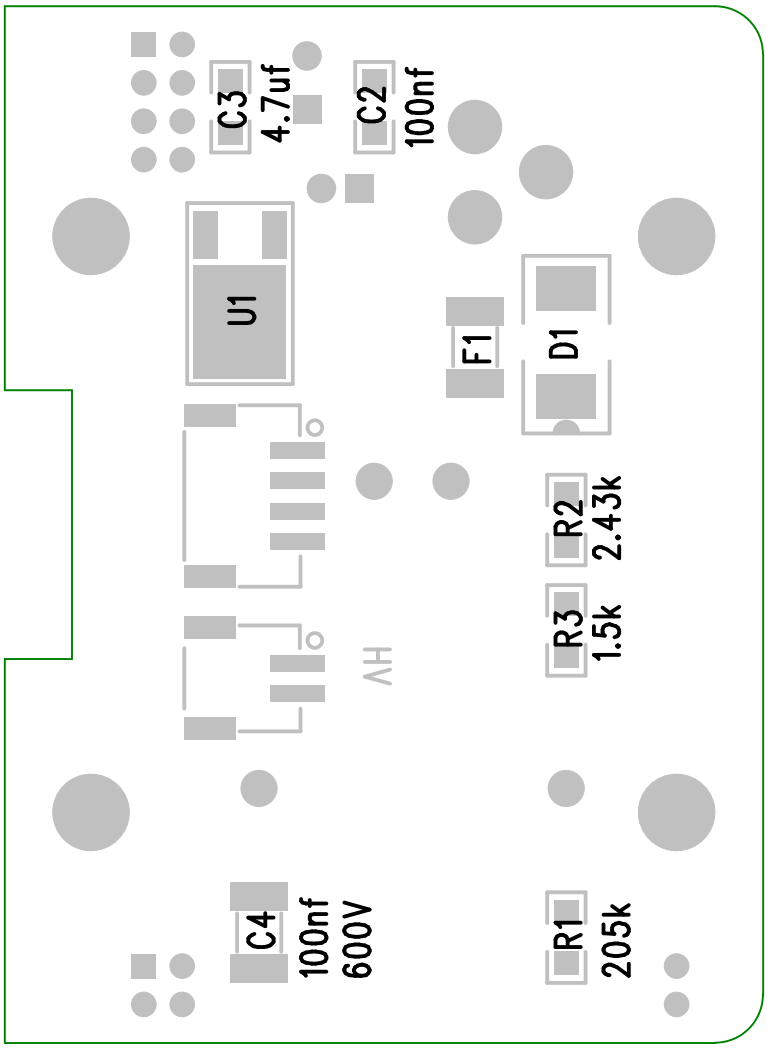
1. PCB image scan. Top and bottom.
2. PSU 7.6 Component placement top. **3. PSU 7.6 Component placement bottom.** **4. PSU 7.6 Schematic.** **5. PSU 7.6 BOM**
6. TDU 1.0 Component placement top. **7. TDU 1.0 Component placement bottom.** **8. TDU 1.0 Schematic.** **9. TDU 1.0 BOM**
10. CPU 7.6 Component placement top. **11. CPU 7.6 Component placement bottom.** **12. CPU 7.6 Schematic.** **13. CPU 7.6 BOM**



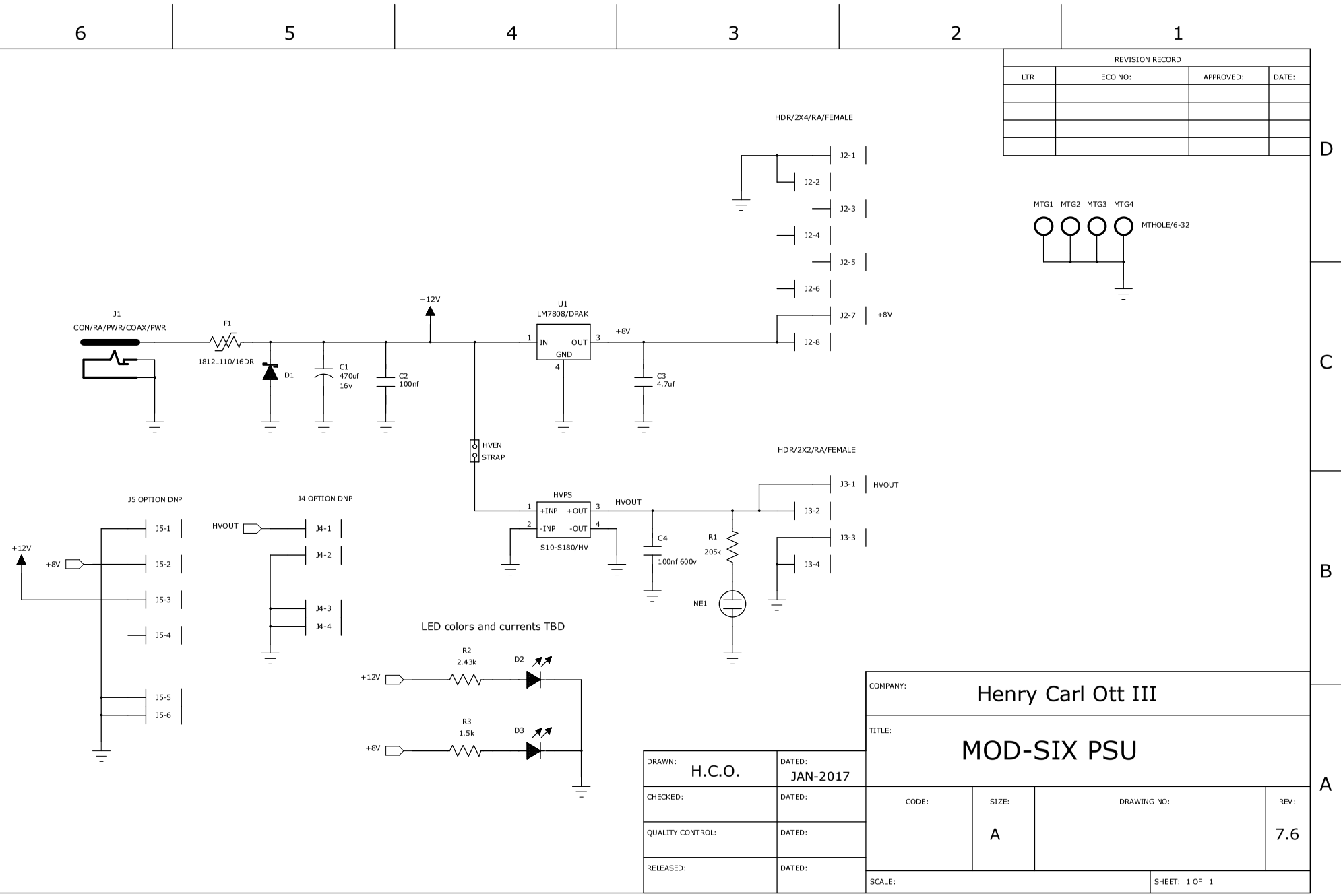
CPU-7.6
ISP
RF1
BATT1
MOD-SIX
SERIAL NO.
Y1
HV
TDU 1.0
NIXIE2
NIXIE1
NE1
NE2
HVEN
HVPS
PSU 7.6
12V
8V
MOD-SIX_7971



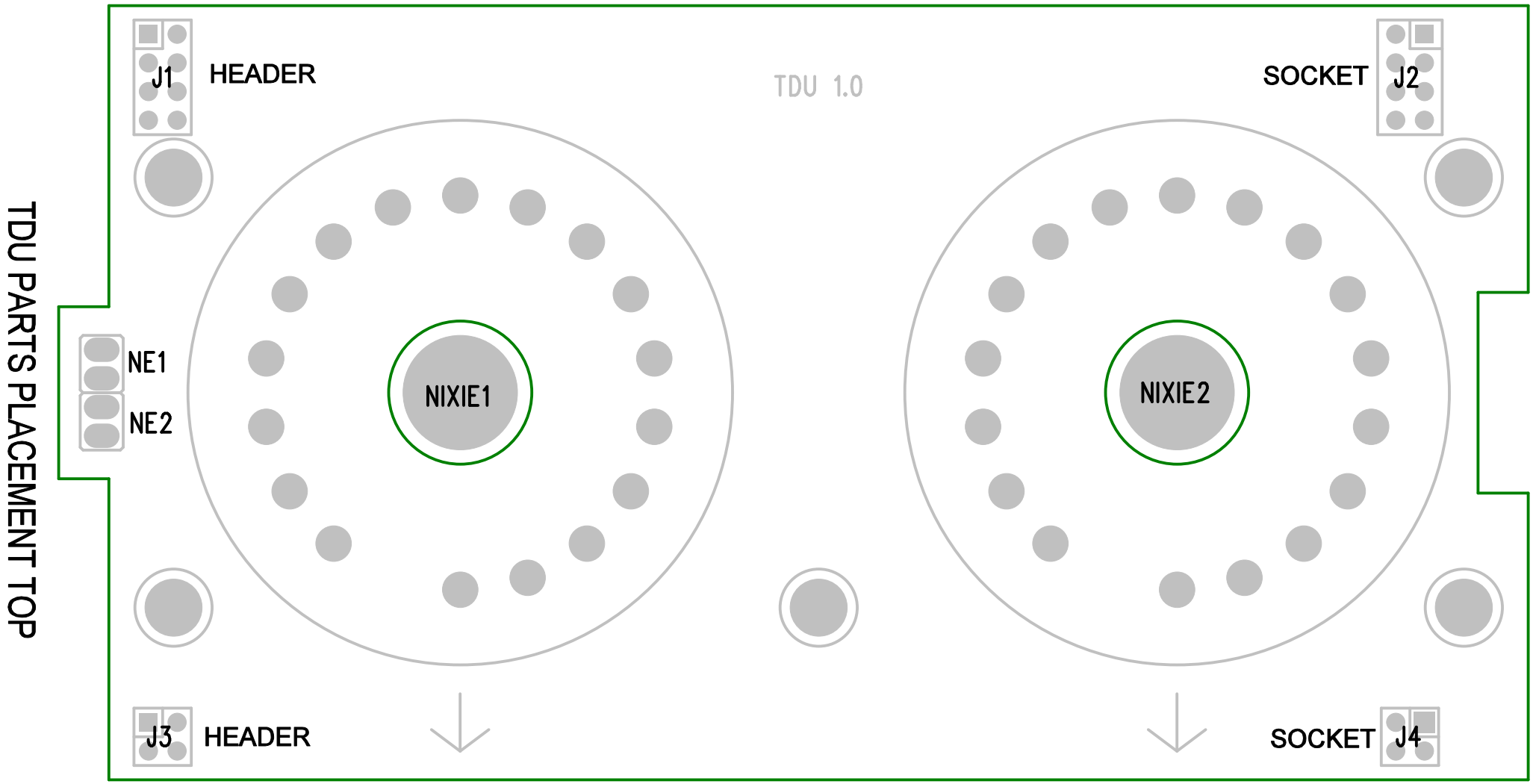
PSU PARTS PLACEMENT TOP

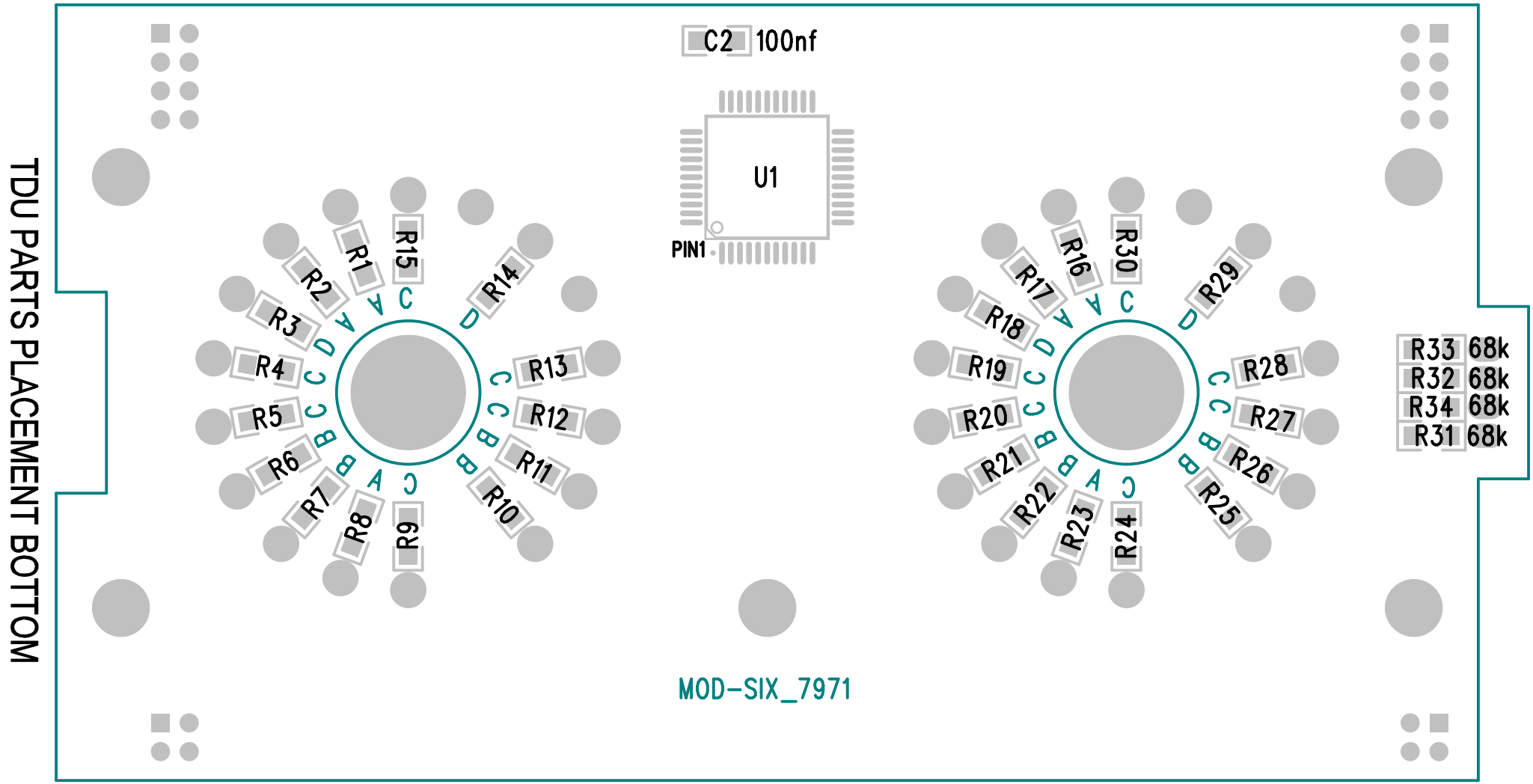


PSU PARTS PLACEMENT BOTTOM


6
5
4
3
2
1
A
B
C
D
REVISION RECORD
LTR
ECO NO:
APPROVED:
DATE:
HDR/2X4/RA/FEMALE
J2-1
J2-2
J2-3
J2-4
J2-5
J2-6
J2-7
J2-8
+8V
MTG1
MTG2
MTG3
MTG4
MTHOLE/6-32
J1
CON/RA/PWR/COAX/PWR
F1
1812L110/16DR
D1
C1
470uf
16v
C2
100nf
+12V
U1
LM7808/DPAK
IN
OUT
GND
C3
4.7uf
HVEN
STRAP
HDR/2X2/RA/FEMALE
J3-1
J3-2
J3-3
J3-4
HVOUT
HVPS
+INP
-INP
+OUT
-OUT
S10-S180/HV
C4
100nf 600v
R1
205k
NE1
J5 OPTION DNP
J5-1
J5-2
J5-3
J5-4
J5-5
J5-6
J4 OPTION DNP
J4-1
J4-2
J4-3
J4-4
LED colors and currents TBD
R2
2.43k
D2
R3
1.5k
D3
DRAWN:
H.C.O.
DATED:
JAN-2017
CHECKED:
QUALITY CONTROL:
RELEASED:
COMPANY:
Henry Carl Ott III
TITLE:
MOD-SIX PSU
CODE:
SIZE:
A
DRAWING NO:
REV:
7.6
SCALE:
SHEET: 1 OF 1

MOD-SIX PSU 7.6 BOM								
Item #	Qty	Ref.	VALUE	Part Name	Desription	Mfg.	Mfg. Part Number	Note
1	1	C1	470uf	CAP/RAD/3.5MM/8MM	CAP RAD 2.5mm/8mm	Generic		Bulk Decouple.
2	1	C2	100nf	CAP/SMD/1206	CAP SMD 1206	Generic		
3	1	C3	4.7uf	CAP/SMD/1206	CAP SMD 1206	Generic		
4	1	C4	100nf 600v	CAP/SMD/1812	CAP SMD 1812	Generic		
5	1	J1		CON/RA/PWR/COAX/PWR	COAXIAL POWER JACK 2.0MM	CUI STACK	PJ-102A	Tapered pins (not slots)
6	1	J4		SMD/2MM/2POS/JST/S2B-PH-SM4-TB	CONN HEADER PH 2POS 2MM SMD	JST	S2B-PH-SM4-TB	Do not place.
7	1	J5		SMD/2MM/4POS/JST/S4B-PH-SM4-TB	CONN HEADER PH 4POS 2MM SMD	JST	S4B-PH-SM4-TB	Do not place.
8	1	D1	40V 3A	DIODE\SHOT\SMC\30BQ040	Diode 3A 40V	Vishay	30BQ040	Reverse polarity protection
9	1	F1	1.5 AMP	FUSE\POLY\SMD\1812	PTC Resettable Fuse	Littlefuse		1.95 Trip
10	1	HVEN		HDR/100/1X2/STRAP/POL	1X2 .100 HEADER W/STRAP	Generic		
11	1	J3		HDR/2X2/RA/FEMALE	2X2 .100 RA FEMALE HEADER	Sullins	PPPC022LJBN-RC	
12	1	J2		HDR/2X4/RA/FEMALE	2X4 .100 RA FEMALE HEADER	Sullins	PPPC042LJBN-RC	
13	2	D2-3		LED/SMD/OSRAM/T670	LED SMD PLCC-2	OSRAM		
14	1	U1		LM7808/DPAK	VOLTAGE REGULATOR	Fixed 8V		
15	1	NE1		NEON	Neon Bulb Small	Generic		
16	1	R1	205k	RES\SMD\1206	RES SMD 1206	Generic		
17	1	R2	2.43k	RES\SMD\1206	RES SMD 1206	Generic		
18	1	R3	1.5k	RES\SMD\1206	RES SMD 1206	Generic		
19	1	HVPS		S10-S180/HV	HV SMPS 180V 10watt	American Power Design	S10-S180	
20	1	PCB	V7.6		PCB-PSU		7.6	


TDU PARTS PLACEMENT TOP
J1
HEADER
TDU 1.0
SOCKET
J2
NE1
NE2
NIXIE1
NIXIE2
J3
HEADER
SOCKET
J4



RA=22k RB=24k RC=27k RD=33k

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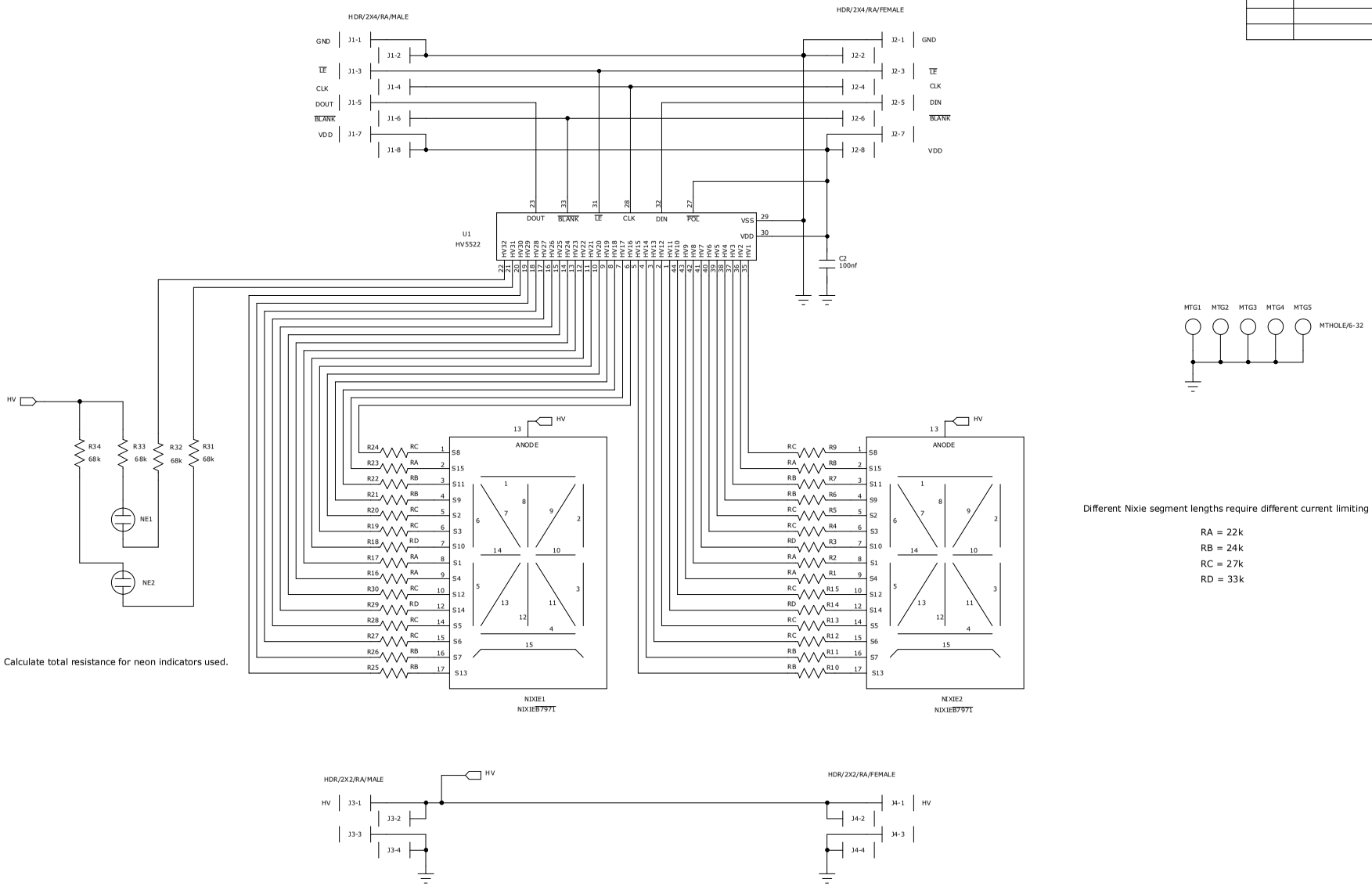


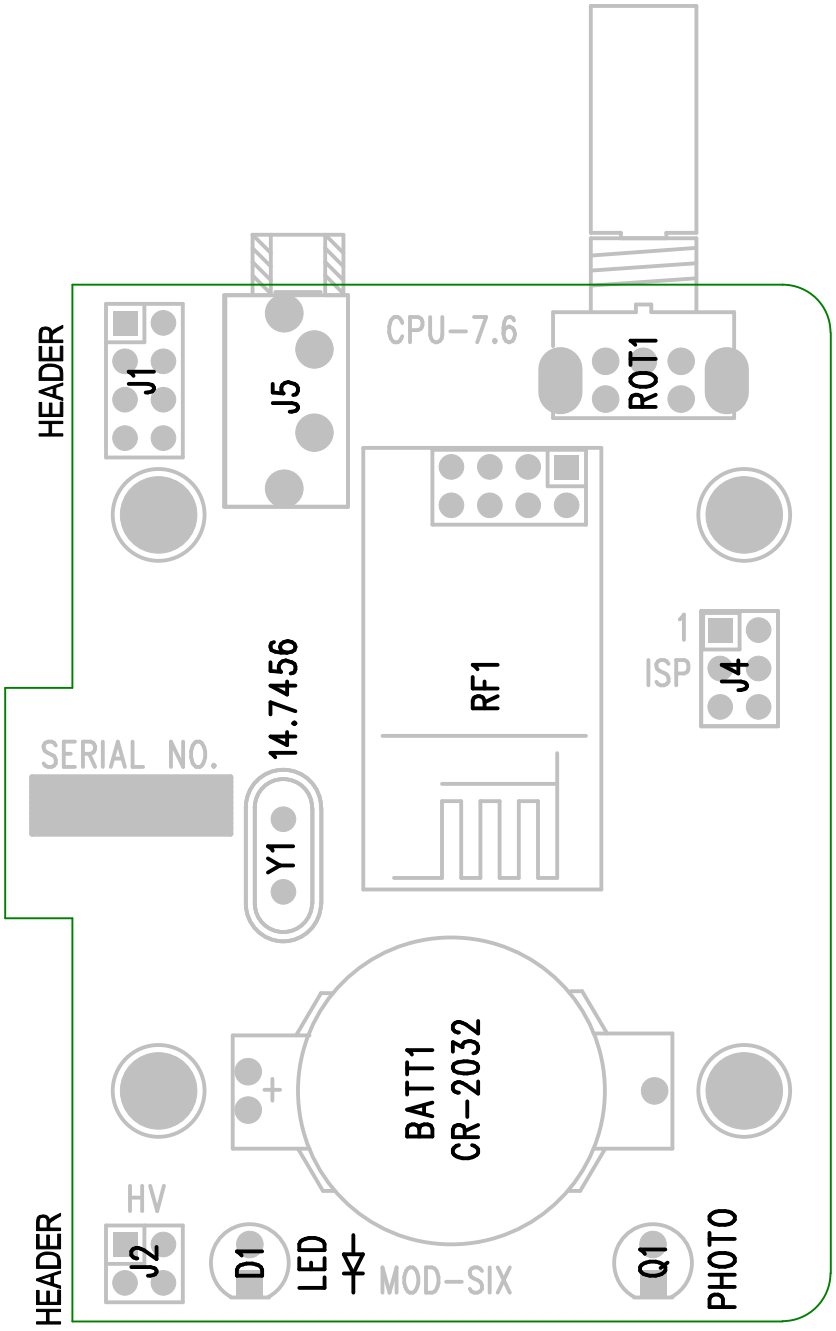
Calculate total resistance for neon indicators used.

Different Nixie segment lengths require different current limiting resistors.

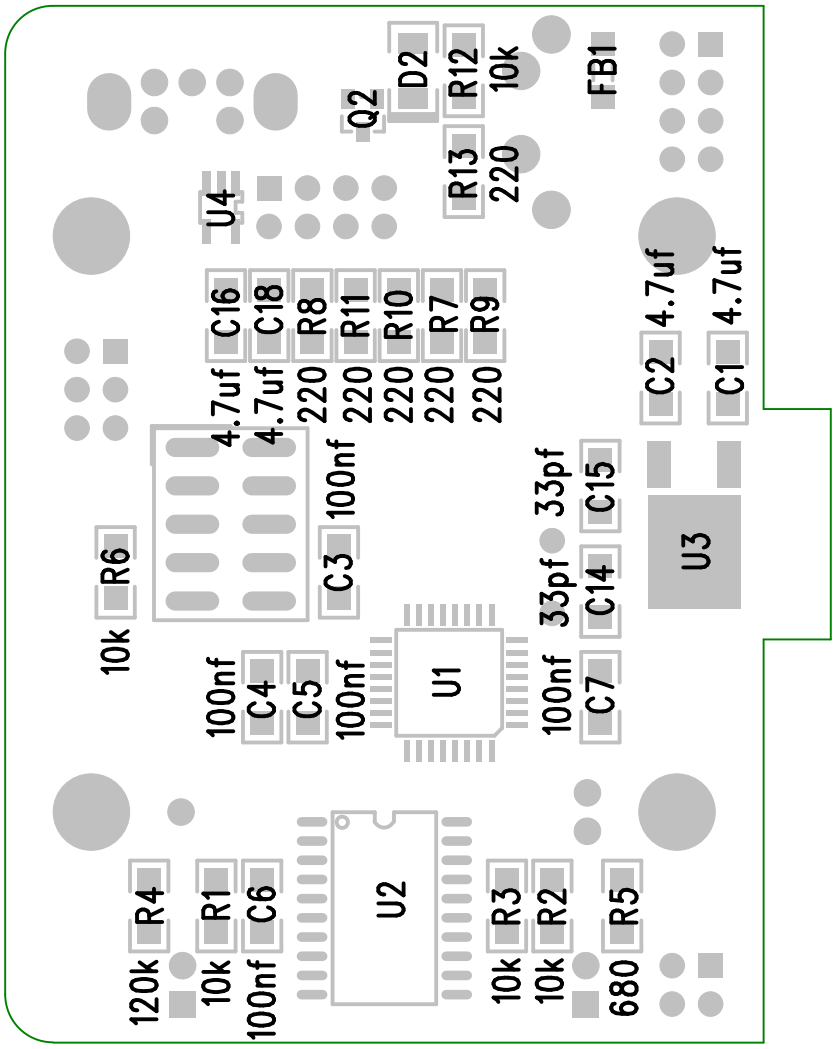
RA = 22k
RB = 24k
RC = 27k
RD = 33k

DRAWN: H.C.O.	DATED: MAR-2011	COMPANY: Henry Carl Ott III	
CHECKED:	DATED:	TITLE: MOD-6_7971 TDU	
QUALITY CONTROL:	DATED:	CODE:	SIZE: C / DRAWING NO: / REV: 1.0
RELEASED:	DATED:	SCALE:	SHEET: 1 OF 1

MOD-SIX TDU 1.0 BOM								
Item #	Qty	Ref.	VALUE	Part Name	Description	Mfg.	Mfg. part Number	Note
1	1	C2	100nf	CAP\SMD\1206	SMD Capacitor 1206	Generic		
2	1	J4		HDR\2X2\RA\FEMALE	2X2 .100 RA FEMALE HEADER	Sullins	PPPC022LJBN-RC	
3	1	J3		HDR\2X2\RA\MALE	2X2 .100 RA MALE HEADER		68021-204HLF	
4	1	J2		HDR\2X4\RA\FEMALE	2X4 .100 RA FEMALE HEADER	Sullins	PPPC042LJBN-RC	
5	1	J1		HDR\2X4\RA\MALE	2X4 .100 RA MALE HEADER		68021-208HLF	
6	1	U1		HV5522	32-Channel HV Shift Register	Supertex	HV5522PG-G	Can substitute higher voltage HV5530PG
8	1	NE1		NEON\UPRIGHT\MINI	Small Neon Bulb NE-2 6X15			See project documentation for mounting options.
9	1	NE2		NEON\UPRIGHT\MINI	Small Neon Bulb NE-2 6X12			See project documentation for mounting options.
10	34	NIXIE1-2		NIXIE\B7971	Nixie Tube (why we are here)	Burroughs	B7971	Milmax 0327-0-15-01-34-27-10-0, 0327-0-15-01-34-27-10-0
11	6	R1-2 R8 R16-17 R23	RA	RES\SMD\1206	RES SMD 1206	Generic	Nominal 22k	See schematic for value.
12	8	R7 R10-11 R21-22 R6 R25-26	RB	RES\SMD\1206	RES SMD 1206	Generic	Nominal 24k	See schematic for value.
13	12	R15 R4-5 R19-20 R9 R12 R24 R13 R27-28 R30	RC	RES\SMD\1206	RES SMD 1206	Generic	Nominal 27k	See schematic for value.
14	4	R18 R3 R29 R14	RD	RES\SMD\1206	RES SMD 1206	Generic	Nominal 33k	See schematic for value.
15	4	R31-34	68k	RES\SMD\1206	RES SMD 1206	Generic		
16	1	PCB	V1.0	NA	PCB-TDU			



CPU PARTS PLACEMENT TOP

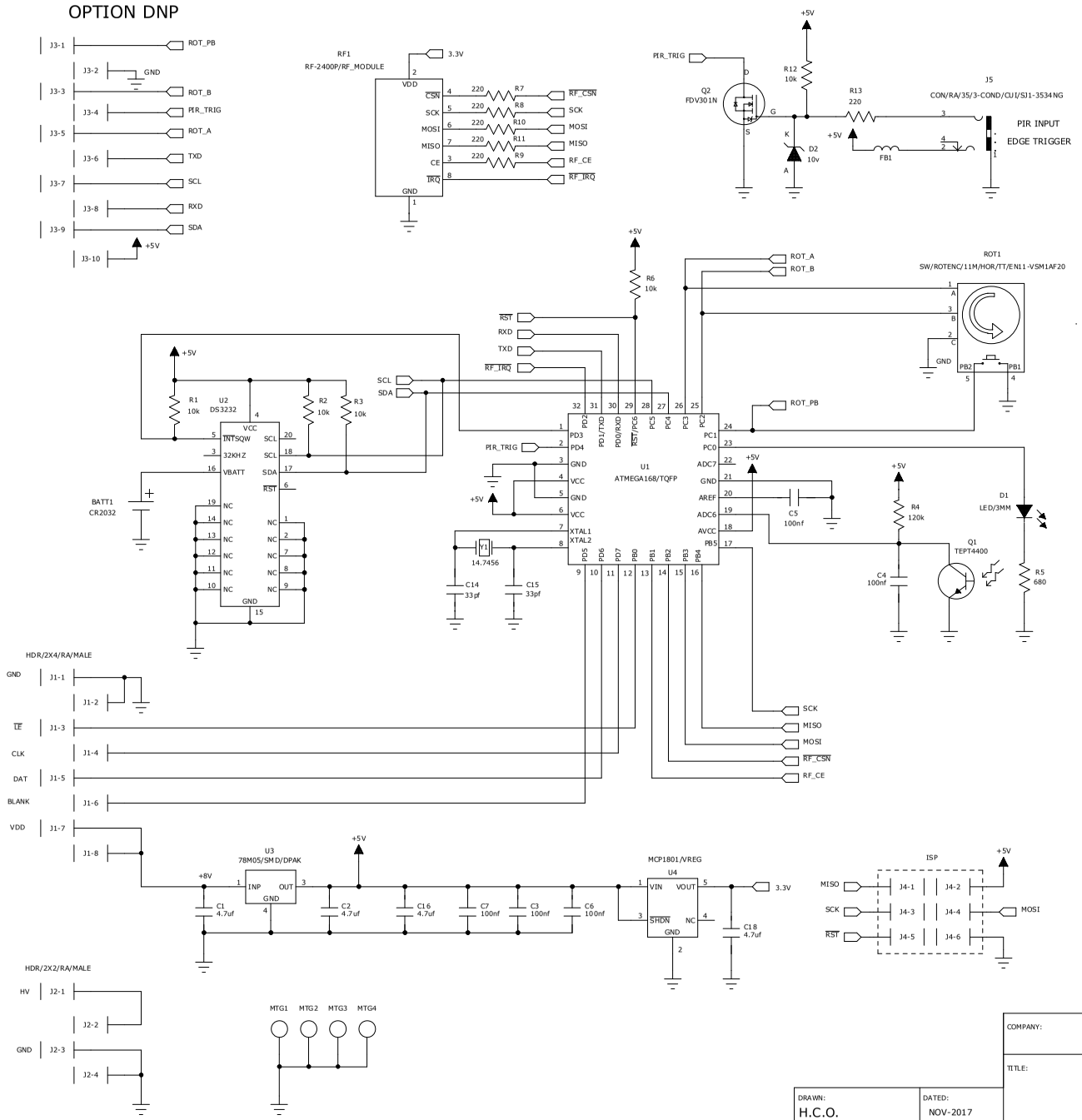


CPU PARTS PLACEMENT BOTTOM

REVISION RECORD			
LTR	ECO NO:	APPROVED:	DATE:

ASSEMBLY NOTES:

1. Q1 Longer lead is emiter.
2. D1 Longer lead is anode.
3. RF1 Place 2x4 header.
4. ROT1 bushing hardware not used.



DRAWN: H.C.O.	DATED: NOV-2017	COMPANY: Henry Carl Ott III	
CHECKED:	DATED:	TITLE: MOD-SIX CPU	
QUALITY CONTROL:	DATED:	CODE:	SIZE: C
RELEASED:	DATED:	DRAWING NO:	REV: 7.6
		SCALE: N.A.	SHEET: 1 OF 1

MOD-SIX CPU 7.6 BOM								
Item #	Qty	Ref.	VALUE	Part Name	Desription	Mfg.	Mfg. Part Number	Note
1	1	U3	5v	78M05/SMD/DPAK	5 VOLT REG SMD DPAK	Generic		
2	1	U1	MCU	ATMEGA168/TQFP	Microcontroller	Atmel	ATmega168-20AU	TQFP
3	1	BATT1	CR2032	BATT/COIN/20MM/RENATA/HU-2032-1	CR2032 BATTERY HOLDER	Renata	HU2032-LF	
4	4	C1-2 C16 C18	4.7uf	CAP/SMD/1206	CAP SMD 1206	Generic		
5	5	C5-7 C3-4	100nf	CAP/SMD/1206	CAP SMD 1206	Generic		
6	2	C14-15	33pf	CAP/SMD/1206	CAP SMD 1206	Generic		
7	1	J5		CON/RA/35/3-COND/CUI/SJ1-3534NG	3.5 MM TRS JACK	CUI STACK	SJ1-3534NG	
8	1	D2	10v	DIODE/ZENER/MELF	DIODE ZENER SMD MELF	Generic		
9	1	U2	RTC	DS3232	RTC W/TCXO 20-SOIC	MAXIM	DS3232	
10	1	FB1		FB1206	FERRITE BEAD 1206	Generic		
11	1	Q2		FDV301N	Digital FET N-Channel	Fairchild	FDV301N	
12	1	J4		HDR/100/2X3	2x3 .100 MALE HEADER	Generic		ISP
13	1	J3		HDR/100/2X5/SMD	HEADER SMD .100 2x5	Generic		Do Not Place
14	1	J2		HDR/2X2/RA/MALE	2x2 .100 RA MALE HEADER	FCI	68021-204HLF	
15	1	J1		HDR/2X4/RA/MALE	2x4 .100 RA MALE HEADER	FCI	68021-208HLF	
16	1	D1	GREEN	LED/3MM	LIGHT EMITTING DIODE 3mm	Generic		Longer Lead = Anode
17	1	U4		MCP1801/VREG	3.3V LDO SOT23-5	Microchip	MCP1801T-3302I/OT	May substitute TOKO part.
18	1	Q1		PHOTO-TRANS\ROHM\RPT-311PTA49	Photo Transistor 3mm	ROHM	TEPT4400	Longer Lead = Emitter
19	5	R1-3 R6 R12	10k	RES\SMD\1206	RES SMD 1206	Generic		
20	1	R4	120k	RES\SMD\1206	RES SMD 1206	Generic		
21	6	R7-11 R13	220	RES\SMD\1206	RES SMD 1206	Generic		
22	1	R5	680	RES\SMD\1206	RES SMD 1206	Generic		
23	1	RF1		RF-2400P/RF_MODULE	NRF24L01P 2.4GHZ RF Module	VARIOUS	MOD-NRF24L01	Populate PCB with 2x4 header
24	1	ROT1		ROTENC/11M/HOR/TT/EN11-VSM1AF20	ROTARY ENCODER RA W/SWITCH	TT Electronics/BI	EN11-VSM1AF20	
25	1	Y1	14.7456MHZ	XTAL_HC-49US	Quartz Crystal HC49/US PKG	ABRACON	ABL-14.7456MHZ-B2	18pf
26	1	KNOB		NA	Knob for rotary encoder	KILO	OEDA-50-2-5	
27	1	PCB	V7.6	NA	PCB-CPU			