

MOD-SIX_7971 GEN-II V8 Clock assembly notes.

Version 2.4 AUG-2015, HCO.

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Revision list.

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 special attention to **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. 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 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 - Cental Processing Unit.

Contains microprocessor and battery backed Real Time Clock functions.

Supports the GPS wired and wireless RF-LINK circuitry.

RPTR - Standalone GPS repeater unit.

Receives RS232 NMEA messages from SIRF-III compatible GPS receiver and retransmits a synchronized time beacon to the MOD-SIX clock via 2.4 ghz digital radio link. Also reads and broadcasts ambient temperature information.

Some General Notes:

Some extra and possibly alternate components are included in the kits. 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**, then the **CPU** before proceeding onto constructing the **TDU** boards.

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.

You can then assemble a single 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:

After installing J4, insert the included strap between pins 3&4 on the header to disable the HV module's output.

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

Change the strap at J4 to enable the HV module and adjust trim pot VR1 to set the HV output to approx 180 volts as measured at J3. Please use caution around any **High Voltages**.

NOTE, the **High Voltage** output **WILL** be enabled if no strap is installed (the enable pin is left floating) The Neon lamp NE1 is installed as an HV live indicator, but will only illuminate if the HV is above approximately 90volts.

U1 - LM7808 T0-220 voltage regulator. 4-40 hardware is included, but a heat sink is not required.

TDU specific notes:

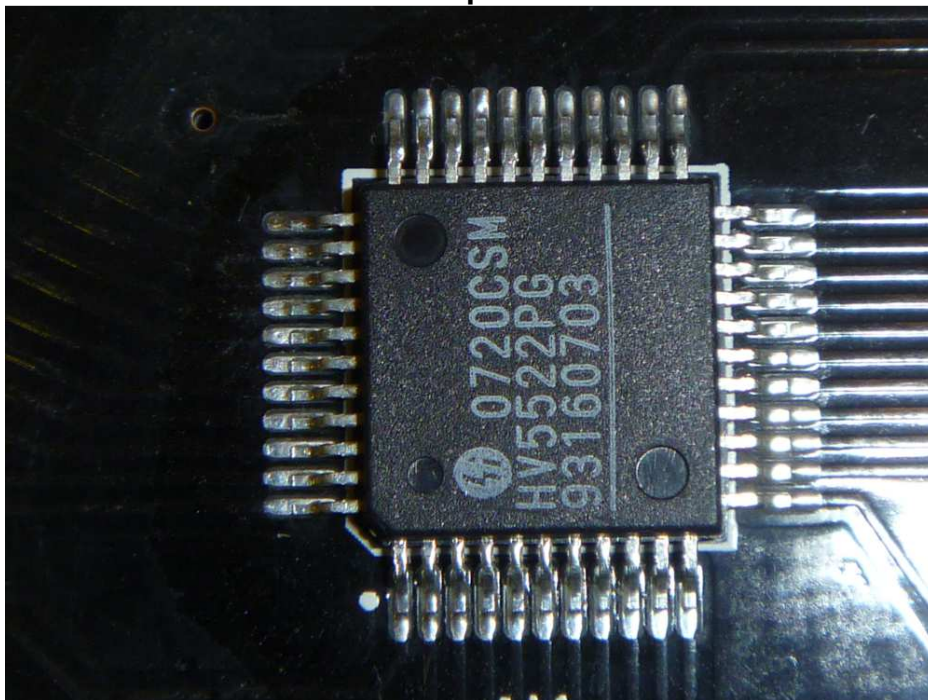
NOTE: If you wish to have the mill-max pins raised above the PCB it is **VERY** important to solder the pins in before any other components.

Please see the separate document provided for detailed instructions on installing the Nixie tube socket pins and constructing the copper neon colon & AM/PM towers.

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 “ABCD” designators on the TDU PCB silkscreen correspond to the 4 different cathode resistor values for the B7971 tubes. Different length cathodes 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 resistor 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.

J3 - GPS Mini-Din. **NOTE** This connector is mounted on the **BOTTOM** side of the pcb! Please install the GPS connector **BEFORE** the RF-MODULE. For custom builds the connector could possibly be top mounted, but the GPS signal and power pins would be moved, and the connector would physically interfere with the RF-MODULE's normal placement.

RF1 - 2.4ghz RF-MODULE. The module is normally installed raised slightly off of the PCB to provide additional clearance for the module's antenna and to improve reception. **NOTE** The RF module should be installed **After** the GPS connector J3. Otherwise it may be difficult or even impossible to solder the GPS connector.

Some kit builders have reported difficulty getting a good solder connection on the plating used on some of the supplied module's header. Additional heating time or the use of some solder flux will help to get a good clean solder joint.

The RF module is only used in conjunction with the RF-LINK option. Depending on how you've decided to configure your clock, you may install the RF-MODULE, the wired GPS MINI-DIN connector, both, or neither. The clock firmware supports all configurations, but only one option may be active at a time.

J4 – ISP. Used to reprogram / upgrade the firmware of the AVR ATMEGA168 MCU. External compatible AVR programming hardware is required.

J5 – EXP. Optional expansion header. For future features. (1PPS output / PIR sensor input)

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

U4 - Voltage regulator TK71734. SOT23-5 package. Take care to properly orient pin 1.

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 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.

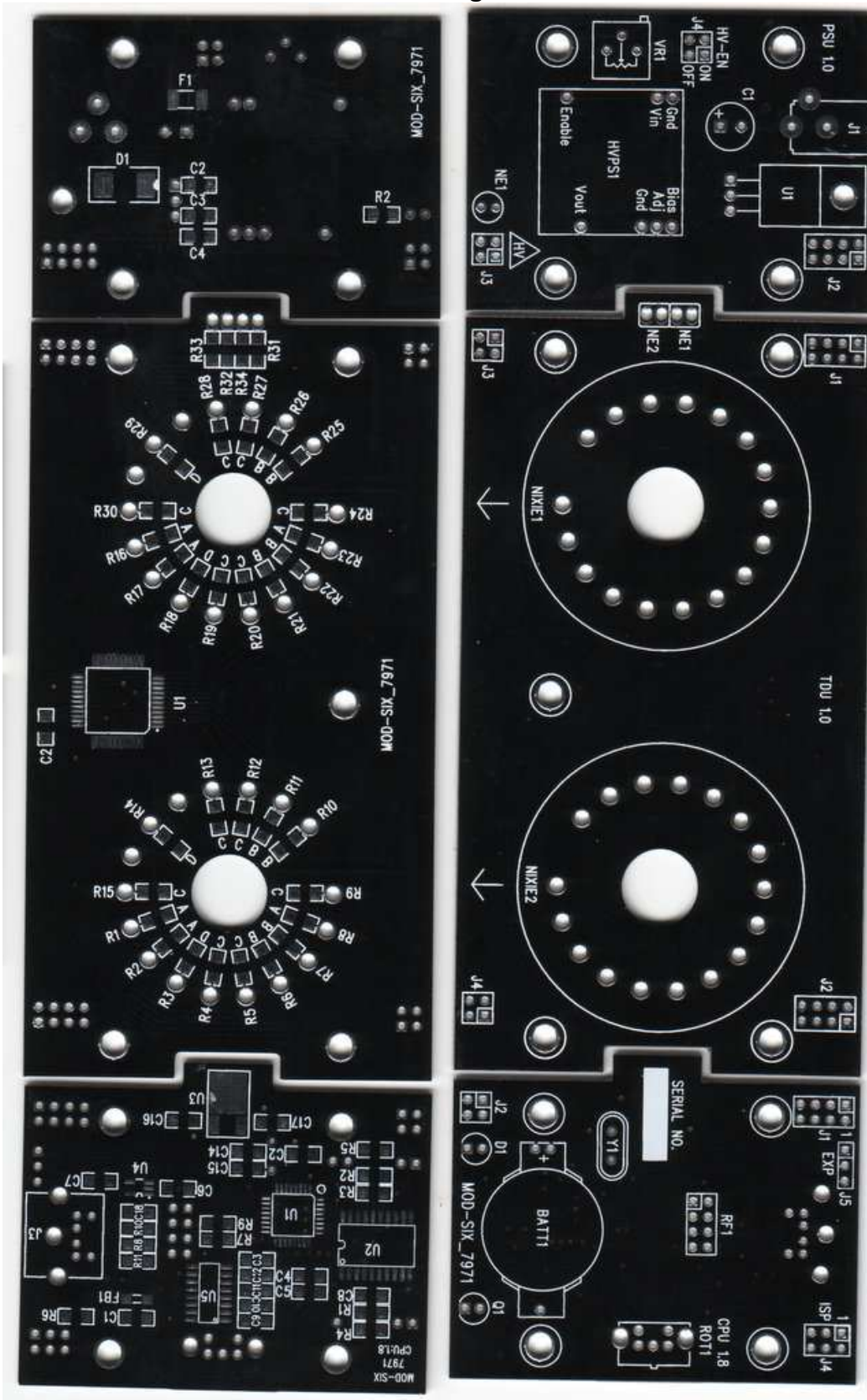
If the rotary encoder is depressed and held while power is applied to the clock, a tube segment bit test pattern will be displayed on the Nixie tubes. It will run continuously until the power is

cycled. You can use this to test, and help find possible soldering issues on the **TDU** boards.

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**.

PCB Images:



MOD-SIX PSU TDU CPU

6

5

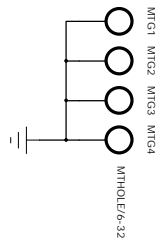
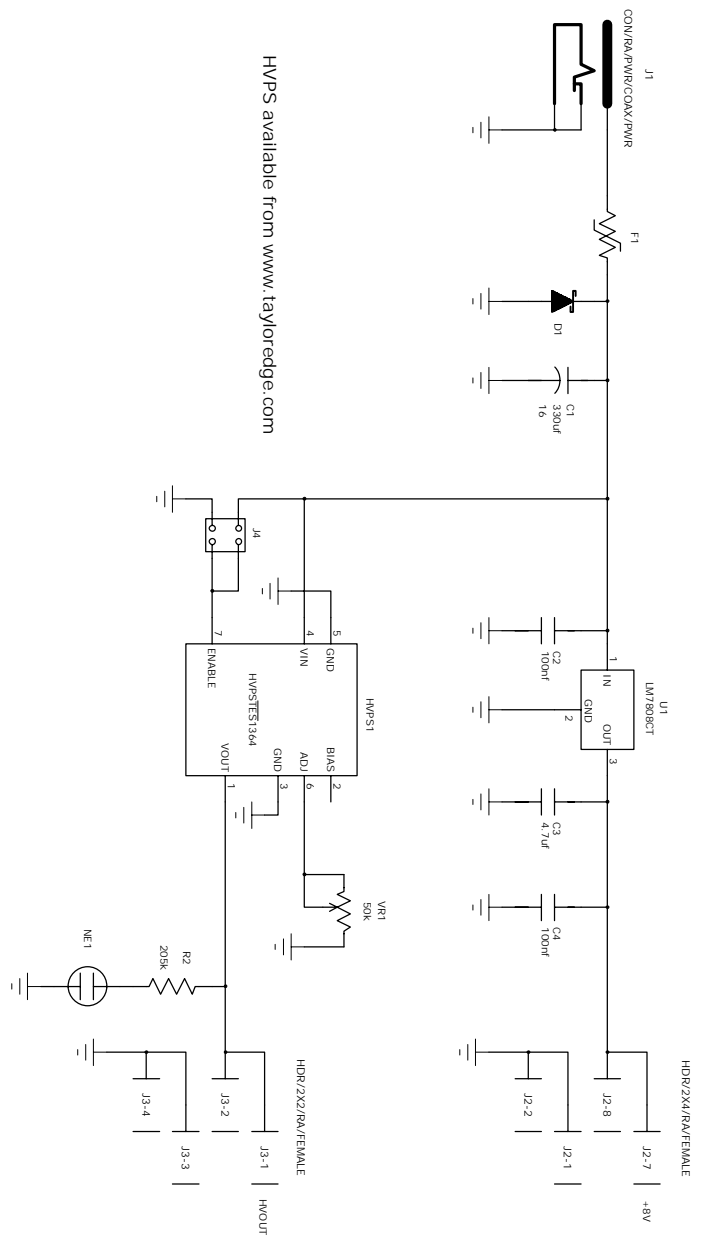
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3

2

1

REVISION RECORD			
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COMPANY: Henry Carl Ott III

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DRAWN: H.C.O.	DATED: MAR-2011
CHECKED:	DATED:
QUALITY CONTROL:	DATED:
RELEASED:	DATED:

CODE:	SIZE: A	DRAWING NO.:	REV: 6.0
SCALE:	SHEET: 1 OF 1		

A

B

C

D

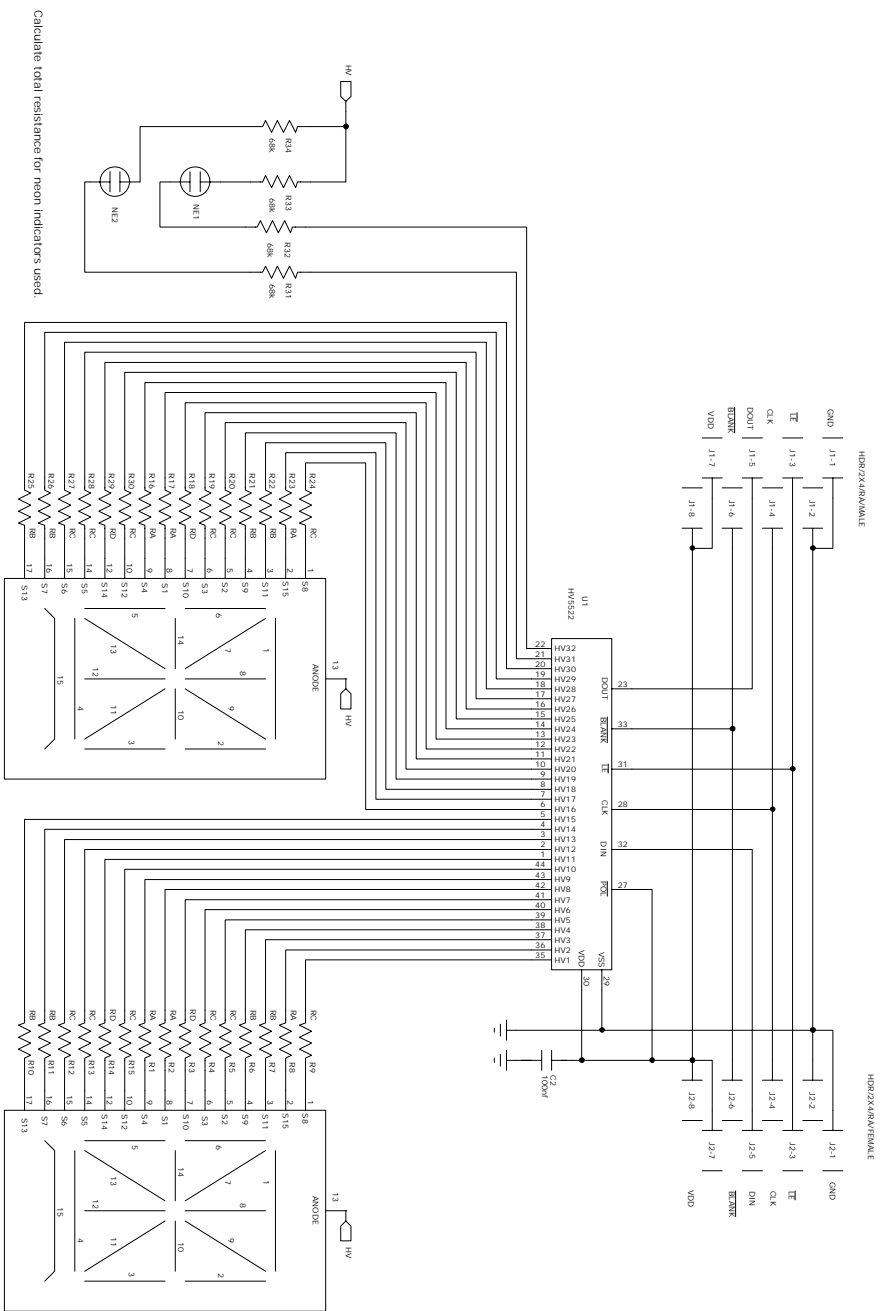
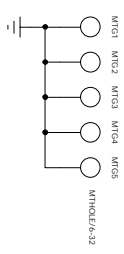
A

B

C

D

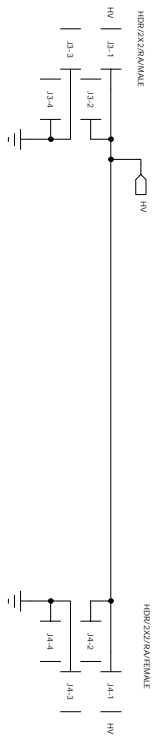
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Different Nike segment lengths require different current limiting resistors.

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

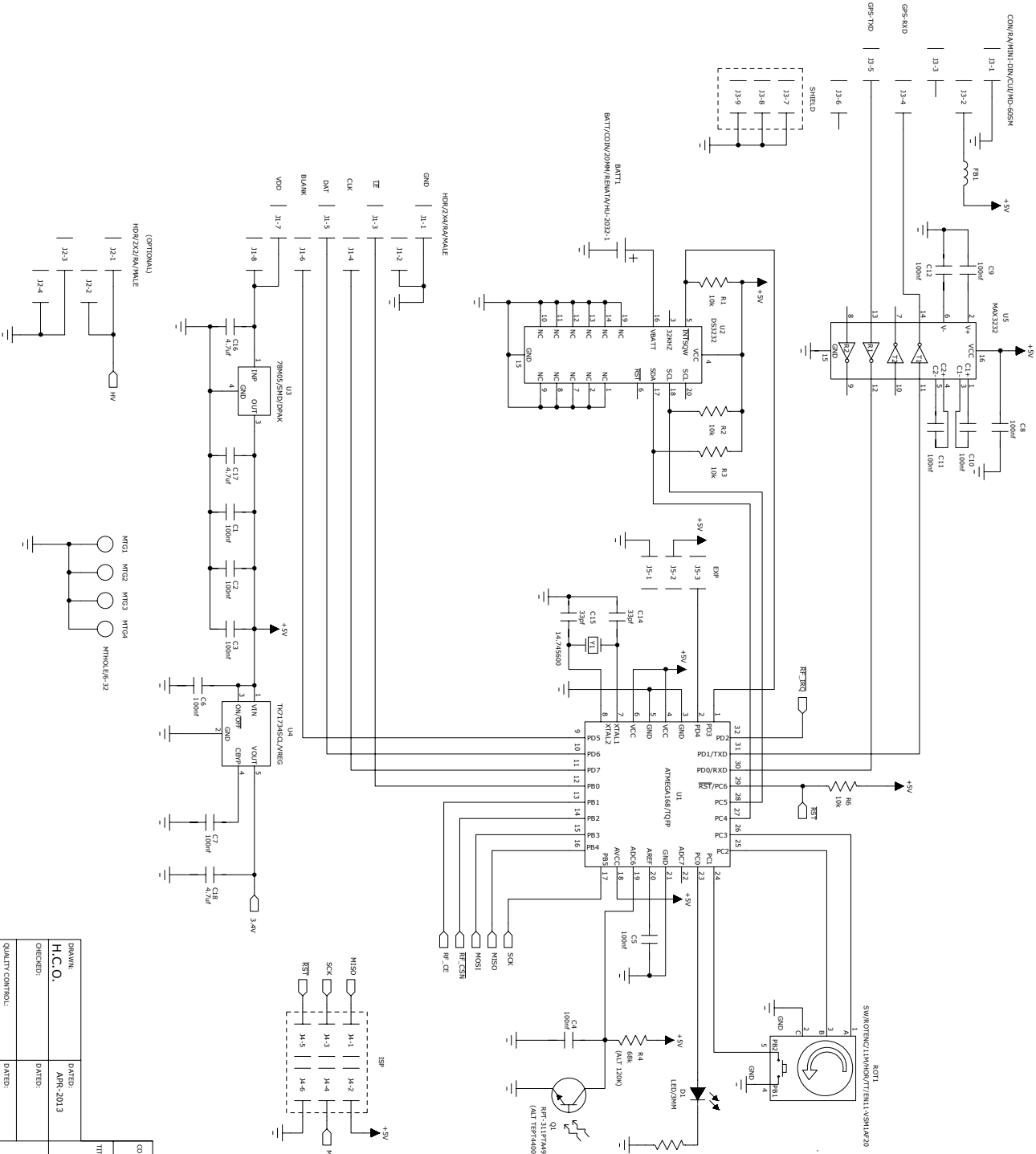
Calculate total resistance for neon indicators used



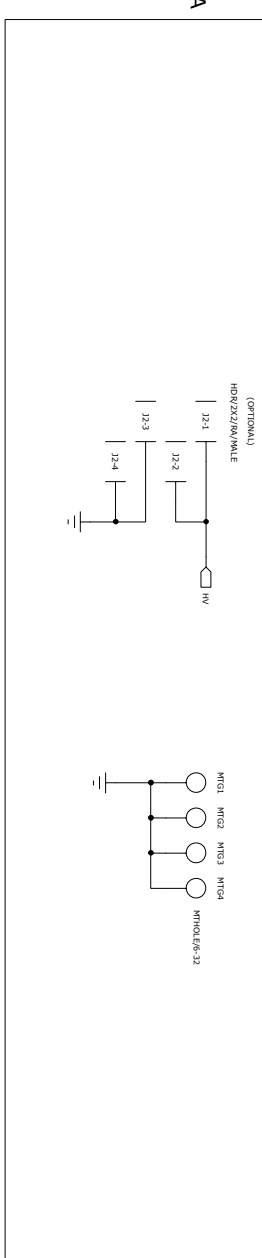
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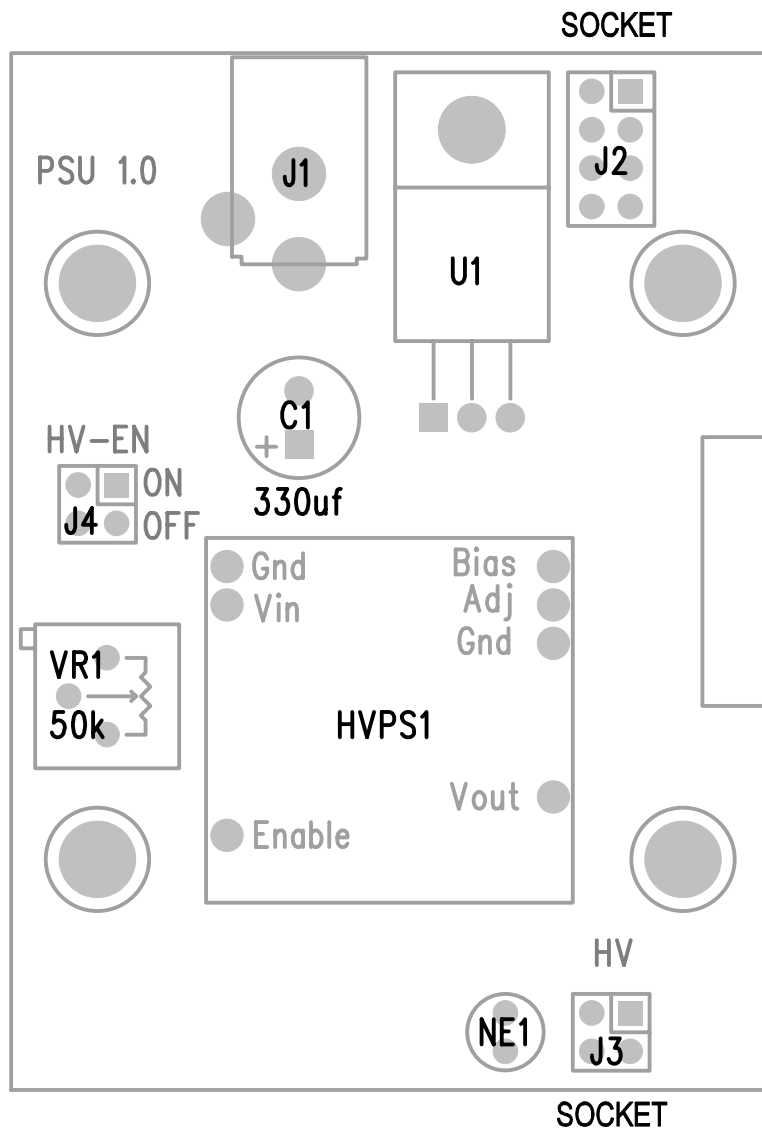
A B C D

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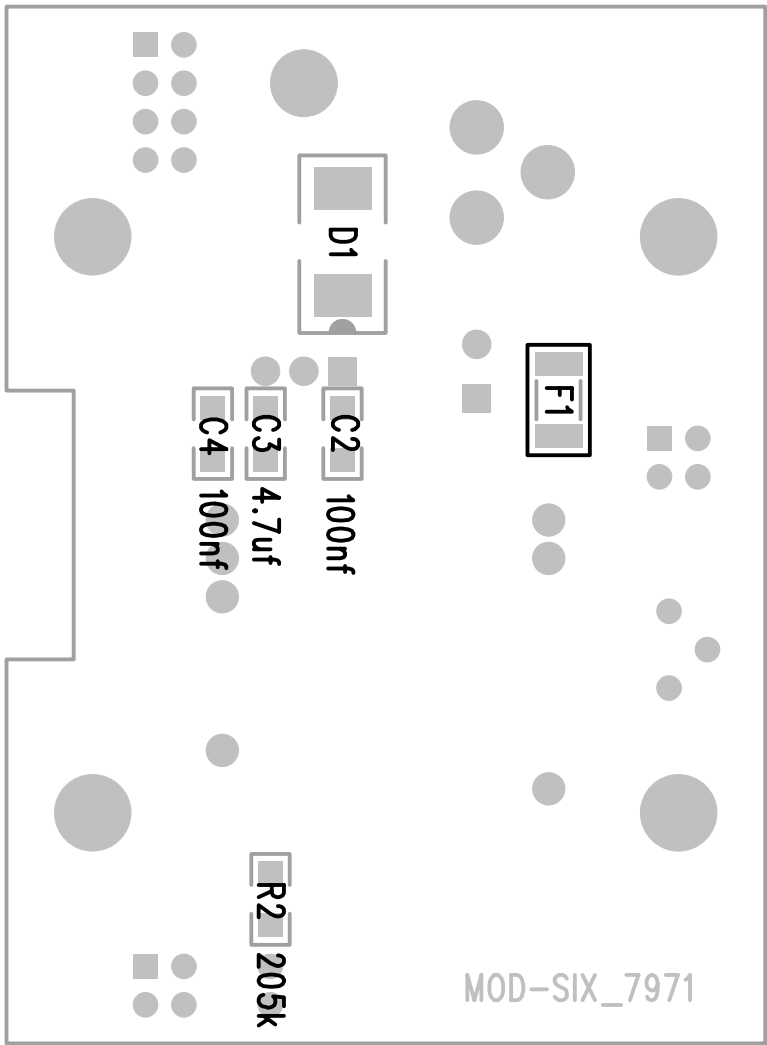


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CHECKED:		DATE:	
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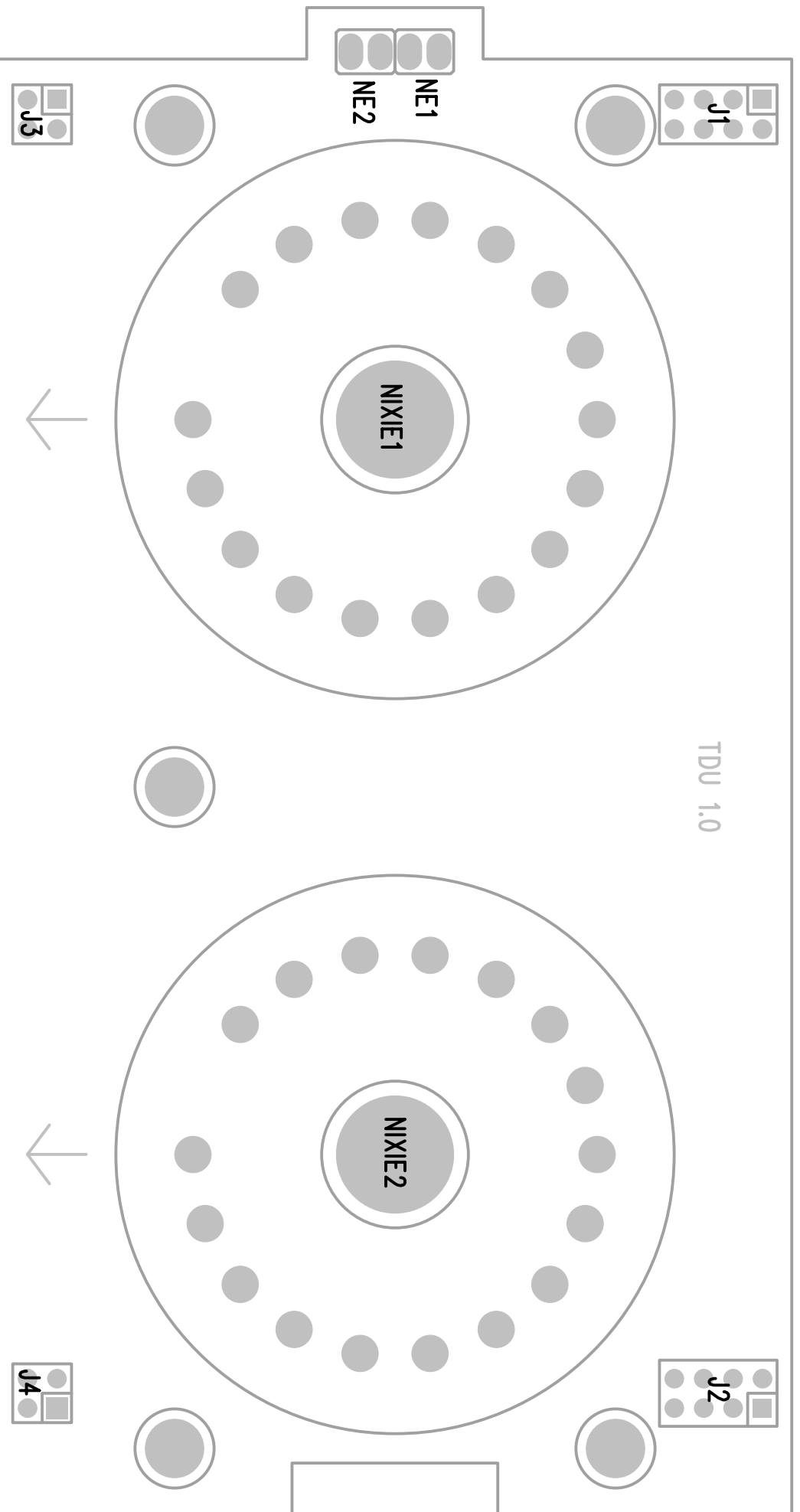




PSU PARTS PLACEMENT TOP



PSU PARTS PLACEMENT BOTTOM



HEADER

SOCKET

TDU 1.0

HEADER

SOCKET

TDU PARTS PLACEMENT TOP

NIXIE1

NIXIE2

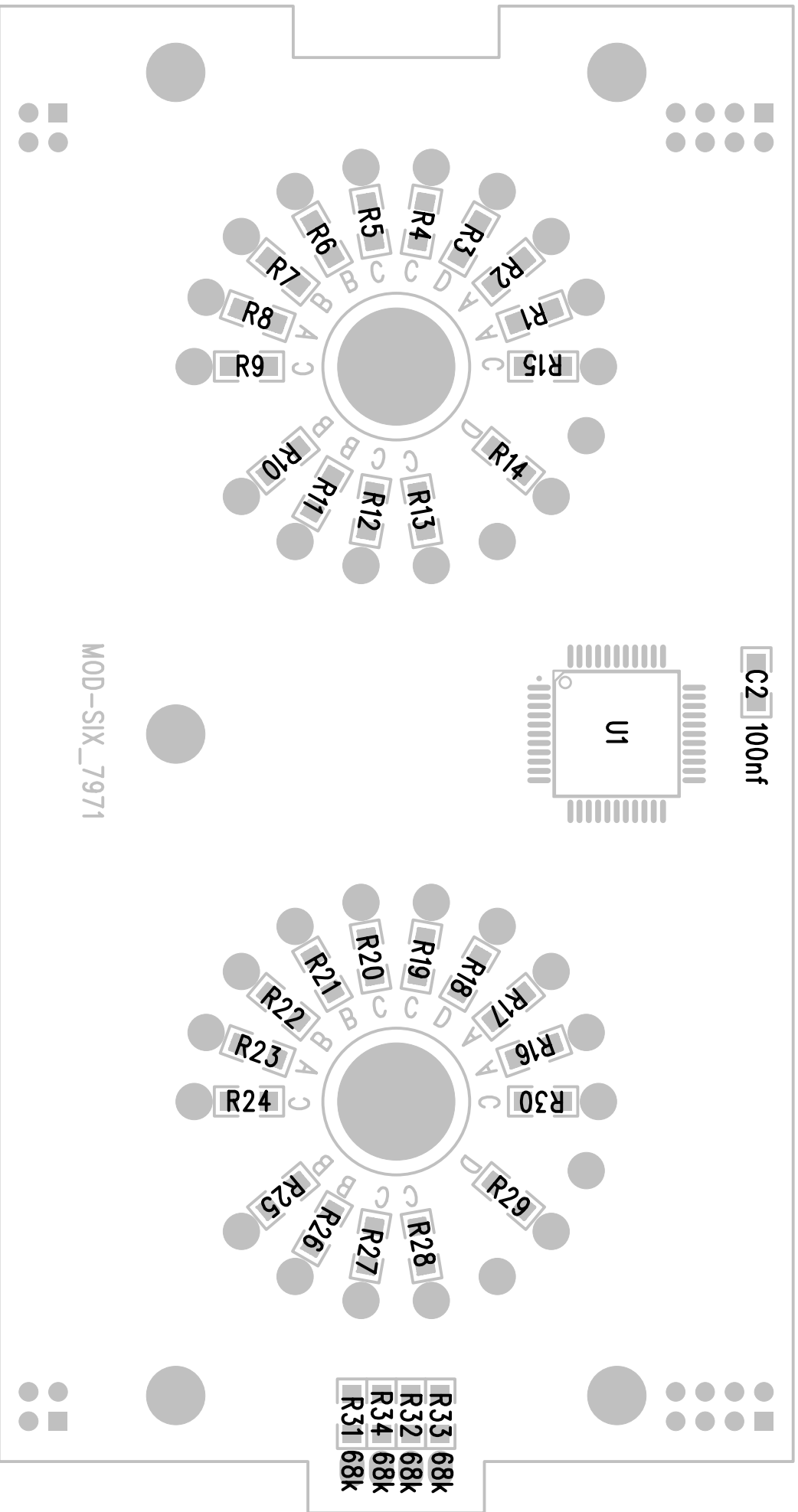
J1

J2

NE1

NE2

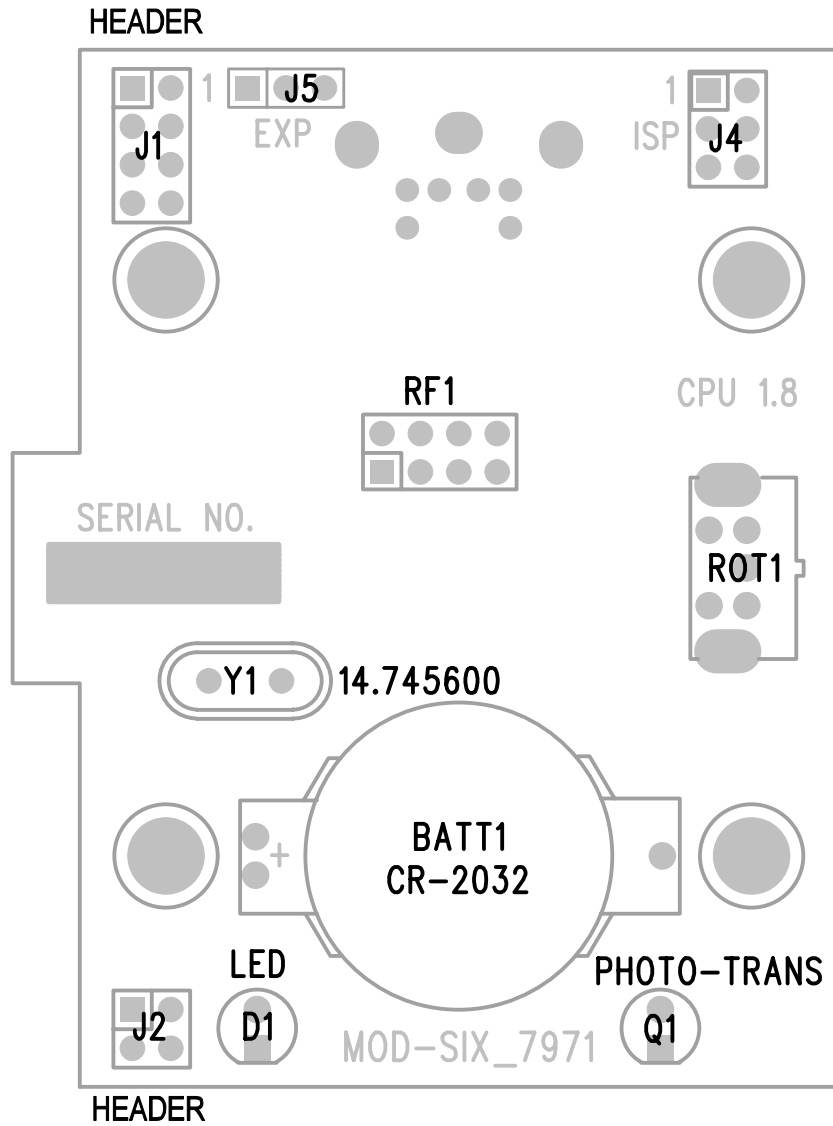




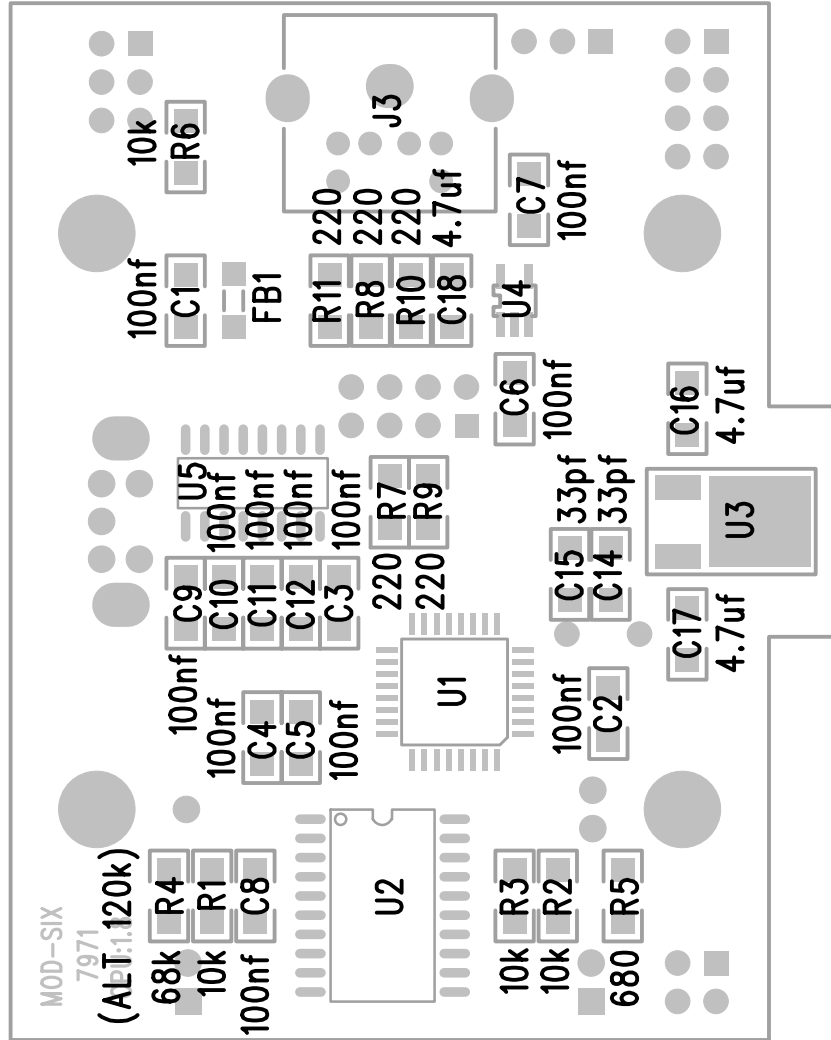
MOD-SIX_7971

TDU PARTS PLACEMENT BOTTOM

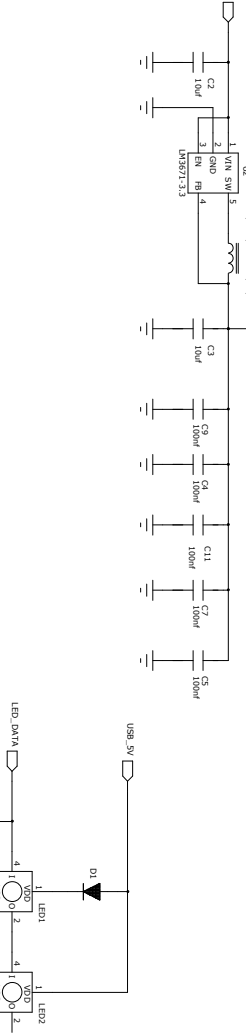
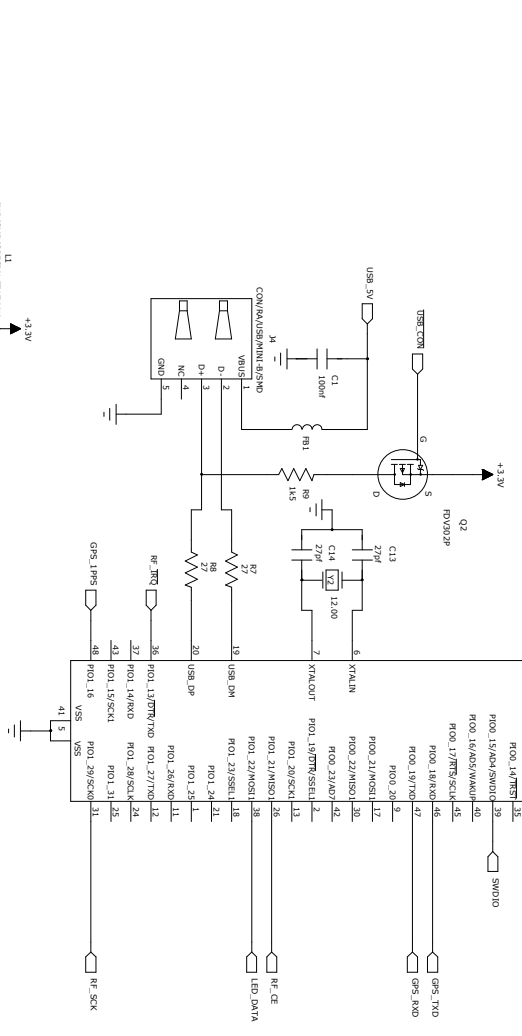
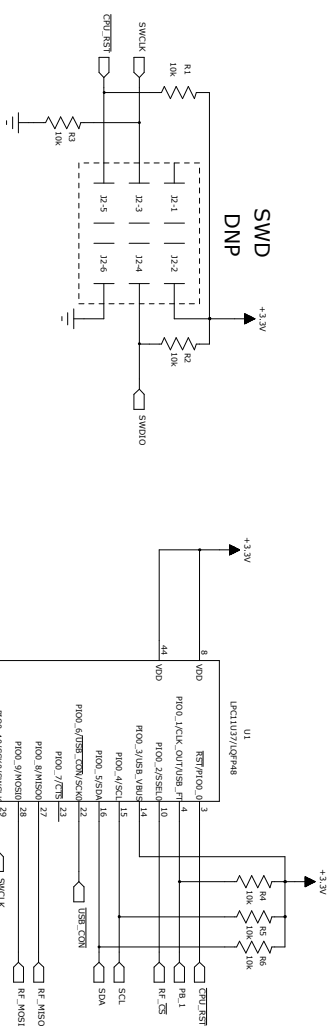
RA=22K RB=24K RC=27K RD=33K



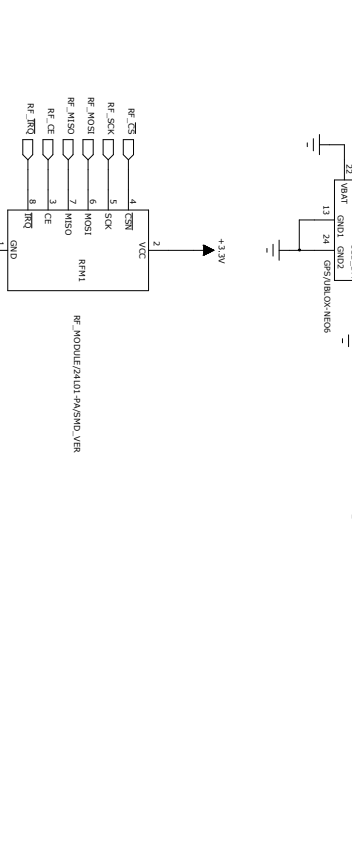
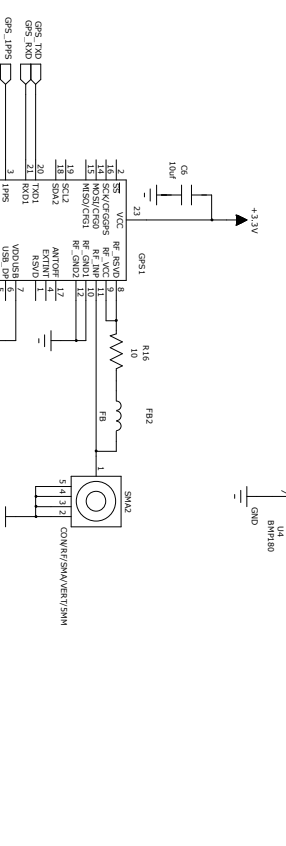
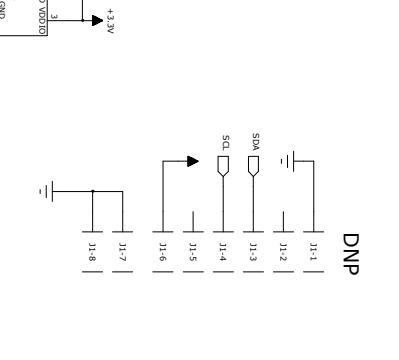
CPU PARTS PLACEMENT TOP



CPU PARTS PLACEMENT BOTTOM



REV.	DATE	APPROVED:	REVISION RECORD



REV.	DATE	APPROVED:	REVISION RECORD

COMPANY: Henry Carl Ott III

RPTR-NEX

REV.	DATE	APPROVED:	REVISION RECORD

DATE:	APR-2015
DATE:	
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SCALE:	1:1
SIZE:	
CODE:	
SHRINK:	
DATE:	
DATE:	
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Bill of Material

CPU PCB								
Item #	Qty	Ref.	VALUE	Part Name	Mfg.	Description	PART NUMBER	Note
1	1	U3		78M05/SMD/DPAK	Generic	LOW POWER 5 VOLT REGULATOR	LM78M05	SMD
2	1	U1		ATMEGA168T/QFP	Atmel	Microcontroller	ATmega168A-20AU	Pre-Programmed
3	1	BATT1		BATT/CON/20MM/RENA/TAIHU-2032-1	Renata	BATTERY HOLDER	HU2032-LF	
4	12	C-112	100nf	CAP/SMD/1206	Generic	SMD Capacitor 1206		
5	2	C14-15	33pf	CAP/SMD/1206	Generic	SMD Capacitor 1206		
6	3	C16-18	4.7uf	CAP/SMD/1206	Generic	SMD Capacitor 1206		
7	1	J3		CON/R/AMINI-DIN/CUM/D-60SM	CUI	MINI-DIN CONNECTOR	MD-60SM	Bottom Mounted!
8	1	U2		DS3232	MAXIM	RTC W/TCXO 20-SOIC		
9	1	FB1		FB1206	Generic	Ferrite Bead 1206	non critical	>100ma
10	1	J5		HDR/100/1X3	Generic	.100 MALE HEADER	EXP	Optional Expansion connector
11	1	J2		HDR/2X4/RA/MALE	FCI	2X2 .100 RA MALE HEADER	68021-204HLF	
12	1	J1		HDR/2X4/RA/MALE	FCI	2X4 .100 RA MALE HEADER	68021-208HLF	
13	1	J4		HEADER/2X3	Generic	2X3 .100 MALE HEADER		ISP Connection
14	1	D1		LED/3MM	Generic	3mm LIGHT EMITTING DIODE		Default Green Color / Long Lead = Anode
15	1	U5		MAX3232	MAXIM	RS-232 DRIVER/RECEIVER	MAX3232CSE	
16	1	Q1		PHOTO-TRANS/ROHM/RPT-311PTA49	ROHM	Photo Transistor	RPT-311PTA49	Long Lead = Emitter
16 ALT	1	Q1 (Q1-ALT)		Alternate Phototransistor:	VISHAY	Photo Transistor	TEPT4400	Long Lead = Emitter (shipped with GENII V7 & V8 Clocks)
17	4	R1-3 R6	10k	RESS/SMD/1206	Generic	SMD Resistor 1206 1/8 watt		
18	5	R7-11	220	RESS/SMD/1206	Generic	SMD Resistor 1206 1/8 watt		
19	1	R5	680	RESS/SMD/1206	Generic	SMD Resistor 1206 1/8 watt		
20	1	R4 (R4-ALT)	68k (120k)	RESS/SMD/1206	Generic	SMD Resistor 1206 1/8 watt		Alternate value of 120k used with TEPT4400 Q1
21	1	RF1		RF-2400/PRF_MODULE	Various	NRF24L01P 2.4GHZ RF Module	MOD-NRF24L01P	
22	1	ROT1		VSM14E20	TT Electronics/BI	ROTARY ENCODER RA W/SWITCH	EN11-VSM14E20	Mounting hardware not used.
23	1	U4		TK71734SCLVREG	TOKO	3.4V LDO S0123-5	TK71734SCL	
24	1	Y1	14.7456	XTAL_HC-49US	ABRACON	Quartz Crystal HC49US PKG	ABL-14.7456MHZ-B2	14.7456 MHz 18pf
25	1	KNOB1			KILO	Knob for Rotary Encoder	OEDA-50-2-5	
TDU PCB								
Item #	Qty	Ref.	VALUE	Part Name	Mfg.	Description	PART NUMBER	Note
1	1	C2	100nf	CAP/SMD/1206	Generic	SMD Capacitor 1206		
2	1	J4		HDR/2X2/RA/FE/MALE	Sullins	2X2 .100 RA FEMALE HEADER	PPPC022LJBN-RC	
3	1	J3		HDR/2X2/RA/MALE	Sullins	2X2 .100 RA MALE HEADER	68021-204HLF	
4	1	J2		HDR/2X4/RA/FE/MALE	Sullins	2X4 .100 RA FEMALE HEADER	PPPC042LJBN-RC	
5	1	J1		HDR/2X4/RA/MALE	Sullins	2X4 .100 RA MALE HEADER	68021-208HLF	
6	1	U1		HV5522	Supertex	32-Channel HV Serial to Parallel Converter	HV5522PG-G	PQFP, could also substitute higher voltage HV5530PG
8	1	NE1		NEON/UP/RIGHT/MINI	Small Neon Bulb	Small Neon Bulb NE-2 6X15		See project documentation for mounting options.
9	1	NE2		NEON/UP/RIGHT/MINI	Small Neon Bulb	Small Neon Bulb NE-2 6X12		See project documentation for mounting options.
10	34	NIXIE1-2		NIXIE/B7971	Burrnoughs	Nixie Tube	B7971	Use milmax 0327-0-15-01-34-27-10-0, 0327-0-15-01-34-27-10-0, or equiv pins for socket. See project documentation.
11	6	R23	RA	RESS/SMD/1206	Generic	SMD Resistor 1206 1/8 Watt	Nominal 22k	See schematic for value.
12	8	R6 R25-26	RB	RESS/SMD/1206	Generic	SMD Resistor 1206 1/8 Watt	Nominal 24k	See schematic for value.
13	12	R9 R12 R24 R13	RC	RESS/SMD/1206	Generic	SMD Resistor 1206 1/8 Watt	Nominal 27k	See schematic for value.
14	4	R18 R3 R29 R14	RD	RESS/SMD/1206	Generic	SMD Resistor 1206 1/8 Watt	Nominal 33k	See schematic for value.
15	4	R31-34	68k	RESS/SMD/1206	Generic	SMD Resistor 1206 1/8 Watt		
PSU PCB								
Item #	Qty	Ref.	VALUE	Part Name	Mfg.	Description	PART NUMBER	Note
1	1	C1	330uf	CAP/RAD/3.5MM/8MM	Generic	Cap Radial 2.5mm Pin Spacing 8mm Dia.		16-25V Bulk Decouple (supplied with HVPS)
2	2	C2 C4	100nf	CAP/SMD/1206	Generic	SMD Capacitor 1206		
3	1	C3	4.7uf	CAP/SMD/1206	Generic	SMD Capacitor 1206		
4	1	J1		CON/R/AMP/R/COAX/PWR	CUI STACK	COAXIAL POWER JACK 2.0MM	PL-102A	Tapered pins (not slots)
5	1	D1		DIODE/SHOT/SMD/C30BQ040	Vishay	Diode 3A 40V	30BQ040	Reverse polarity protection. Optional/non-critical
6	1	F1		FUSE/POLY/SMD/1812	Littlefuse	PTC Resettable Fuse	1812L110/16DR	16V 1.1 HOLL 1.95 TRIP

7	1	J3		HDR/2X2RA/FEMALE	Sullins	2X2 .100 RA FEMALE HEADER	PPPC022LIBN-RC	
8	1	J4		HDR/2X2/STRAP	Generic	2X2 .100 MALE HEADER	PPPC042LIBN-RC	
9	1	J2		HDR/2X4RA/FEMALE	Sullins	2X4 .100 RA FEMALE HEADER	PPPC042LIBN-RC	
10	1	HVP/PS1		HV/PS/TESTS1364	Taylor Electronics	High Voltage Module	1364 HV/PS-H	www.taylorcorp.com
11	1	U1		LM7808CT	Generic	VOL TAGE REGUL A TOR	LM7808CT	
12	1	NE1		NEON	Generic	Small Neon Bulb NE-2		
13	1	R2		RESS/SMD/1206	Generic	SMD resistor 1206 1/8W		
14	1	VR1		VRES/375/SIDE	Generic	Multi Turn Trim Pot		0.375"
15	1				Generic	#4-40 X 3/8" SS SHS and Lock Nut		Voltage regulator anchor. No Heatsink required.

Clock Mechanical and Misc. Hardware

Item #	Qty	Ref.	VALUE	Part Name	Mfg.	Description	PART NUMBER	Note
1	1				Custom	Alum. Base Plate 3-1/2" X 19-3/4" X 1/2"		
2	1				Custom	Acrylic top		
3	23				Generic	#6-32 X 5/8" Hex Steel/Zinc.standoffs F/F	# 92196A146	
4	23				McMaster	#6-32 X 3/8" SS Allen Socket screws	# 90272A148	
5	23				McMaster	#6-32 X 3/4" Steel Philips PanHead		
6	23				McMaster	#6 Star lock washers	# 91114A007	Use with #6-32 Screws to anchor clock standoffs from bottom of plate
7	12				McMaster	#6 Nylon washers - Black	# 90295A376	One used on each #6-32 X 3/8" SS screw between screw and PCB
8	5				McMaster	#10-24 X 1/8" SS SHS - Outer edge	# 92196A239	Insert into threaded holes around perimeter of base plate
9	4				McMaster	#4-40 X 3/8" SS Allen Socket Screws		4 Used for large rubber feet, 1 used to anchor VREG with Lock Nut
10	4				McMaster	#4-40 Lock Nut		Use to anchor VREG
11	8				Bumper Spec.	1" X 1/2" Rubber Feet	# 98032A421	Use on #4-40 screws to anchor large rubber feet.
12	2				Custom	.062" Copper Tubing / Towers pieces	BS-17	Puncture center of bumper with all and insert #4-40 screw with washer and thread into bottom of base
13	1				Generic	2 X 1/16" Clear Heat shrink		Precut to length
14	4				Various	1/4" Diameter Clear Rubber Bumper	# SP-HE00121	Precut to length
15	1				Various	12VDC 1.5 Amp Minimum power Supply		For use on Clear acrylic top www.cabineparts.com
16	1				Various	Coin Cell Battery	CR2032	For use on Clear acrylic top www.cabineparts.com

RPTS-NEX 2.8

Item #	Qty	Ref.	VALUE	Part Name	Mfg.	Description	PART NUMBER	Note
1	1	U4		BMP180	Bosch	Barometric Pressure/Temperature Sensor	BMP180	
2	1	O6		CAP/SMD/0805	Generic	SMD CAP		
3	1	C11		CAP/SMD/0805	Generic	SMD CAP		
4	6	C1 C4-5 C7-9		CAP/SMD/0805	Generic	SMD CAP		
5	2	C2-3		CAP/SMD/0805	Generic	SMD CAP		
6	2	C13-14		CAP/SMD/0805	Generic	SMD CAP		
7	1	U3		CC2D33/RH	Generic	SMD CAP		
8	1	J4		CON/R/A/USB/MINI-B/SMD	Amphenol Sense	Relative Humidity Sensor	CC2D33	
9	2	SMA1-2		CON/R/F/SMA/VERT/5MM	Generic	Mini USB Connector		
10	1	ID1		DIODE /1N4148/SOD-123	Generic	SMA Connector RA		
11	2	FBI-2		FB0805	Generic	Diode	1N4148	
12	1	O2		FDV302P	Fairchild	Ferrite Bead		
13	1	GPS1		GPS/UBLOX-NEO6	Ublox	MOSFET Digital FET P-Ch	NEO-6M	
14	1	J2		HDR/100/2X3/SMD		GPS Module		
15	1	L1		IND/SMD/SPEGLALTY/PANA	Panasonic	SMD Debug Header		DNP
16	2	LED1-2		LED/WS2812B		Inductor		
17	1	U2		LM3671-3.3	TI	RGB LED	WS2812B	
18	1	U1		LP/C1U37/LQFP48	NXP	Switching Voltage Regulator	LM3671MF-3.3/NOPB	
19	1	R16		RES/SMD/0805	Generic	IC MCU ARM 128KB FLASH	LP/C1U37/FBD48/401	
20	6	R1-6		RES/SMD/0805	Generic	SMD Resistor		

21	2	R9-10	1K5	RES/SMD/0805	Generic	SMD Resistor			
22	2	R7-8	27	RES/SMD/0805	Generic	SMD Resistor			
23	1	RFM1		RF MODULE/24L01-PA/SMD_VER	AI	RF Module		Modified	
24	1	PB1		SW/PBR/ACT/LE/5MM	Generic	Switch	RS-046		
25	1	Y2	12MHZ	XTAL/ABM8G/3.2X2.5MM/12.00	Abrakon	Crystal	ABM8G-12.000		
RPTR-NEX Mechanical and Misc. Hardware									
Item #	Qty	Ref	VALUE	Part Name	Mfg.	Description	PART NUMBER	Note	
1	1			RPTR-TOP-PLATE	Custom	#4-40 X 7/8" X 1/4" Hex Alum. standoffs M/F	Clear Acrylic Top Plate		
2	4					#4-40 X 3/8" X 1/4" Hex Alum. standoffs M/F			
3	4				McMaster	#4-40 X 3/8" SS Allen Socket screws			
4	4				McMaster	#4-40 Nylon washers- Black		One used on either side of acrylic top	
5	8			RPTR-PLATE	Custom	5 Volt USB Power Supply		Aluminum Base Plate-Threaded.	
7	1			PS-USB	Various	GPS antenna		500ma Minimum	
8	1			GPS-ANT	Various	Radio link Antenna Normal Polarity SMA Rubber Duck			
9	1			LNK-ANT	Various	1" X 1/2" Rubber Feet	BS-17		
10	1			Rubber Feet	Bumper Spec.				
11	4								