TASS Assembly and Operation Manual

Relay Switching System

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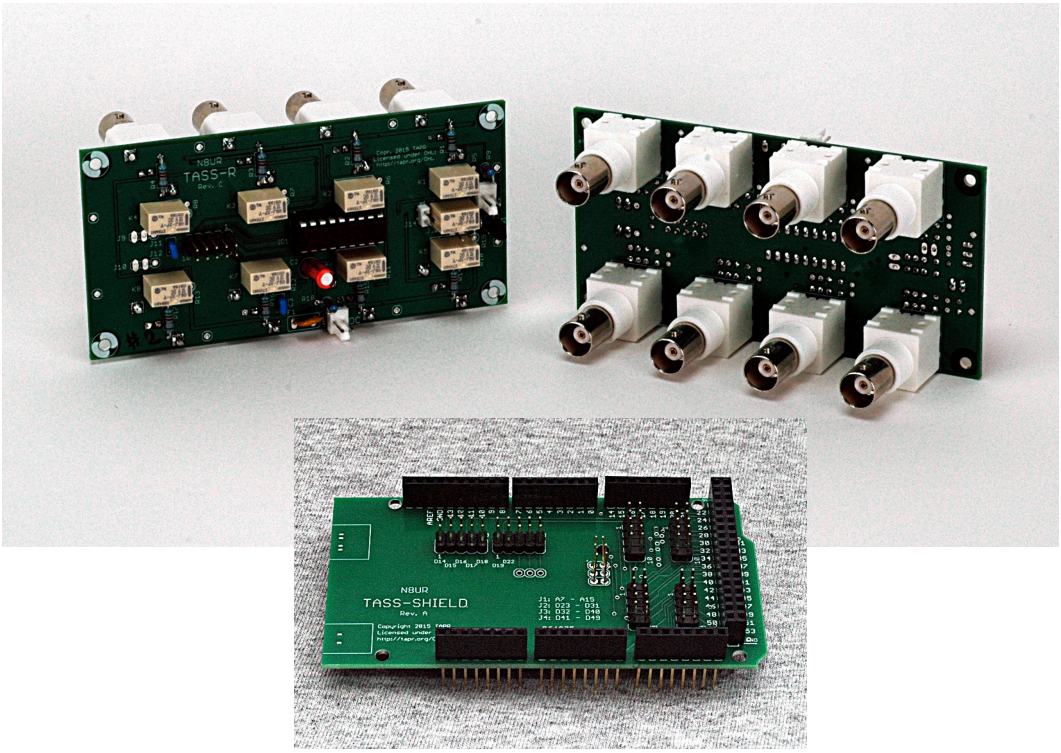


Introduction

The TASS[1] is a relay switching system and associated controller that are building blocks for automatic analog switches of varying complexity. The TASS system consists of three components:

- The TASS-R relay board, which has 8 BNC connectors as well as solder pads for external connections. It is controlled through a 10-conductor ribbon cable.
- The TASS-SHIELD daughterboard for the Arduino Mega 2560 (not supplied). One Arduino/TASS-SHIELD can control up to four TASS-R boards.
- The TASS software, which is open source and written in the Arduino IDE.

The TASS-R board handles signals from DC through 150 MHz (VHF performance varies based on configuration; see details below). It will handle 10W of power continuously; damage may occur with higher power levels. It requires 12V at from 0 to about 135mA, depending on how many relays are energized.

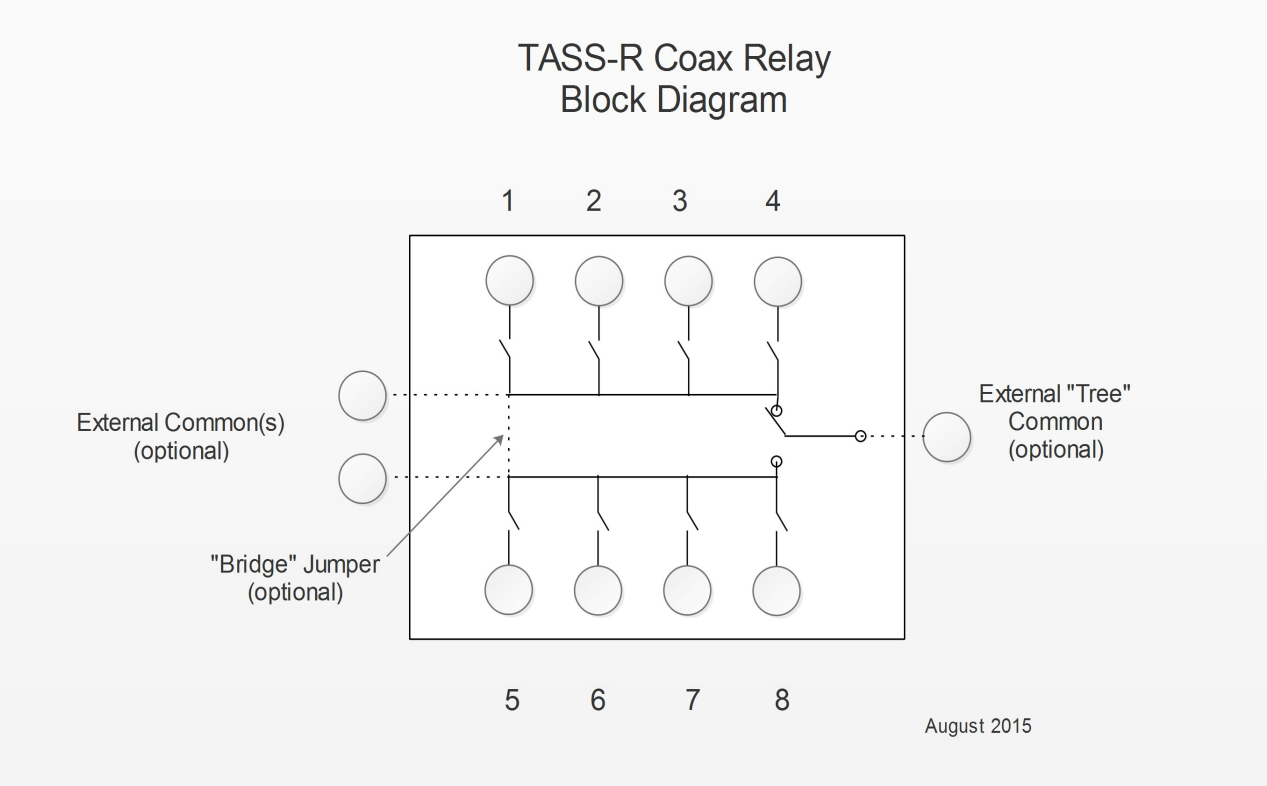
The TASS-R board is 2.2 inches high and 4.4 inches wide. It will mount into a 2U rack panel and is secured by the threaded BNC connectors. The connectors are spaced 1.0 inches horizontally and 1.6 inches vertically.

The TASS-SHIELD board is 2.10 inches high and 4.05 inches wide. It mounts directly to the Arduino Mega 2560 controller. It has headers for four 10-pin ribbon cables, one to each TASS-R board. TAPR does not supply the Arduino; you can obtain it from many sources just as cheaply as we can.

1 TASS = “Totally Awesome Switching System”. This name has a long story, well worth a beer the next time you see me.

We've created a TASS Introduction video that describes the system. It's available on YouTube at

This is the basic layout of the TASS-R board:



The numbered circles represent BNC connectors which mount on the rear of the board. The circles on the left represent connection points that can be used for external connectors, or to daisy-chain multiple boards together. The relay on the right and its associated connector allow a single input to connect to any of the eight ports. That relay is controlled by the TASS software to track the port selection command – ports 1 through 4 toggle the relay to one side; ports 5 through 8 toggle it to the other.

Also shown is the ability to bridge the two branches together via a jumper on the board. The tree connection is probably more useful, but permanently joining the two branches may sometimes be required. Note that using the bridged connectors will reduce high frequency performance.

To this point, the relays are arranged in a bus configuration rather than a star. That provides great flexibility, but has an RF cost. When any other than the end ports of a bus are used, there is the equivalent of a coax stub a couple of inches long hanging off the connection. While the RF traces on the circuit board are well-matched 50 ohm striplines, there is still an impact that increases with frequency. The four port bus performs well up to 150 MHz, but the SWR and insertion loss plots below show the impact. Daisy-chaining boards together will increase the stub length and substantially reduce VHF performance. However, lower frequency operation should not be affected.

The nine switches are actually relays. Each is connected to a relay driver, which in turn connects to one pin on a ten-pin header into which an IDC ribbon cable can be plugged. As a result, each relay is independently controlled; there can be from zero to nine active relays at any time.

The TASS-SHIELD is a convenient interface from the Arduino MEGA 2560 controller to the TASS-R board. It simply routes signals and doesn't have any active components.

Performance

RF Power:

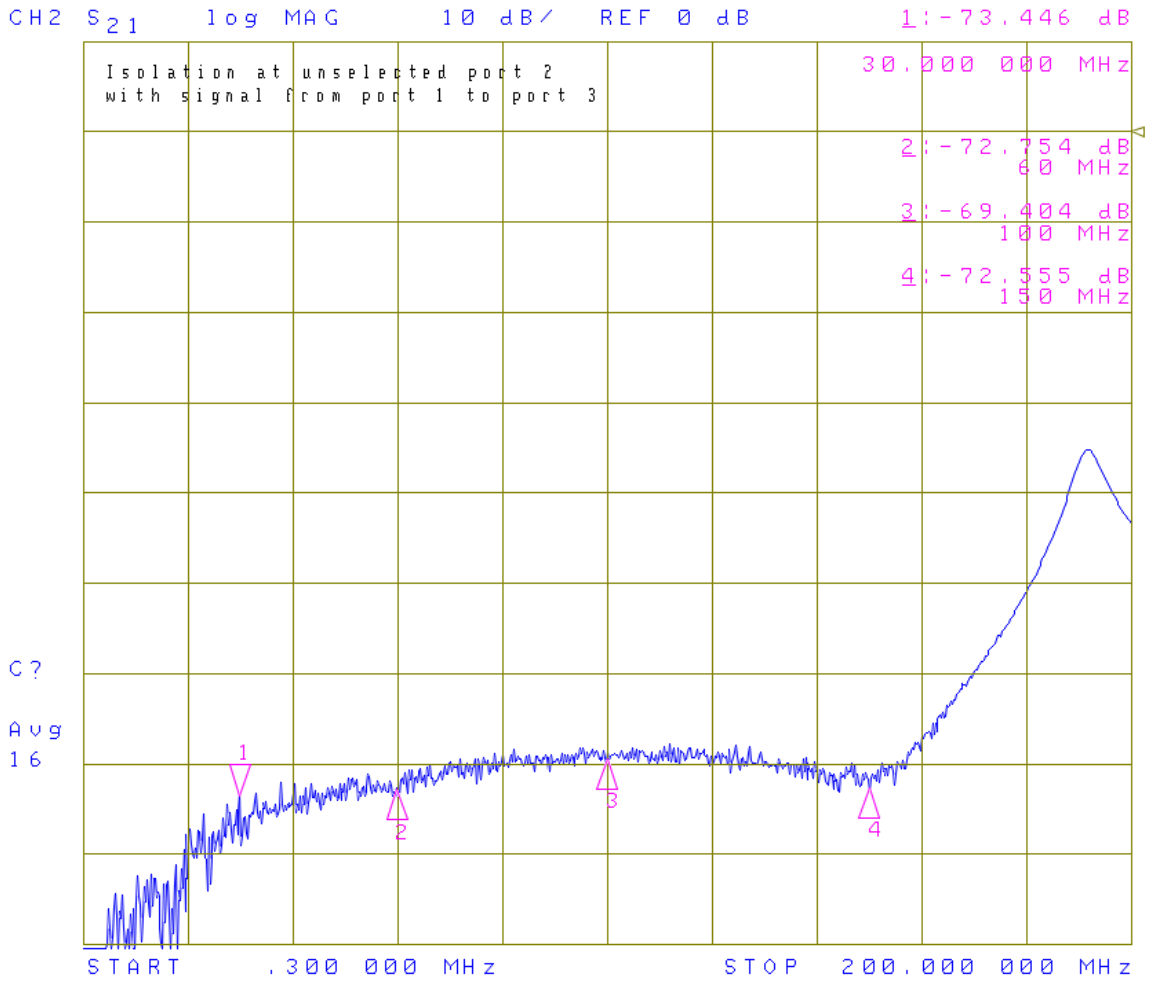
The main limiting factor is heating of the internal PCB signal traces. 10W continuous power should be fine, but heating may occur at higher power levels, and damage could occur.

Power consumption:

The TASS-R uses 12 volts of DC power. Current consumption is about 13 mA per relay (about 135 mA maximum if all relays are energized).

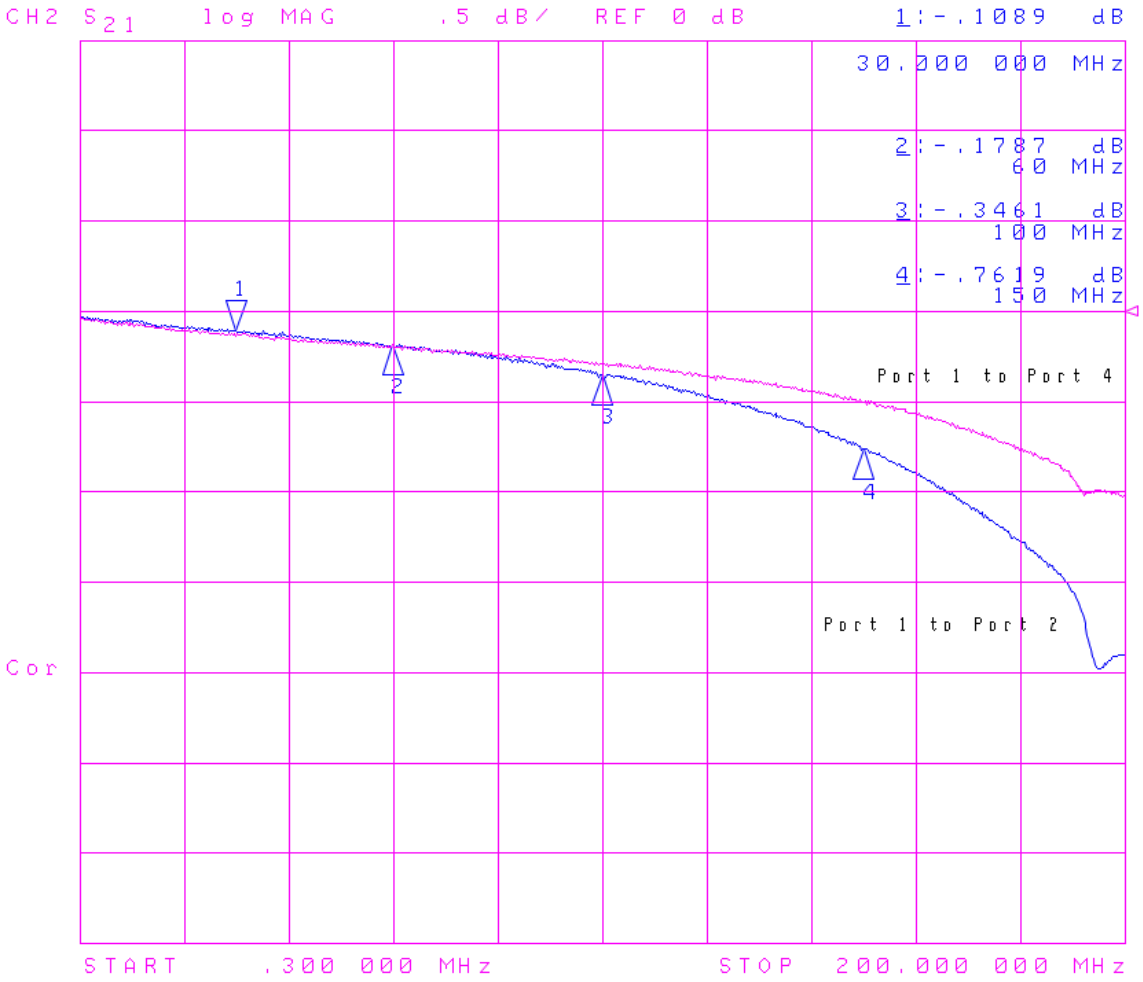
Port-to-port Isolation:

Isolation, or crosstalk, is determined by sending a signal from port 1 to port 3, and measuring the level at port 2. The TASS-R shows isolation of approximately 70dB or better through 150 MHz.



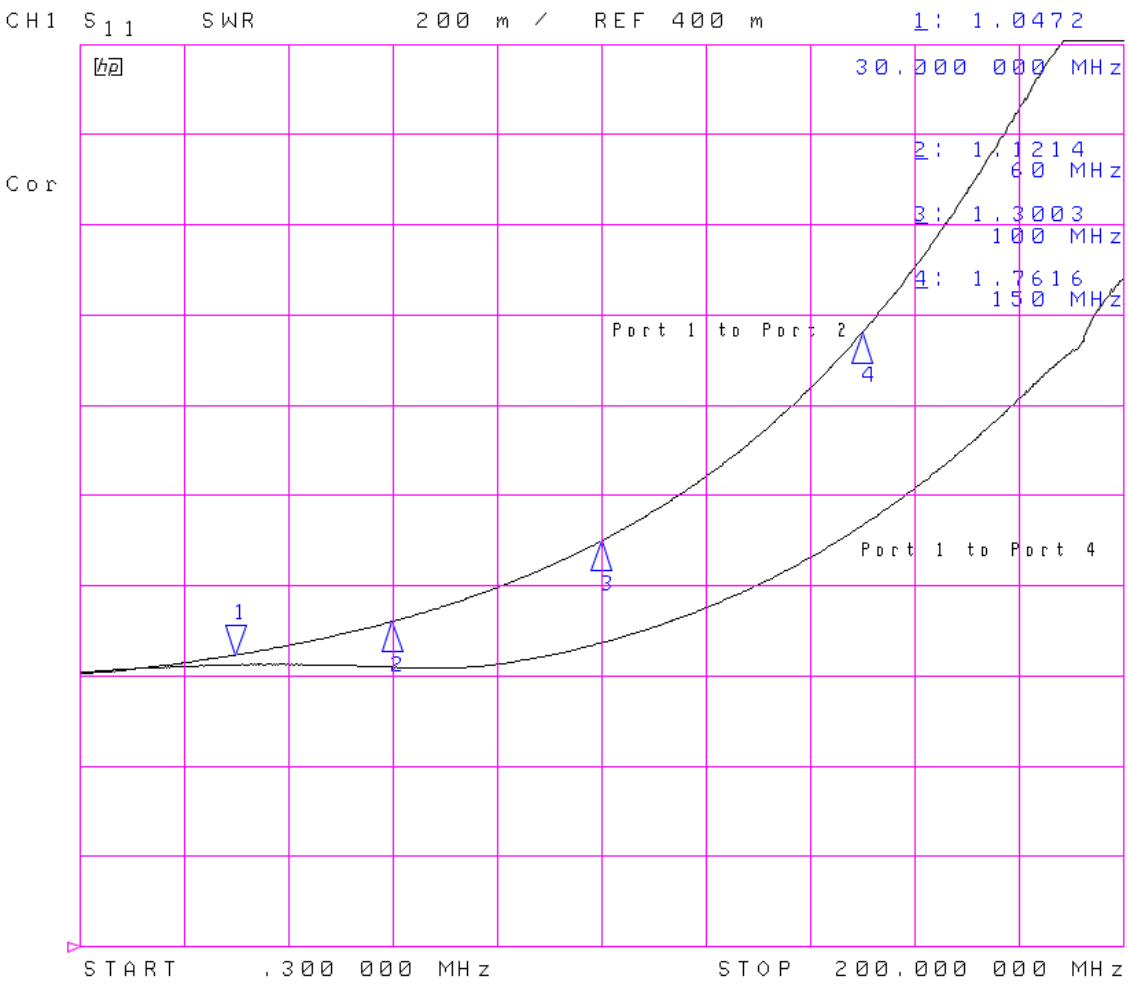
Insertion Loss:

Insertion loss is measured between ports 1 and 4, which represents the best case for insertion loss and SWR, and then between ports 1 and 2, which represents the worst case for a normal configuration. Insertion loss is below 0.8dB through 150 MHz.



SWR:

SWR is measured from port 1 to port 4 (best case) and from port 1 to port 2 (worst case). SWR is below 1.8:1 through 150 MHz.



Assembly

General Tips

- Make sure that you have all the parts shown in the inventory lists below.
- Check your soldering iron to be sure the tip is in good condition. The tip should be the small conical tip type and must be clean. If you can't remember when you last replaced the tip, now would be a good time to do so.
- All parts should be mounted as nearly flush to the board surface as practical without stressing the lead.

TASS-R Assembly

- The TASS-R printed circuit board has four layers and a lot of ground copper. Soldering any grounded pad, and particularly the BNC mounting stubs, requires quite a bit of heat. I use an 80 watt iron for those parts; it will heat the ground copper much more readily than a smaller iron.
- It's easiest to install the flattest parts first – e.g., start with horizontally mounted resistors and mount C2 and the polarized connectors at "DC" and J16 last. Install all components on the front of the board, then mount the eight BNC connectors on the back side. There is further information on mounting the BNC connectors below.
- The relay leads are made of soft metal and break easily if folded over, so treat them carefully. They are also somewhat smaller than the mounting hole size, so the relay can end up mounted crooked if the leads aren't all centered in the holes. This won't affect electrical performance, but may offend your sense of style.
- The 1K resistors across the relay coils are intended for additional EMI protection. They are probably not needed. Each of the relay drivers already provides a snubbing diode.
- Some component leads in the area of the DC connector can interfere with mounting BNC connectors J6 and, especially, J7. Make sure that those leads are clipped off as short as possible, and minimize any solder blob. You will need to trim off one of the mounting feet on J7 with a sharp knife; otherwise the pins of C3 will prevent flush mounting.
- To make sure the BNC connectors are mounted flush and true, I place a connector and tack solder its center (not grounded) pin. Then I hold the board in my hand, reheat the joint, and use a finger to push the top of the connector down until it is pressed evenly against the board. When properly mounted with just the center pin soldered, the connector should feel solid, with minimal rocking. Once all the BNC connectors are tacked down this way, I use an 80 watt iron to solder the fat mounting pins and the ground pin.
- J16 connects to the common pole of K9, and is normally used for an external common input connector. Since this is likely to be a common configuration, I recommend that you install this polarized connector.

- J9, J10, J14, and J15 are used for optional off-board connectors, or to daisy-chain boards together. You can install 2-pin headers at these points if you'd like, but unless you plan to use the external capabilities, I suggest that you not install them. There isn't enough room around these points to allow polarized connectors, so a regular 2-pin header, or soldering the cable directly to the board, are recommended. **NOTE: There is a logic error (in the designer's mind) that makes J14 and J15 not function as intended. There is an easy fix, though. See the "Errata" section below.**
- The non-grounded pins of J11 and J12 can be connected with a wire to allow the buses to be connected. This is an alternate way to form an 8-port switch, but its RF performance will be much worse than using relay K9 to toggle busses. Therefore, don't apply this jumper without careful thought.
- My convention is to mount Molex polarized connectors with the plastic clip facing the bottom edge of the long side of the board. This puts the ground pin is to the right.
- There are extra holes along all four edges of the board. These are ground points that can be used if/as needed.
- The DC return for the relays is NOT directly tied to the ground plane on the board. This helps reduce analog noise. R18 (10K) connects the relay common to the ground plane to allow static drain.
- https://www.youtube.com/watch?v=p1yZKT3Yock is a helpful video showing how to install IDC connectors on a ribbon cable. If you don't have a vice, you can use a standard pliers – but be sure to apply pressure evenly, and don't allow the jaws to deform the sockets.

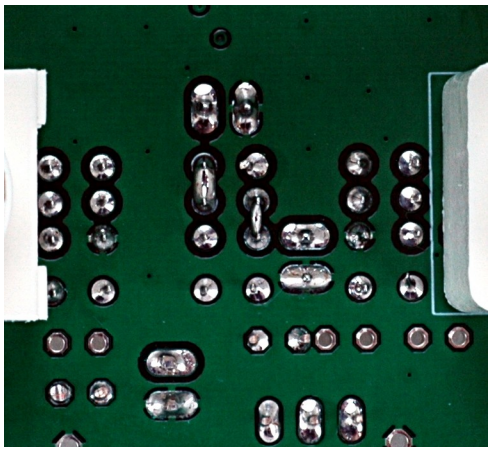
TASS-SHIELD Assembly

- Installing the 8x1 and 10x1 long-pin headers requires some dexterity. I haven't found an ideal solution, but it's important that the headers are mounted true on the board so that the pins below are parallel and at a 90 degree angle from the board. This is necessary to allow easy mounting to the Arduino.
- Note that the 2x3 long-pin header mounts on the bottom of the board, instead of the top.
- Try not to wipe solder down the long pins as you solder them to the board. The pins need to push into the sockets on the Arduino, and extra solder may make that difficult.
- J1 through J4 control TASS-R boards 1 through 4 respectively.
- CFG1 and CFG2 allow digital I/Os D14-D19 and D22 to be grounded by a 2-pin shorting jumper. The TASS software can read the state of these lines at startup to set configuration. The last three pin pairs on CFG2 route to J8, J9, and J10 so that you can use additional pins for conguration. The extra pads on the bottom left side of the TASS-SHIELD provide access to voltage, ground, and reset signals, as well as analog I/Os A0-A6.
- At the moment, the TASS software (v. 0.32) does not use the configuration pins, though that is on the short-list of things to do. The idea is that you'll be able to use these pins to set configuration items that now have to be set within the code. For example, you'll be able to use a config pin to enable or disable the touchscreen display without having to recompile the software.

ERRATA

J14 and J15 are intended to extend the two relay buses, for example to daisychain boards together. They should work identically to J9 and J10. For reasons that the designer cannot remember now, they are routed to relay K9 and as a result don't perform as intended. There is an easy fix.

Simply short together pins 3 and 4, and separately pins 5 and 6, on K9. This can be done with a solder blob between the adjacent pins on the board. See the photo below.



Obtaining and Loading the TASS Software

- The Arduino development environment software is available for Windows, Linux, and Mac platforms. Download it from https://www.arduino.cc and install on your computer.
- The latest version of the TASS software is available from http://www.tapr.org/~n8ur/TASS. Download and unzip it into the "sketchbook" folder that the Arduino IDE created when it was installed. The files will unzip into a folder called "TASS" or something similar.
- Connect your Arduino to the computer with a USB cable.
- Start the Arduino software and open the TASS sketch by navigating to File/Sketchbook and clicking on the appropriate name.
- You should see the source code appear in the window. Navigate to Sketch/"Verify/Compile", or click the checkmark at the upper left part of the toolbar. If all is well, the code will compile and you'll see a non-error message in the area at the bottom of the screen.
- Now, navigate to File/Upload or click the "Upload" icon at the upper left, and you should see a progress indicator showing that the code is being sent to the Arduino. If the program cannot find the Arduino, you may need to change the serial port settings.
- Once the code has been uploaded, you can use the serial monitor within the Arduino environment, or another serial port terminal program, to communicate with the board. The serial parameters are "115200, N, 8, 1" although you can change these within the source code.

TASS Software Basics

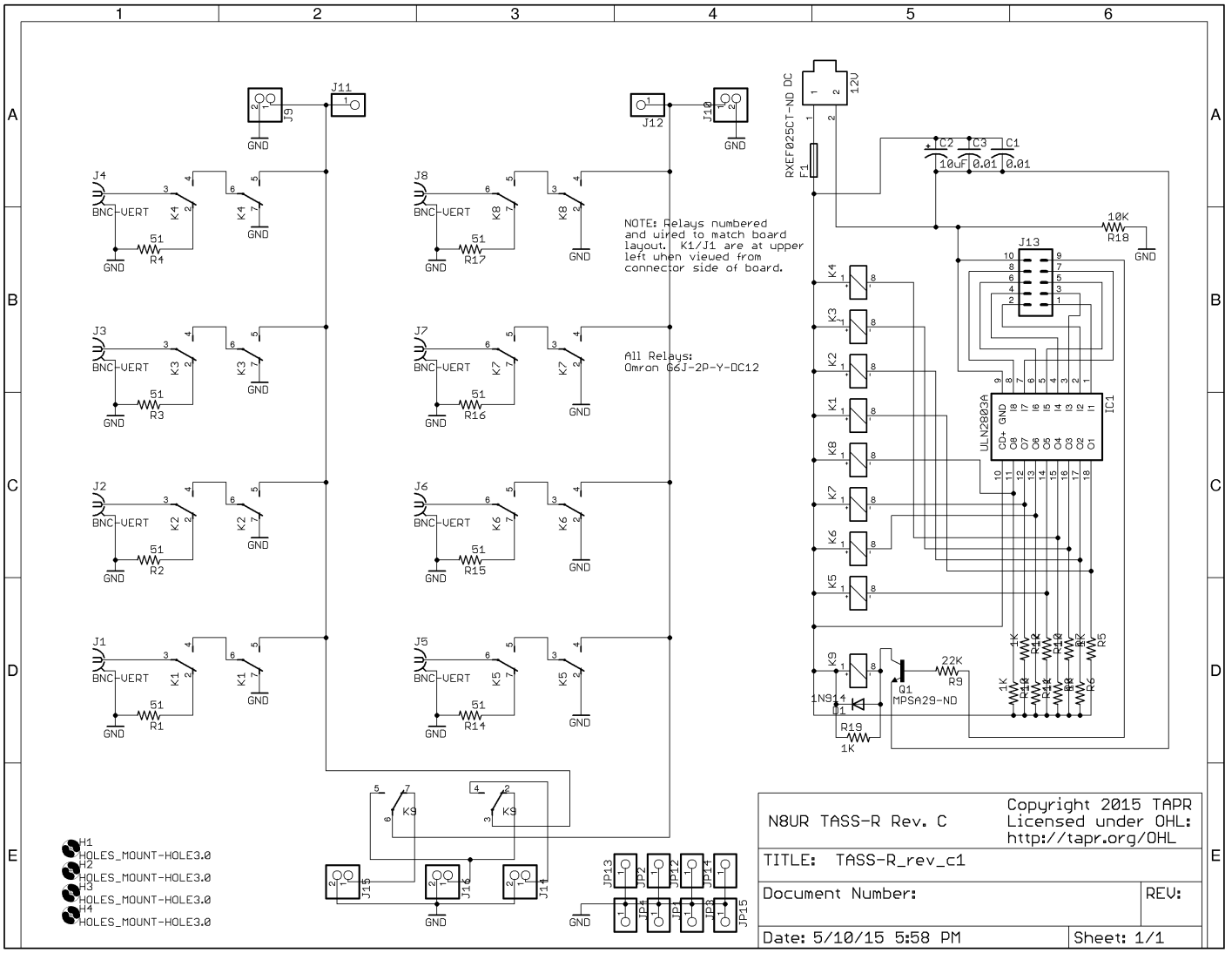
- The TASS software should be considered a starting point, but it's not a finished product. The current version (0.40) supports multiple boards as well as the switched-tree capability that uses relay K9 to create an 8-port switch. It does not support daisy-chained boards or other configurations such as double-pole switching, though I am working toward that.
- Version 0.40 supports USB and ethernet using W5100-based shields.
- The software also supports a simple touchscreen interface. It is compatible with the 2.8" capacitive TFT shield available from Adafruit for about $45 (https://www.adafruit.com/products/1947). To enable the touchscreen, uncomment the line near the beginning of the main source file that says "#define_USE_TS", then compile and upload. If you enable the touchscreen code, the Arduino program will fail if it can't find the touchscreen on startup.
- Commands are sent to the TASS system via ASCII strings. Each command begins with an "<" character and ends with a ">" character. The command will execute as soon as the ">" character is received; it does not wait for a line feed or carriage return.
- The command format is three characters: board (A-D), port (1-8, with 0 being a special case), and command (H, S, or U).
- The H (hold) command turns the selected relay on. The relay will remain actuated until it is explicitly turned off with the U (unhold) command.
- The S (set) command turns the selected relay on, but issuing another "S" command will turn that relay off and turn the selected relay on. In other words, this allows you to switch from one port to another with a single command.
- The special case of sending 0 as the port, and U as the command, will turn off all relays on the board.

TASS-R Parts Inventory

OK?	Qty	Value	Part
	2	0.01 uF	C1, C3
	1	10 uF	C2
	1	1N4002	D1
	1	0.25A PTC	F1
	1	18 pin DIP socket	
	1	ULN2803A	IC1
	5	2x1 Pin Header	J9, J10, J14, J15, J16
	1	2x5 Pin Header	J13
	2	Molex Pol. Conn.	DC, J16
	2	Plug for above	
	4	Pins for Plug	
	8	BNC	J1 - J8
	9	Relay	K1 - K8
	1	MPSA29	Q1
	8	51 1%, 1/4W	R1, R2, R3, R4, R14, R15, R16, R17
	9	1K, 1/4W	R5, R6, R7, R8, R10, R11, R12, R13, R19
	1	10K, 1/4W	R18
	1	22K, 1/4W	R9
	1	Printed Circuit Board	
	1	30” 10-pin ribbon cable	
	2	10 pin IDC connector	

TASS-SHIELD Parts Inventory

OK?	Qty	Value	Part
	5	8x1 long-pin header	
	1	10x1 long-pin header	
	1	2x3 long-pin header	
	1	2x17 long-pin header	
	6	2x5 short-pin header	J1, J2, J3, J4, CFG1, CFG2
	1	Printed Circuit Board	


NOTE: Relays numbered and wired to match board layout. K1/J1 are at upper left when viewed from connector side of board.
All Relays: Omron G6J-2P-Y-DC12
N8UR TASS-R Rev. C
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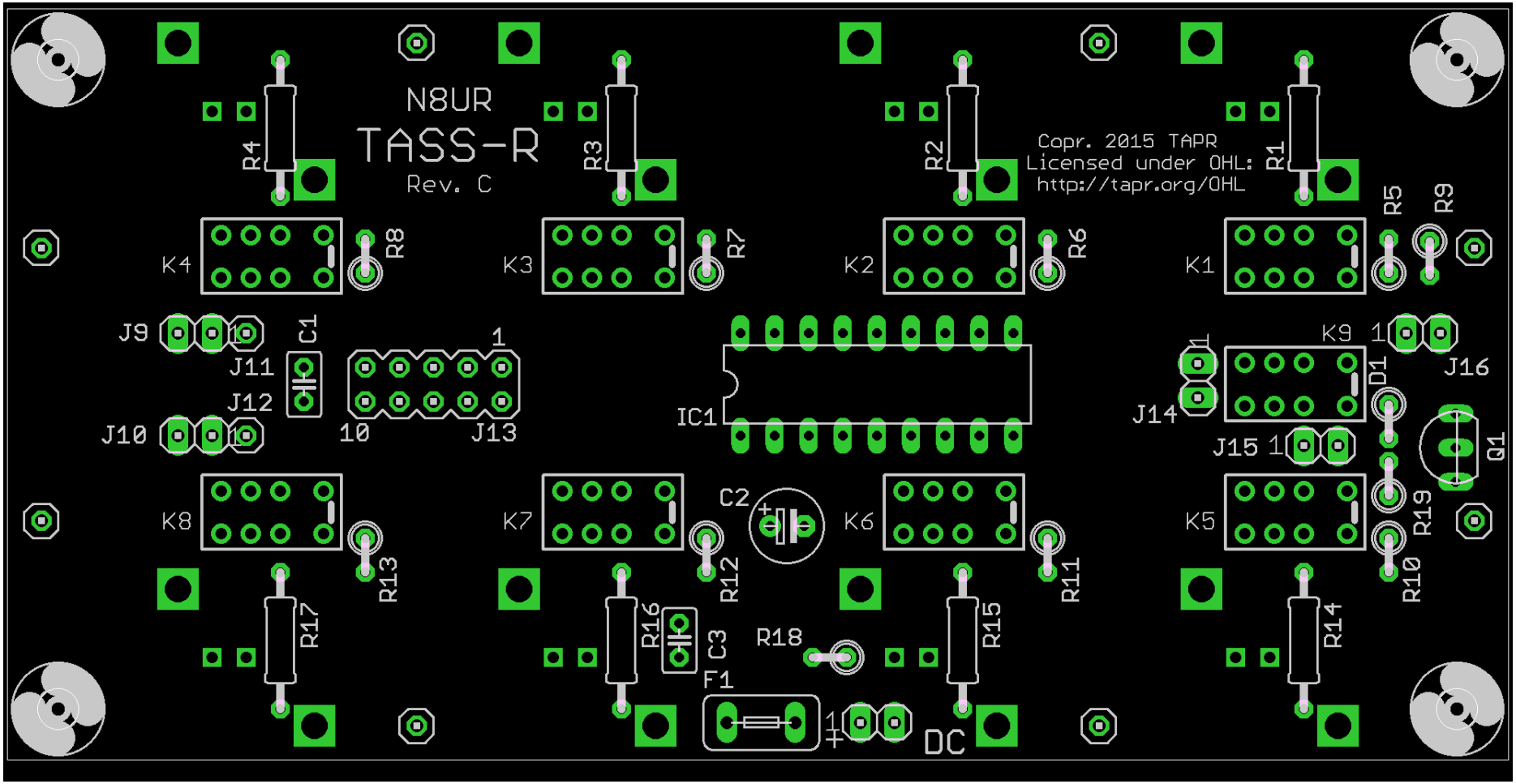
N8UR
TASS-R
Rev. C
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R4
R3
R2
R1
R5
R9
K4
K3
K2
K1
R8
R7
R6
J9
J11
J12
J10
C1
1
10
J13
IC1
K9
J14
J15
J16
D1
Q1
K8
K7
K6
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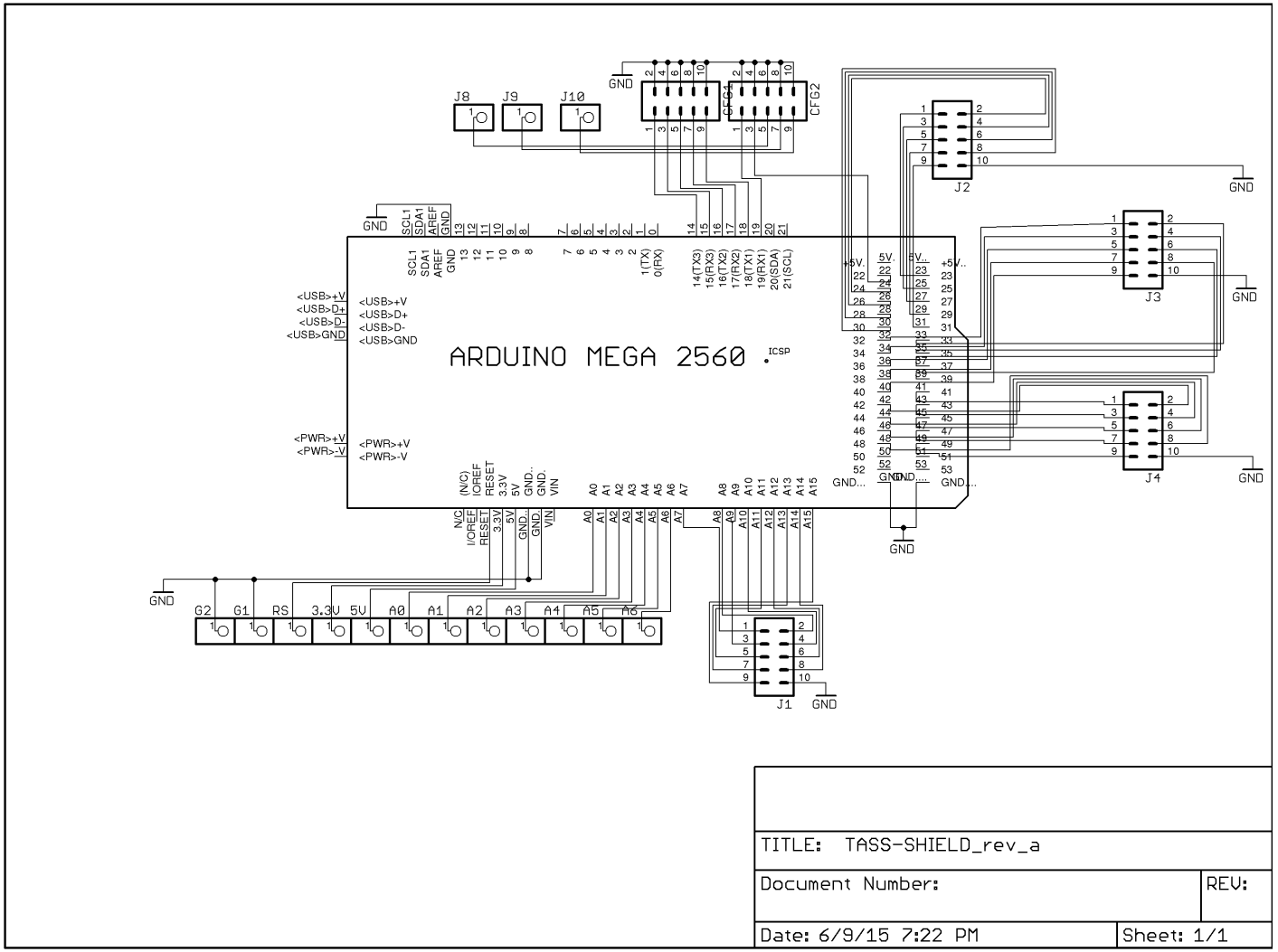
C3
R18
R15
R14
F1
DC



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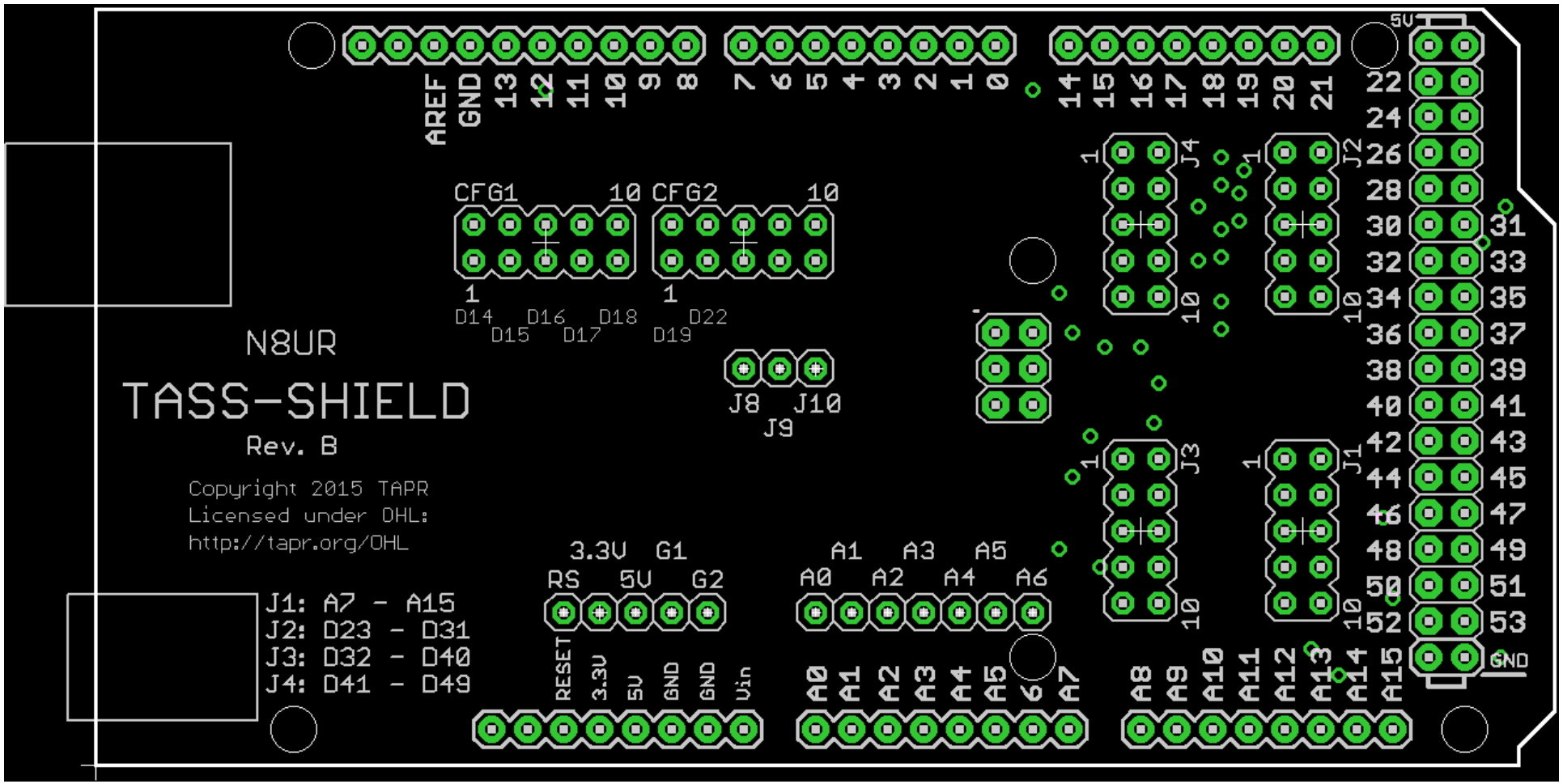
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5V 22 24 26 28 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 GND
CFG1 10
CFG2 10
1
D14 D16 D18 D22
D15 D17 D19
J4
J2
J3
J1
J8 J10
J9
N8UR
TASS-SHIELD
Rev. B
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J1: A7 - A15
J2: D23 - D31
J3: D32 - D40
J4: D41 - D49
3.3V G1
RS 5V G2
A1 A3 A5
A0 A2 A4 A6
RESET 3.3V 5V GND GND Vin
A0 A1 A2 A3 A4 A5 6 A7
A8 A9 A10 A11 A12 A13 A14 A15