MEMSDuino System Element Abstracts

**Rack Mount Wood Board**

This is a wood board slightly more than 2u high for a 19 inch standard instrument rack. Large holes are drilled in the edges so that there is some margin of error for the fit. The basis of the board is a cheap plank of white oak 4 inches wide and 24 inches long, cut to size. This is useful for rapid prototyping of rack mount devices, as unlike in custom metal front panels, the part can be easily modified after the fact with no special tools to any given use case. A set of knurled brass thumb screws are used to hold it in the rack. The Custom Metal Box is bolted to the board by means of through hole screws which thread into the metal box. All other parts are attached to the board by means of 3d printed mounting brackets and #4 wood screws.

**Custom Metal Box**

This is a custom metal box which contains the relay board that connects 90 volts to selected pins on a Dsub connector in the lid. The base of the box is attached to a wood board by 4 screws, and the 90 volt boost board is attached to the inside by means of a bracket screwed to the box. This box fully encloses the 90 volts at room temperature for safety. It is based on making modifications to the diecast aluminum boxes from Bud Industries, part number AN-1304-A. The lid is modified to have a DB25 board mount connector screwed into place by a pair of 4-40 standoffs, allowing a DSub cable to plug directly into the box and be screwed into place. A cutout is also made for cables to go from the Arduino Shield to the DB 25 Relay Board which is captivated on the lid by the pins from the DB25 connector.

**3d printed parts**

3d printed brackets and heat pressed brass thread inserts are used to create adapter brackets from both our custom electronics and the Arduino and the Wood Board. There is also a 3d printed bracket with thread inserts which mounts the DC DC converter which steps up to high voltage into the inside of the Custom Metal Box.

**5 V to 90 V boost**  
 This system consists of a pair of off the shelf DC DC converters (available from Amazon) which are modified and combined to step voltage up from 5 volts to 12 volts and then from 12 volts to 90 volts, allowing the 90 volt lines to all be supplied power from the USB power supply to the Arduino UNO. The second stage of DC-DC converters requires that the voltage be adjusted to 90 volts with a screwdriver on a set knob.

**Arduino Shield Circuit Board**

This board adapts between the Arduino UNO and the rest of the system. It has a digital output which drives the programmable LED array, and an analog input which senses all of the input buttons. It also has digital output lines which go to the DB 25 Relay Power Board and control the electromechanical relays in that board, which in turn controls the 90 volt lines to the MEMS switches.

**DB 25 Relay Board**

This board uses electromechanical relays to connect the 90 volt line with any of 20 pins on a DB25 (25 pin DSUB) board mount connector which is in the lid of the custom metal box. In the 9 way switch, 16 of these lines are actually used. In the SP9T+E-cal system, however, all 20 lines are used.

**Control Panel Circuit Board**

This board is the physical interface between a human operator and the system, with programmed lights indicating the current state and buttons setting the state. This board can be redesigned to accommodate any number or topology of switches.

**SP6T control system**

This is an adaption of the MEMSDuino system to control the off the shelf SP6T switches available from Cryo-Elec. The Arduino output lines drive the inputs to the 5 V to 90 V step up board also sold by Cryo-Elec.

**SP8T + E-Cal system**

A custom-build single pole 8 throw SMP switch with phase matching and built in short-open-load calibration at the top level of switches. This switch has three tiers of switches, with the 8 switches at the bottom tier only in place to increase the isolation. A custom front panel board similar to the SP9T and SP6T board is used to control the state of the switch, and a modified version of any of the other board types can be used to control the state of the calibration at the first tier switch. To realize this system, the Arduino UNO must be replaced by an Arduino Mega, which has more outputs available, and all 20 relays in the DB25 Relay Board must be populated, as all 20 lines will be used to drive the SOLT selector switch, the 8 isolator switches, and the two main switches at the second tier. 8 lines each are needed for the isolation and tier 2 switches, and 4 lines are needed for the top tier switch.

**Micro D to Header Cryogenic Adapter Board**

This board breaks connects the lines in the micro D connector at the bottom of many dilution refrigerators to a set of 4 pin 0.1 inch pitch headers, which are used to connect to the SP9T custom switch boards that are also part of this system. The micro D is female, to match the male connectors at the bottom of many dilution refrigerators.

**Cryogenic mounting Hardware**

This is a set of machined brass parts which attach the Micro D adapter board and the two SP9T switches all to the bottom of a dilution refrigerator with M4 screws. A combination of off the shelf 4-40 hex standoffs, brass 4-40 screws, and four machined parts makes up the whole system. These parts consist of an “H-Bracket” which is a general purpose bracket to mate the M4 screws typical on the base of dilution refrigerators to the “T-Bracket”, which in turn can connect to any experiment.

**SP9T Switch Board**

This board uses four MEMS switches, each in “super port mode”, in 2 tiers, to switch an RF common port between 9 different RF ports, all with surface mount SMP connectors. This switch will be described in detail elsewhere and is included here for completeness. Two of these boards are separated by a fixed distance, allowing a set of calibration or sample boards to be plugged and unplugged around the outside of the whole system.

**Calibration Circuit Boards**

These boards include short, open, load, through, and boards for chips. They have been designed to all be fabricated as a whole panelized single board. These will be documented in greater detail elsewhere and are included here only for compleness.