University of Kansas
Department of Physics and Astronomy

SPICE Pulser: The Guide

Andrew Shultz
Uzair Latif
Alexander (Sasha) Novikov

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Contents

1 Introduction

The purpose of this document is to provide sufficient information to perform the SPICE pulser experiment for the pole season of 2018-19. This experiment involves dropping a pulser down a SPICE core hole (deep hole filled with estisol). Two different pressure vessels and three kinds pulsers will be covered along with the possible setups using these.

2 Important Equipment

Pressure Vessel Components

1. Tube
2. Top cap
3. Bottom cap
4. Bolts (7/16" hex head, 1/4-20 [measured]) x12 (6 per cap)

Pressure Vessel Antenna Components

1. Top pole
2. Top cap
3. Bottom pole
4. Bottom cap
5. Feed point module
6. Wench Bolt
7. 3" 1/4-20 bolt
8. 1" spacer
9. 1/2" spacer x2

Pressure Vessel (PV) x2

Figure 2.1: .

Pressure Vessel Antenna (PVA) x1

Figure 2.2: .

IDL Pulser x2

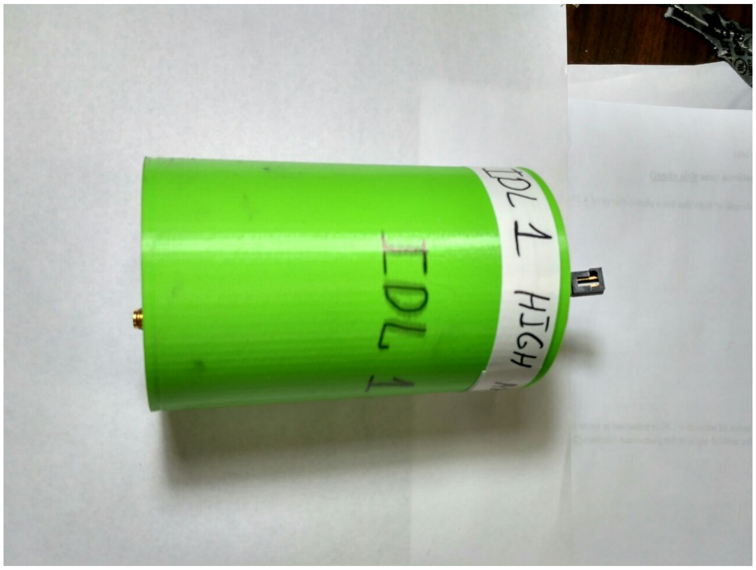


Figure 2.3: .

HVSP Pulser x2

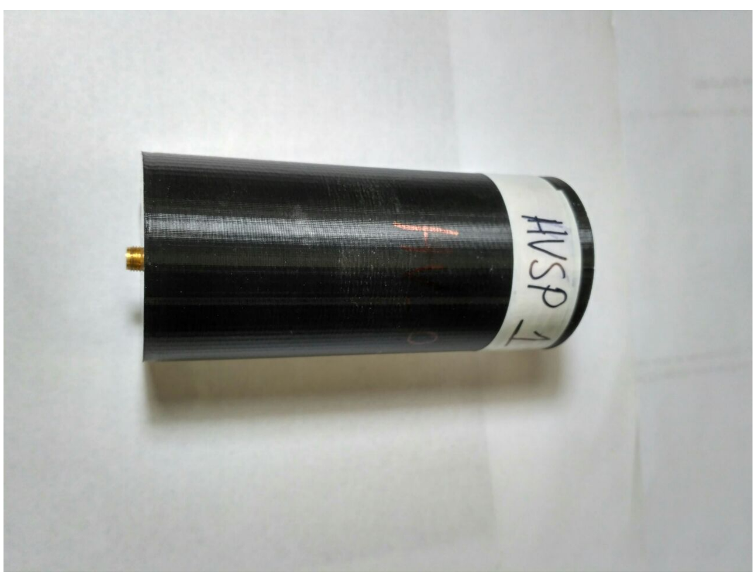


Figure 2.4: .

Motor x2

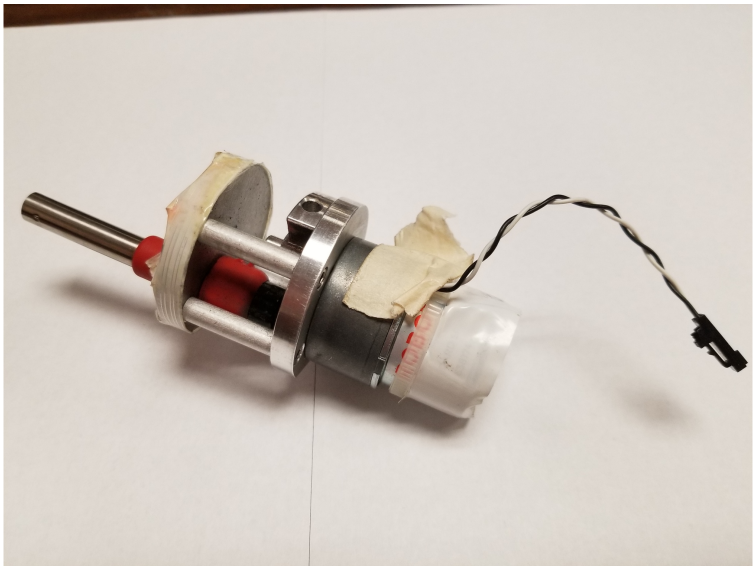


Figure 2.5: .

Piezo Sparker x3

Figure 2.6

Pole Length Cable (F-F Molex) x3

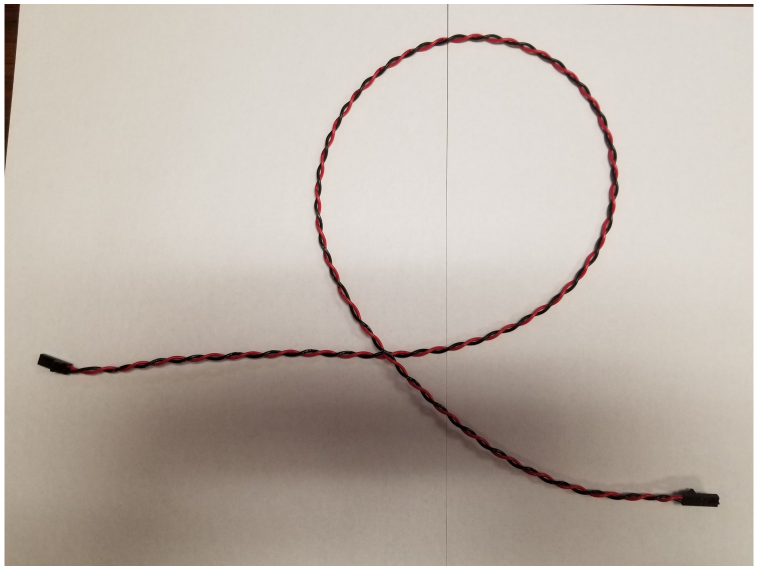


Figure 2.7

Splitter (M-FF Molex) x3

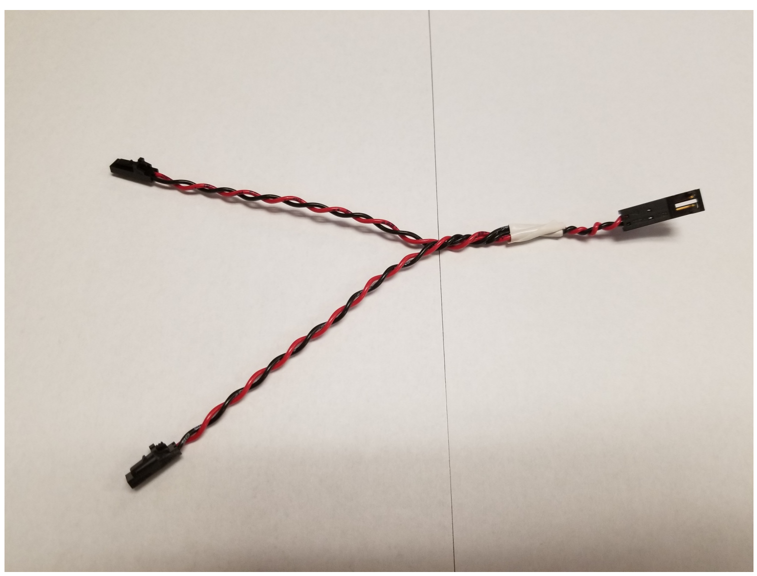


Figure 2.8

Inline-4 (I4) battery cable x2

Figure 2.9

Lead-Acid Batteries x4

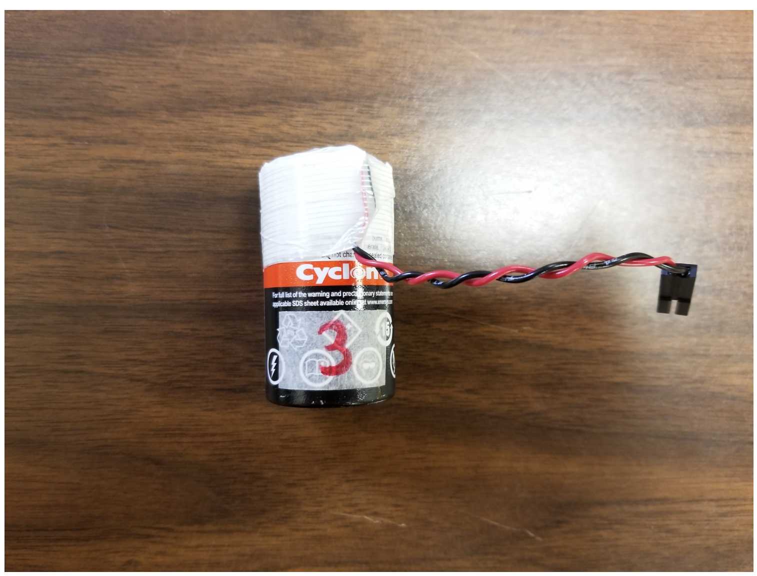


Figure 2.10

Lead-Acid Battery Pack (4 Batteries) x1

Figure 2.11

3 Pulser Setup

In this chapter, the how to for setting up each pulser-antenna system will be covered.

3.1. Piezo Pulser

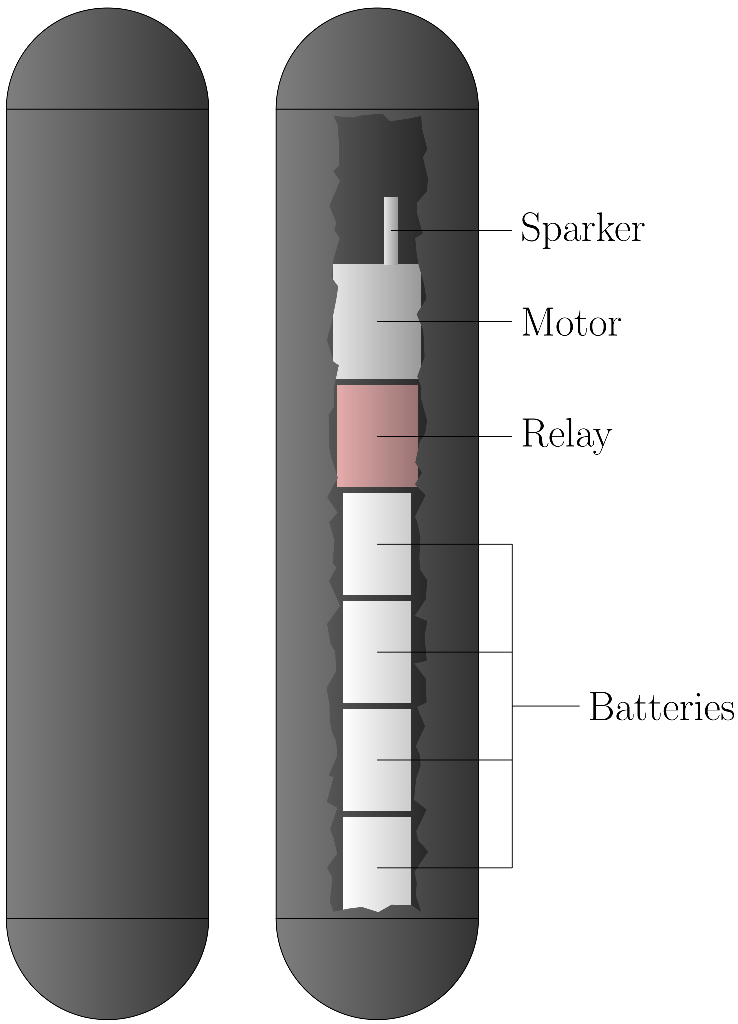
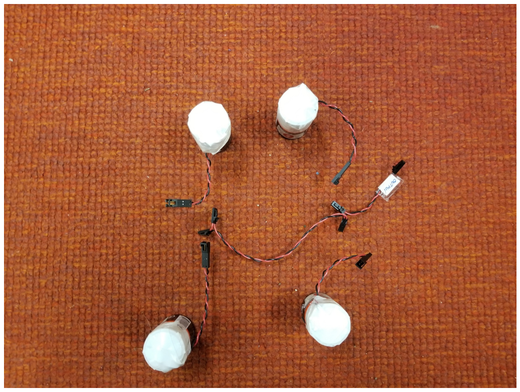
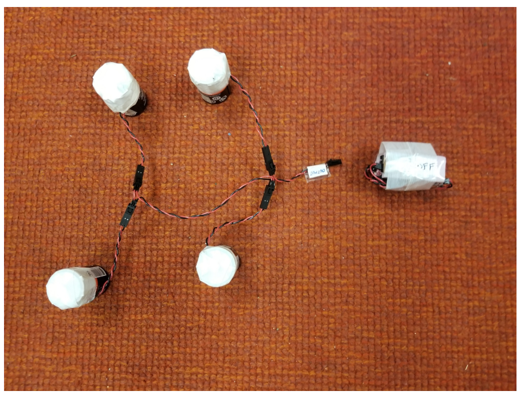


Figure 3.1: *Pressure Vessel setup for piezo pulsers.*

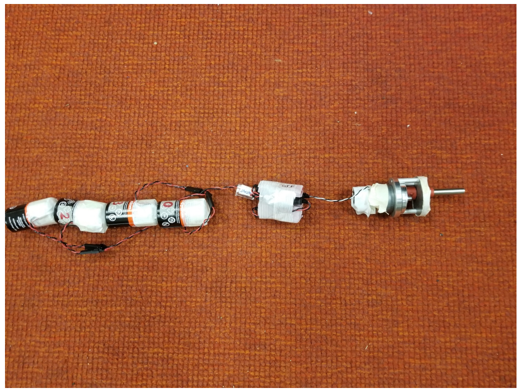
Step 1: *Attach batteries to inline-4 cable, 3 or 4 Batteries may be used. A male Molex connector short needs to be used for 3 batteries.*



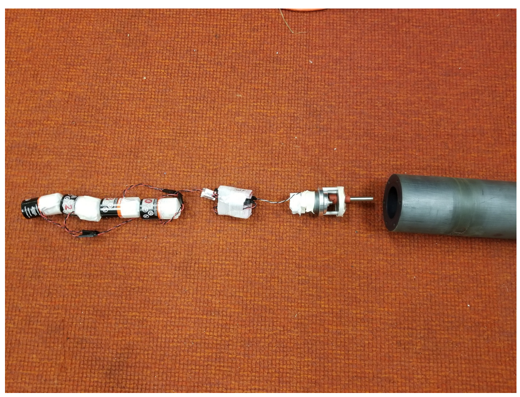
Step 2: *Attach OUTPUT of the inline-4 cable to male Molex connector of the relay marked* ***BATT*** *(or BATTERY).*



Step 3: *Attach the female Molex connector of the motor to the male Molex connector of the relay marked* ***MOTOR****. The magic cable should also be attached to the piezo on the motor at this point (not shown).*



Step 4: *Slide the constructed system into the PV (magic cable not shown).*



Step 5: *Put cap on, do not over tighten the 7/16" hex head bolts. The PV is now ready for pulsing.*

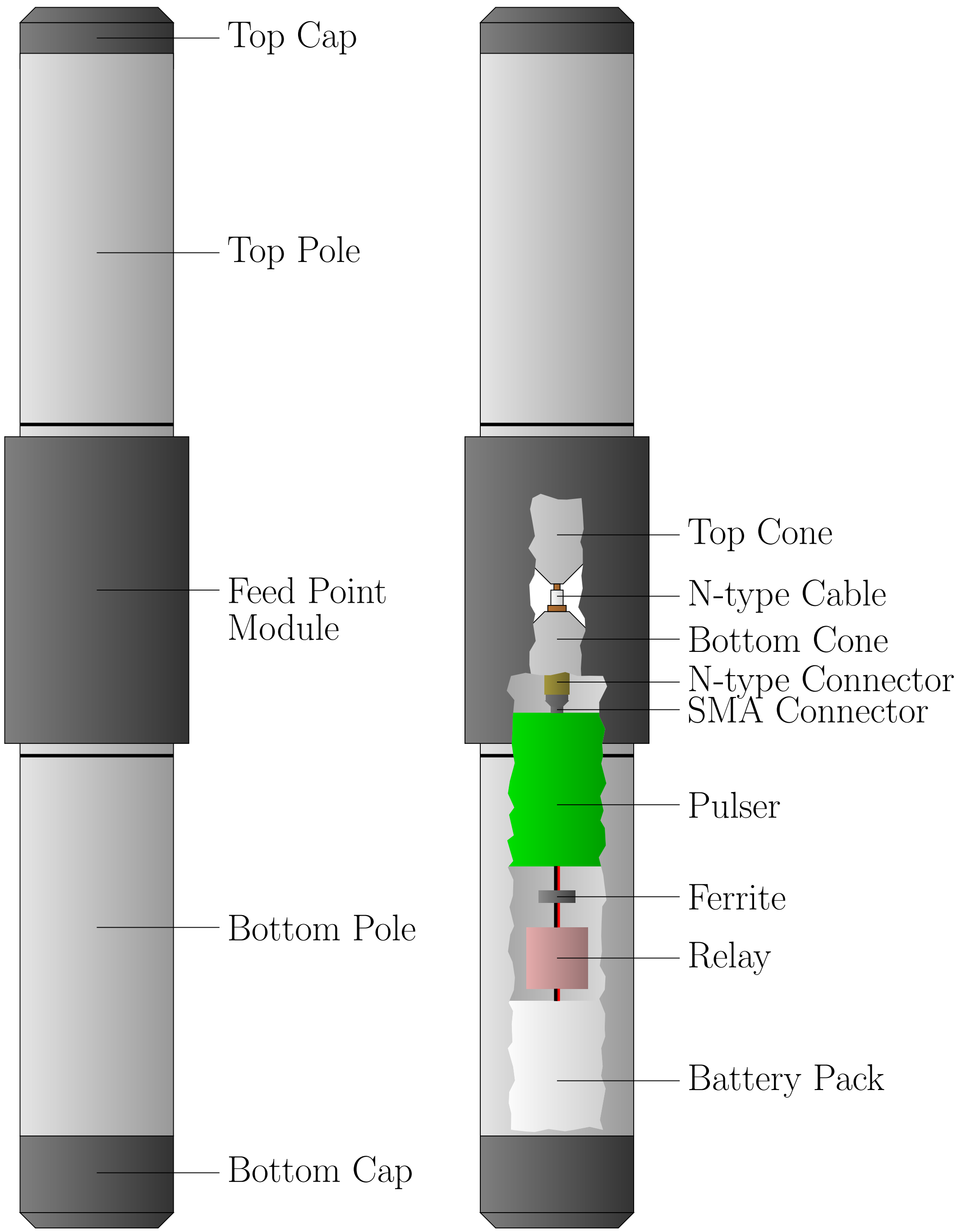


Figure 3.2: *Pressure Vessel Antenna setup (for both HVSP and IDL pulsers).*

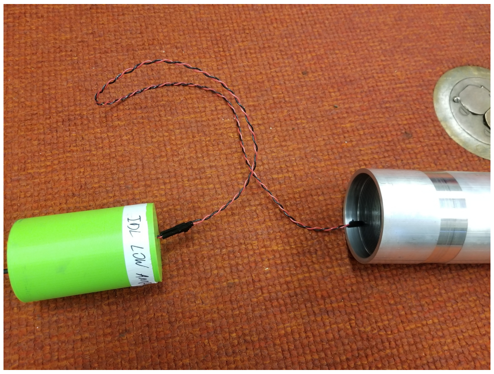
Step 1: *Attach N-Type female / SMA male adapter to N-type connector of the PVA feed-point.*

Step 2: *Attach pulser to the SMA male of the previous step.*

(a) *Attaching the pulser directly.*

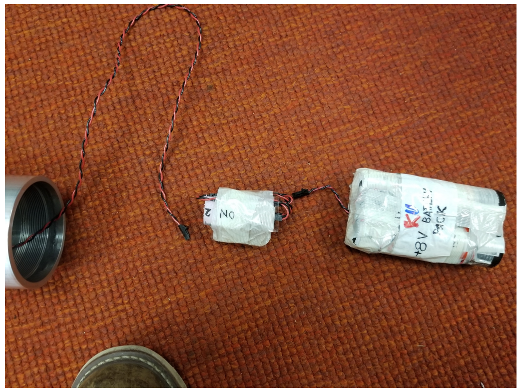
(b) *Using a SMA cable, only needed for the IDL pulser.*

Step 3: *Attach pole length female-female Molex cable to male Molex connector of the pulser (ferrite on the pole length cable is not shown).*



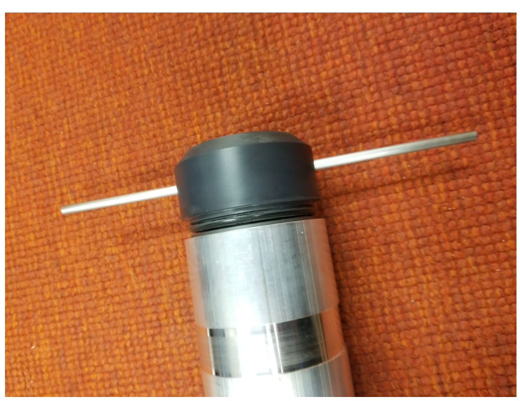
Step 4: *Feed pole length cable through the bottom pole (pressure vessel pole) and attach bottom pole to the feedpoint module.*

Step 5: *Attach pole length cable to male Molex connector of the relay marked **MOTOR** and attach the female Molex connector of the battery pack to the male Molex connector of the relay marked **BATT** (or BATTERY).*



Step 6: *Slide the relay and battery pack into the bottom pole.*

Step 7: *Twist bottom pole cap onto the bottom pole. The cap wrench (pictured) should help.*

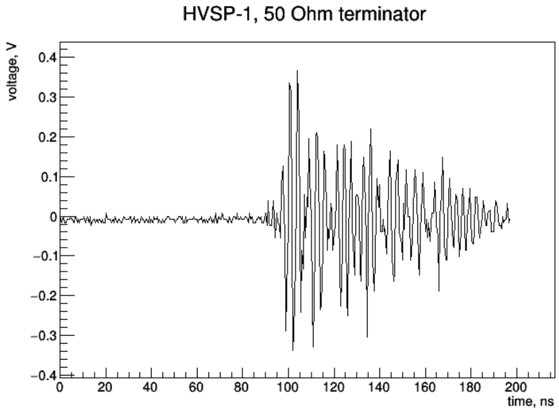


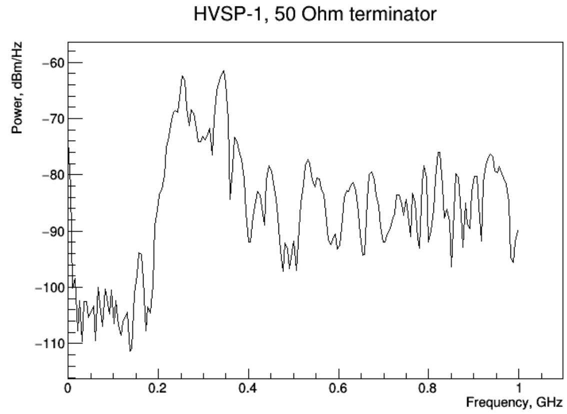
Step 8: *The PVA is ready for use.*

3.3. Extra: High Voltage Sparking Pulser with Terminator

In case things are failing, the HVSP can be armed with a terminator and placed in the PV.

Figure 3.3: *The HVSP-1 with terminator.*





(a) *Waveform.* **(b)** *FFT.*

Figure 3.4: *Example waveform and FFT of the HVSP-1 with terminator.*

4 Pulser Details

This chapter will cover expected pulser signal as viewed by an ANITA horn antenna.

The plots with black lines (top plots, example waveform and FFT) were taken at room temperature.

The plots with red-ish dots (max voltage, pulse width, and period) were taken with the pulser exposed to dry ice. Dry ice was placed around the PV or PVA and data was taken with the system cooling and then warming back up (the piezo data does not have the warming up part, due to complications). The temperature data logger was not working correctly for these tests, thus the data is not plotted as a function of temperature but rather time. Dry ice is at a temperature of about -79C, it is a reasonable assumption that the pulsers reached -60C at their coldest, it is likely they were colder than that.

4.1. Piezo Pulser - With Magic Cable

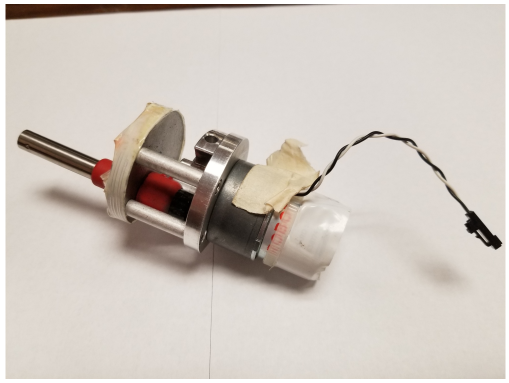


Figure 4.1: *Piezo pulser (clicker) with motor (magic cable not shown).*

Features:

- Period will increase as the motor temperature decreases (should not go over 7 seconds).
- Amplitude can increase or decrease.
- Pulse width typically will get wider at lower temperature.
- There will be after pulses from the piezo pulser.

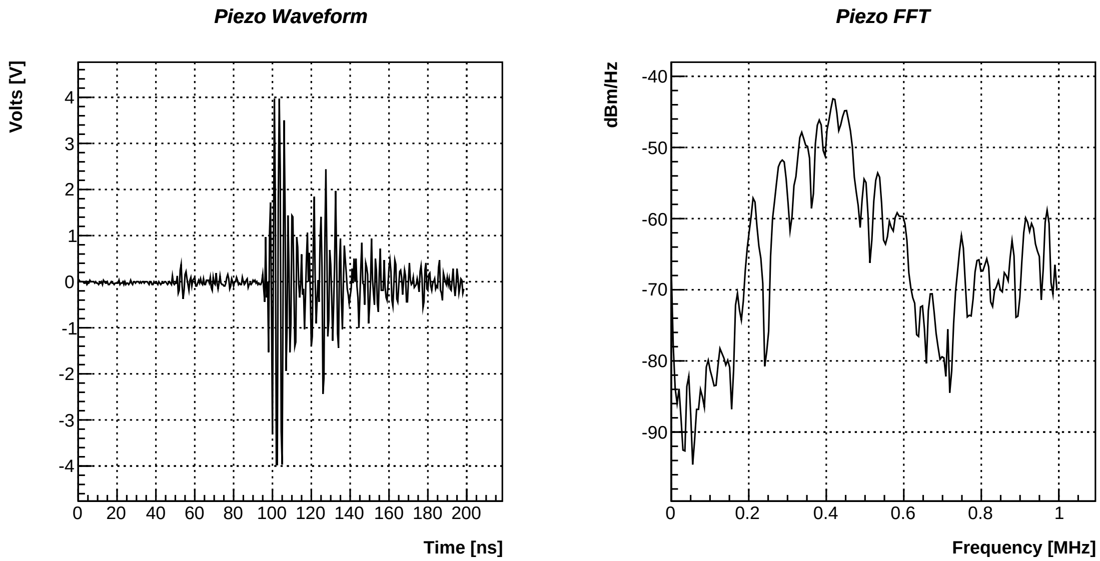
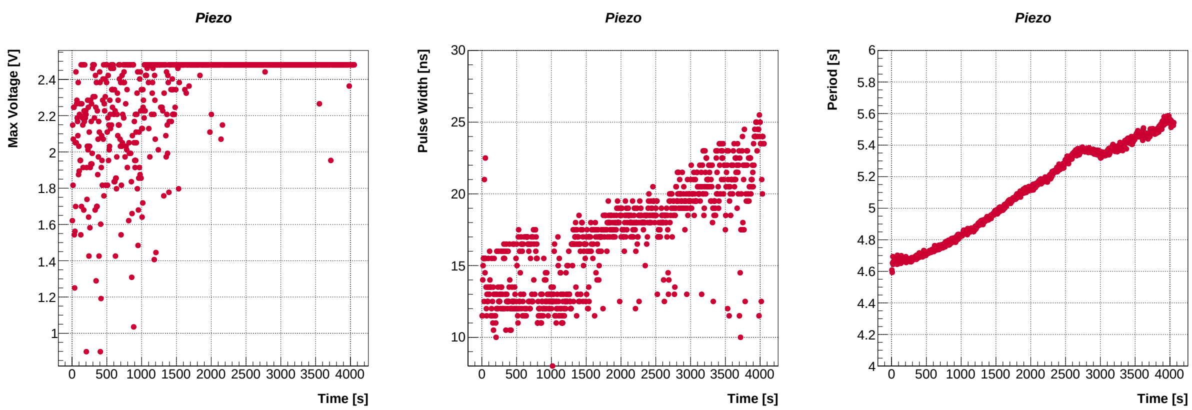


Figure 4.2: *Sample Waveform for a Piezo Pulser armed with the magic cable.*



(a) *Max Voltage.* **(b)** *Pulse width.* **(c)** *Period.*

Figure 4.3: *Piezo dry ice test. No warm up period in this data. Amplitude quickly rose and saturated the oscilloscope.*

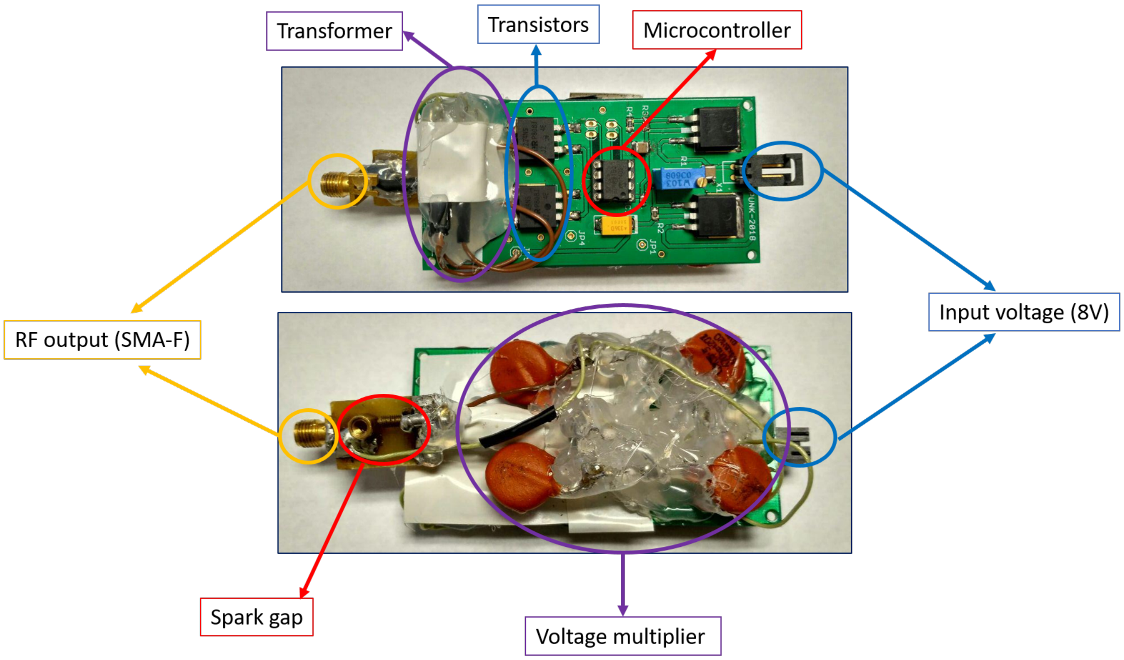


Figure 4.4: *HVSP pulser without case.*

(a) *HSVP-1.*

(b) *HSVP-2.*

Figure 4.5: *HSVP-1 and 2 in their cases.*

HVSP-1 (Black Case) (PRIMARY) Features:

- Extensively tested at cold temperture.
- Period is about 1 second. At low temperature the spark gap will increase and may cause the period to sporatically be an interger multiple of 1 second.
- Max voltage is about 2.5V and can vary with temperature (dependent on the period).
- Pulse shape is stable.
- There should be no after pulses from this pulser.

HVSP-2 (Green Case) (BACKUP) Features:

- Extra sparking may occur with this pulser, for example between the battery pack and the PVA bottom pole. No damage has been observed from this effect. A ferrite on the pole length cable helps reduce this. The battery pack has also been wrapped heavily in insulating tape to further reduce sparking.
- Period is about 1 second. At low temperature the spark gap will increase and may cause the period to sporatically be an interger multiple of 1 second.
- Max voltage is about 1.2V and can vary with temperature (dependent on the period).
- Pulse shape is stable.
- Cold performance not well known for this pulser (fixed sparking after initial test), should be similar to HVSP-1.
- There will be some after pulses with this pulser, it won't happen all the time.

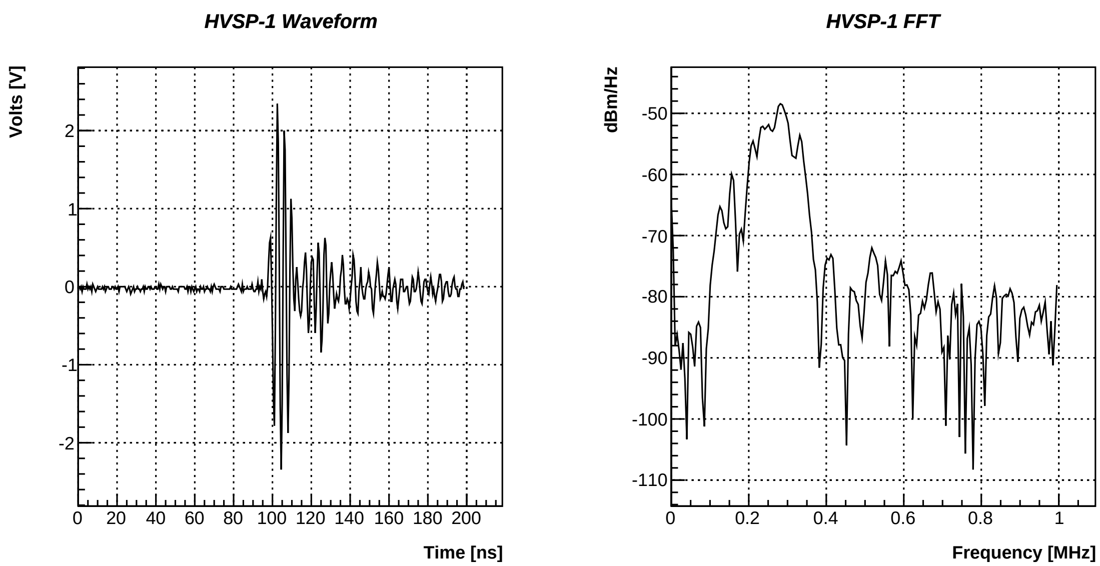
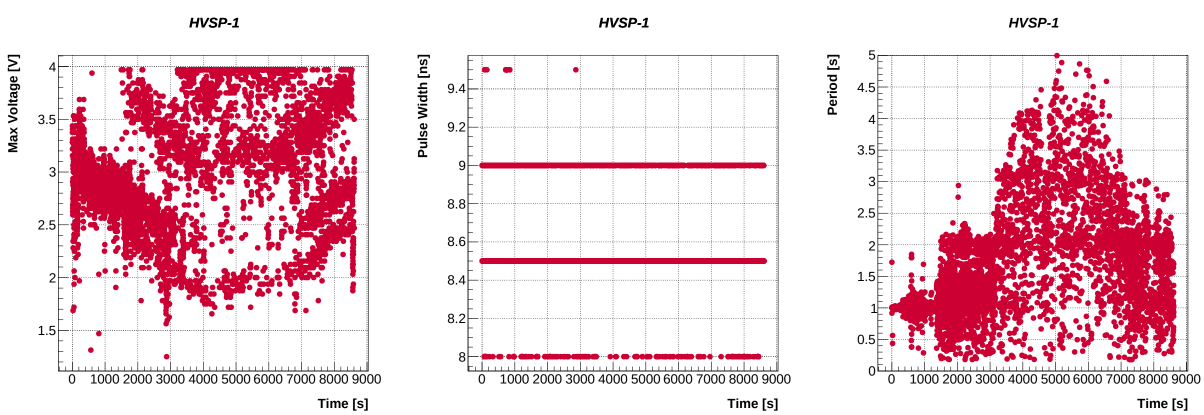


Figure 4.6: *Sample Waveform and FFT for the HVSP-1 Pulser.*



(a) *Max Voltage.* **(b)** *Pulse width.* **(c)** *Period.*

Figure 4.7: *HVSP-1 dry ice test. Quantization due to near integer periods can be observed.*

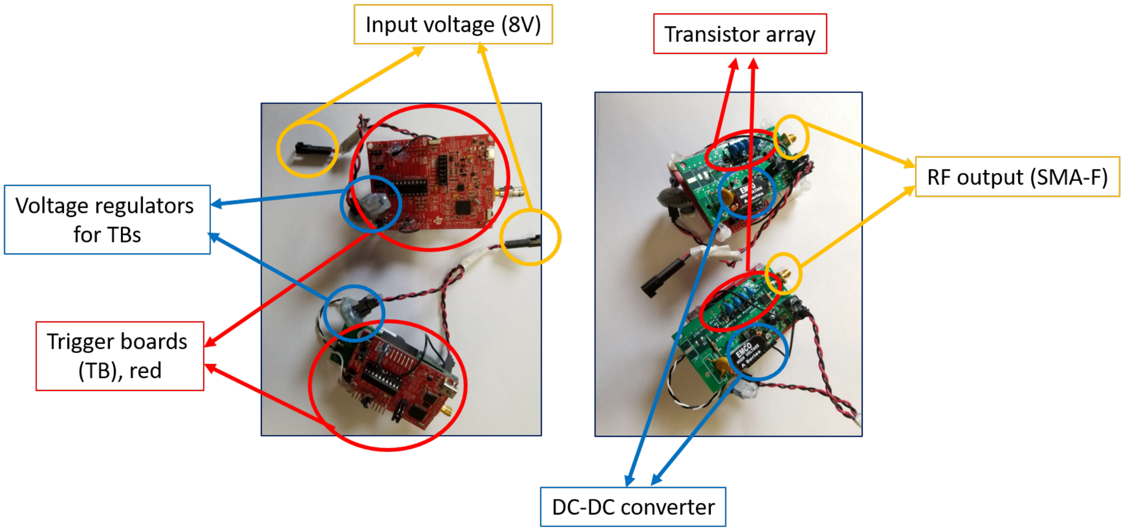


Figure 4.8: *IDL pulser without case.*

Figure 4.9: *IDL-1 in its case.*

IDL-1 (High Amplitude) (PRIMARY) Features:

- Period is stable at about 1 second.
- Max voltage is about 1V and can decrease with temperature.
- Pulse shape is stable.
- This pulser will likely take damage from the extreme cold, performance may degrade.
- There should be no after pulses from this pulser.

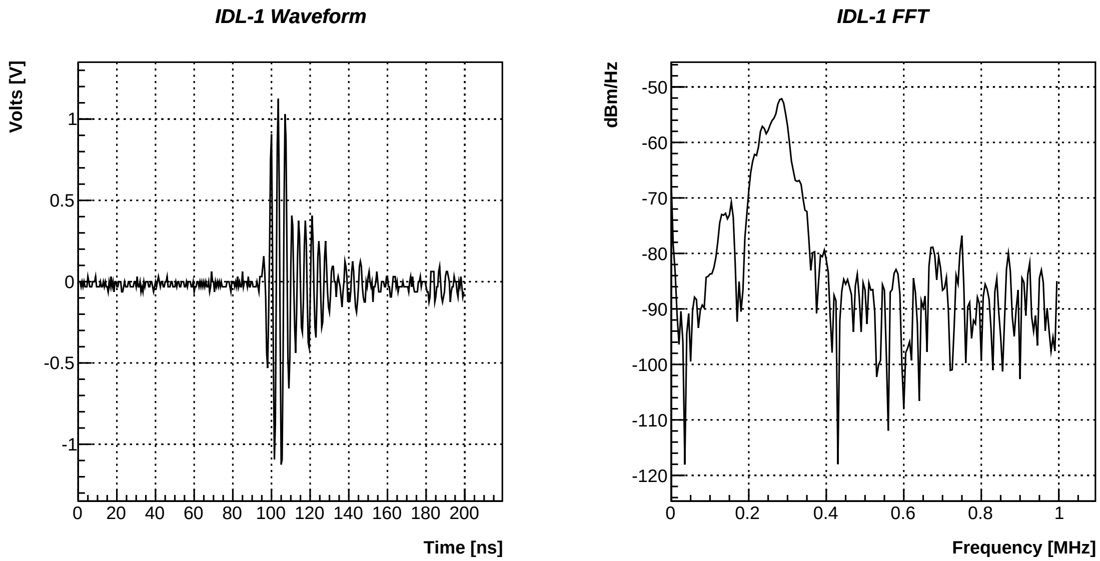
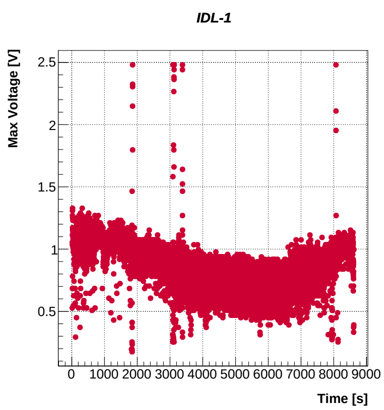
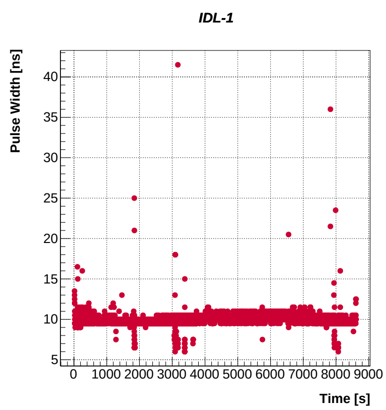


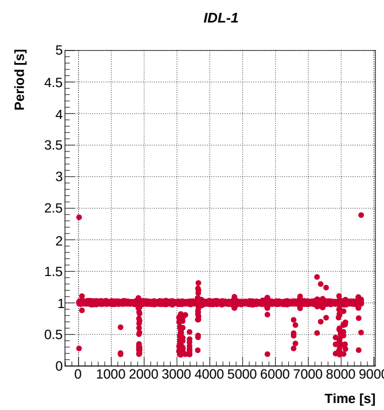
Figure 4.10: *A sample waveform and FFT for IDL 1.*



(a) *Max Voltage.*



(b) *Pulse width.*



(c) *Period.*

Figure 4.11: *IDL-1 dry ice test. Max voltage deceases with temperature.*

Figure 4.12: *IDL-2 in its case.*

IDL-2 (Low Amplitude) (BACKUP) Features:

- This pulser has a weak pulse of about 200mV peak voltage. This will likely not be picked up by all stations.
- Period is stable at about 1 second.
- Max voltage is about 1V and can decrease with temperature.
- Pulse shape is stable.
- This pulser has taken damage from the extreme cold of dry ice, further exposure to extreme cold will have unknown effects.
- There will be some after pulses with this pulser, it won't happen all the time.

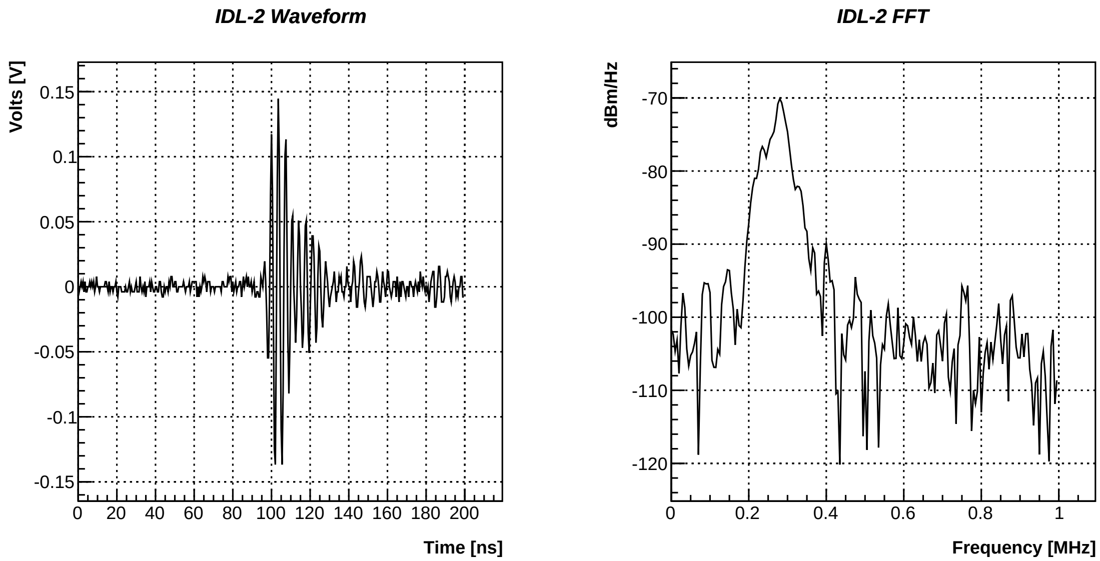
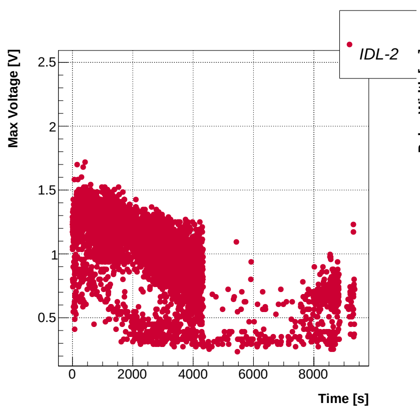
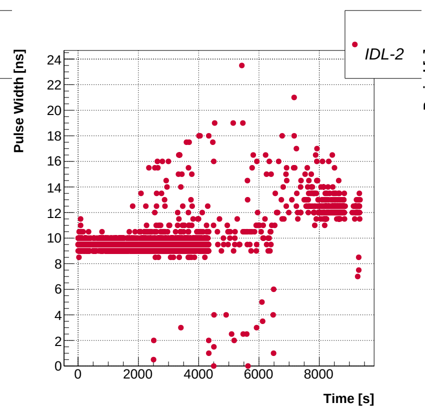


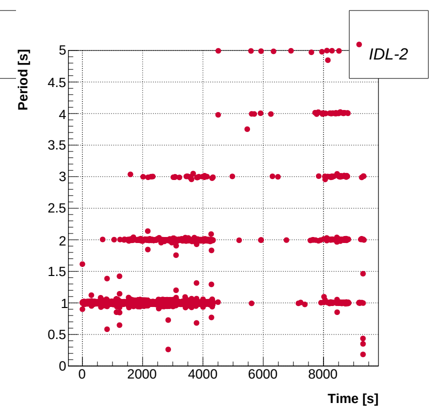
Figure 4.13: *A sample waveform and FFT for IDL 2.*



(a) *Max Voltage.*



(b) *Pulse width.*



(c) *Period.*

Figure 4.14: *IDL-2 dry ice test. Permanent Damage occurred here (noticeable in pulse width pole). Gap in data around 4000-8000 seconds is due to amplitude dropping below trigger threshold of the oscilloscope.*

5 Magnetic Switches (Relays)

As they are an essential piece of the SPICE picture, the relays (magnetically controlled switches in this case) will be covered in this section.

WARNING: Be careful what you plug into the relay. Only plug the batteries into the male Molex connector of the relay marked “battery”. Plugging the batteries into the male Molex connector labeled “motor” will damage the relay and will likely need repair.

TIP: The female Molex connectors that you will plug into the relay can stick at the top of the male connectors on the relay. The effected area has been filed down to ease this problem. In the case of difficulty disconnecting it may help to push down (the top being the side with the push disconnect) slightly on the female connector while trying to pull it out.

6 Lead-Acid Battery

The lead-acid batteries will now be covered in some detail.

6.1. Cautionary Notes

Fuses for the pulser power circuit have not been fully explored and thus are not included. It is important to treat all cables in a loving manner. In the event of a short circuit, the wires closest to the batteries are likely to burn up first. This could be problematic for the battery pack since the wiring linking them in series is encased in the tape that holds together the pack (high heat concentration, possible permanent damage to battery). Both IDL and HVSP pulsers stand a good chance to survive a melt down however (from experience).

6.2. Charging

Each battery (see Figure 2.10) should have a nominal voltage of 2V when charged, a true voltage of about 2.1V should be expected.

The lead-acid batteries can be charged in a number of "correct" ways, only the constant voltage method will be covered as it has the shortest charging time.

When charging, a constant voltage of 2.45-2.5V for each battery should be used. For example, the battery pack (see Figure 2.11) is four batteries in series, to charge them all simultaneously apply 9.8-10V to the pack. Deviating from this voltage range is said to reduce the longevity of the batteries.

Current does not need to be limited, the batteries will take whatever can be supplied (up to their maximum current absorption, which depends on charge level of the batteries). With the batteries highly discharged a max current of 4A has been observed, although only for the first few minutes. The current will start out maximal or will become so within a short period after applying the charging voltage. This current will degrade over time as the battery gets charged. When the batteries are charged a current of a little less than 0.25A should be expected, this is the holding current and is for the most part not actually charging the batteries. Once close to 0.25A it is okay to stop charging as there will be little charge gain from that point on.

The normal charing time (for unlimited current and almost completely discharged batteries) should be about an hour and a half.

7 Surface Monitoring

To start the surface monitor program follow these steps:

1. Open a terminal (Ctrl+T)
2. Navigate to the program's directory: `cd /home/kuap2/spice/surface_mon`
3. Execute the program: `./surface_monitor [output file name ending] [time division (ns/div)] [trigger threshold (V)] [Chan 1 voltage division (V/div)] [Chan 2 voltage division (V/div)]`
   - Items in brakets [ ] are arguments for the `surface_monitor` program, colors are used to help distinguish arguments.

NOTES:

- If the program is crashing, try the original version of the program: `./backup_surface_monitor`. Which takes the same arguments.
- If the program has errors that say something about an inability to find the GPIB device, it may help to reinstall the GPIB drivers:
  1. `cd /home/kuap2/spice/gpib_stuff`
  2. `sudo ./buildgpib`
- After running the surface monitor code the oscilloscope will be in a "locked" state. Either turn off then turn on the oscilloscope or execute: `./reset` (in the `/home/kuap2/spice/surface_m` directory).

8 Processing AraRoot .tar.gz Files Into .root Files

1. Go the AraData directory.
2. Go to the dummy tar data directory. Transfer the `.tar.gz` file that you have into this directory. The `.tar.gz` file is the file that you will get from the ARA stations.
3. Then make directory for the station X (i.e. `ARA0X`) whose file you will be looking at. Right now in AraData you have a directory for ARA02.
4. In the `ARA0X` folder then make two directories.
   a) `raw_data`
   b) `root`
5. Go to the `raw_data` directory. Transfer the executable `makeshfile` from `AraData/ARA02/raw_data` to `AraData/ARA0X/raw_data`.
6. In the executable:
   a) `start` and `till` are the variables that describe the range of the run numbers you are looking at. If you have a file for just one run then `start=till`.
   b) Give the correct address in `PRINT_ARG1` to your `.tar.gz` file.
   c) Replace all the `ARA02` with `ARA0X` where X is the station number you are currently looking at.
   d) If you are looking at a FILTERED file then make sure all the FILTERED commands are uncommented. If you are looking at CALIBRATION file then make sure all the CALIBRATION commands are uncommented.
7. Run the executable by doing: `bash makeshfile`
   a) It will make another bashscript called `extractFiles.sh` and then run it.
   b) The second script will untar the `.tar.gz` file for you and remove any extra files that you would not need.
8. Go back to the AraData directory and open the runAtriFileMaker.sh file.
   a) Set the correct `RAW_BASE_DIR`
   b) Set the correct `ROOT_BASE_DIR`
   c) `RAW_BASE_DIR` and `ROOT_BASE_DIR` are your `ARA0X/raw_data` and `ARA0X/root` directories
9. Once you have done that then just do the following:

   a) For example if you have run 12248: `bash runAtriFileMaker.sh 12248`
   b) This will convert the `raw_data` into the root file for you

10. Your root file will be found `ARA0X/root` directory under the run folder.

A Full Inventory

A.1. Dave's Cache

[1]

1. 1x Agilent Technologies DSO6102A Oscilloscope + power cord + GPIB to USB cord
2. 2x Dell Latitude E5510 Laptop + charger cords
3. 1x Tube of Molykote 33 medium (O-ring grease)
4. 3x Piezo magic cables
5. 1x Standard spur gear motor (20RPM @ 12V)
6. 2x SMA male terminator[1]
7. 1x N-Type male to SMA female adapter[1]
8. 1x N-Type female to female bulkhead connector[1]
9. 2x BNC female to SMA male adapter[1]
10. 2x BNC female to N-Type female adapter[1]
11. 2x N-Type female to SMA male adapter[1]
12. 1x BNC male to SMA female adapter[1]
13. 1x N-Type female to female connector[1]
14. 2x N-Type female to BNC male adapter[1]
15. 1x N-Type terminator[1]
16. 2x N-Type male to BNC female adapter[1]
17. 1x N-Type female to female connector[1]
18. 1x SMA male to male connector[1]
19. 2x Mini-circuits NHP-150
20. 1x Mini-circuits NHP-100
21. 1x Mini-circuits BHP-200
22. 1x Mini-circuits BHP-400
23. 3x N-Type female to female bulkhead connector
24. 1x N-Type female to SMA male adapter
25. 1x PVA top pole
26. 1x PVA bottom pole
27. 1x PVA feed point module
28. 1x PVA top cap
29. 1x PVA bottom cap
30. 1x PVA 1" spacer
31. 2x PVA 1/2" spacer
32. 2x PVA 3" 1/4-20 bolt
33. 8x PVA O-rings
34. 1x PVA top cap wrench
35. 6x MSR piezo sparker

[1] part of compartmentalized plastic box

36. 2x Motor
37. 3x Pole length cable
38. 2x SMA male to female cable
39. 3x ring ferrite
40. 2x clam shell ferrite
41. 2x Inline-4 battery connector cable
42. 1x Molex male to male cable
43. 4x Lead-acid 2V batteries
44. 3x Molex male shorters
45. 2x SMA terminator
46. 1x Molex male split to 2 females
47. 1x High-power neodymium magnet
48. 1x Magnet wand
49. 4x NPN transistors (spares for IDL pulser)
50. 10x Zener diodes (spares for IDL pulser)

A.2. Ilya's Cache

1. 3x SMA high pass filter
2. 1x BNC high pass filter
3. 1x 20 dB attenuator
4. 2x N-Type female-female connector
5. 2x Notch filter 450MHz
6. 2x Bias T 1-1000MHz
7. 1x 15V amplifier 1-1000MHz
8. 1x 12V amplifier 1-1000MHz
9. 1x 15V amplifier 1-600MHz
10. 1x "AMP 130" 3.3V amplifier (brass bar)
11. 1x Topward Electric Instruments Co. LTD. power supply (0-30V, 0-6A) + power cord
12. 1x FID GmbH pulser (model: FPG 5-1KN, Serial: FPG2008000012) + power cord
13. 2x PV tube
14. 6x PV cap
15. 48x 7/16" Hex head 1/4-18 bolts (for PV cap)
16. 1x RICE warmer
17. 1x taller copper bicone antenna
18. 1x shorter copper bicone antenna
19. 1x Fluke 79 III true RMS multimeter + leads
20. 1x N-Type male to SMA male adapter
21. 1x RICE nylon tube
22. 1x RICE nylon cap
23. 1x RICE nylon cap with feed through
24. 1x RICE aluminum cap with feed through
25. 1x Mini-circuits BHP-100
26. 1x Mini-circuits SHP-200
27. 1x 7/16" Hex head screwdriver
28. 5x PV O-rings

B Pressure Vessel Schematics

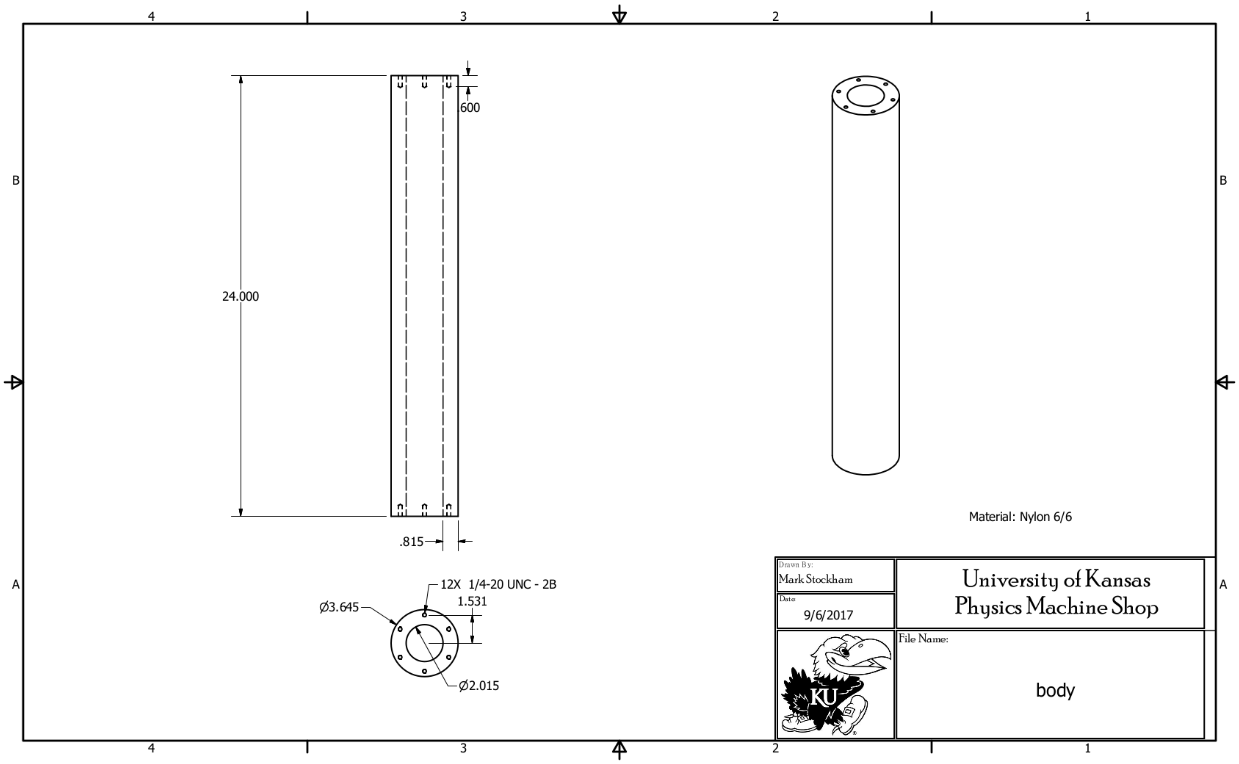


Figure B.1: *Nylon PV body.*

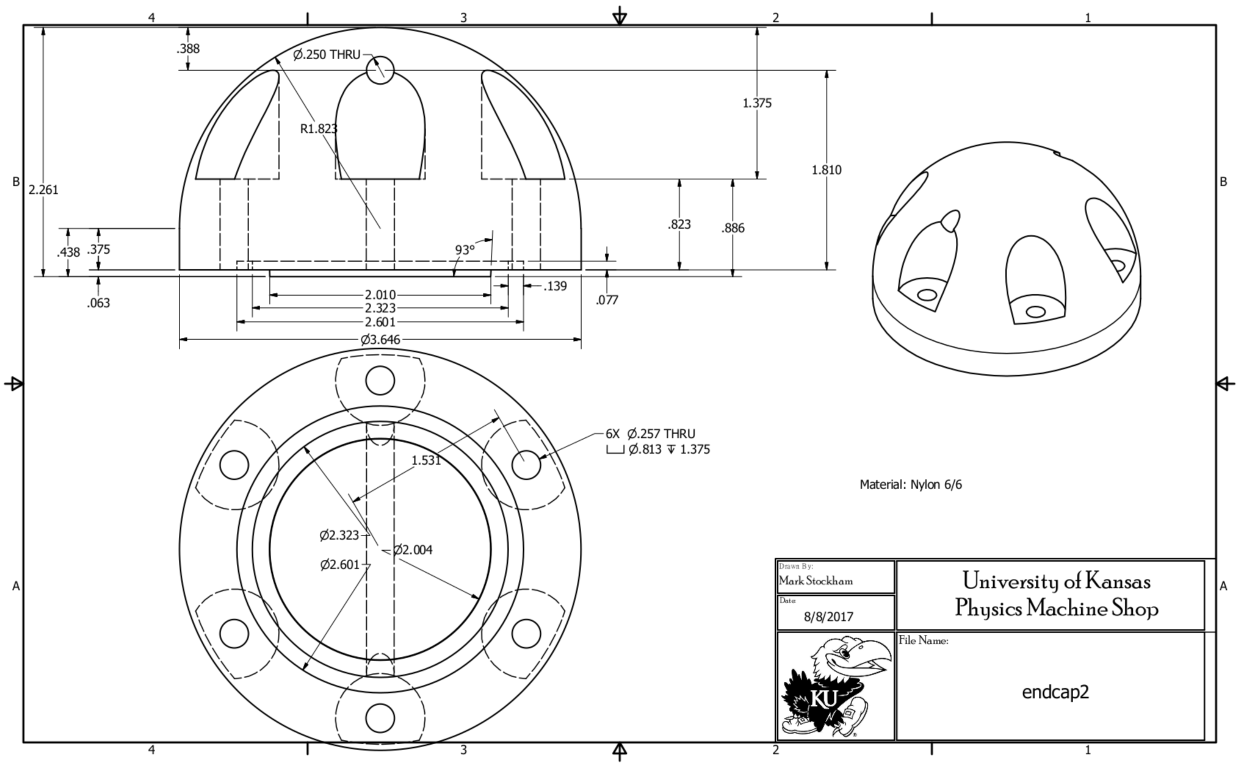


Figure B.2: *Nylon PV cap.*

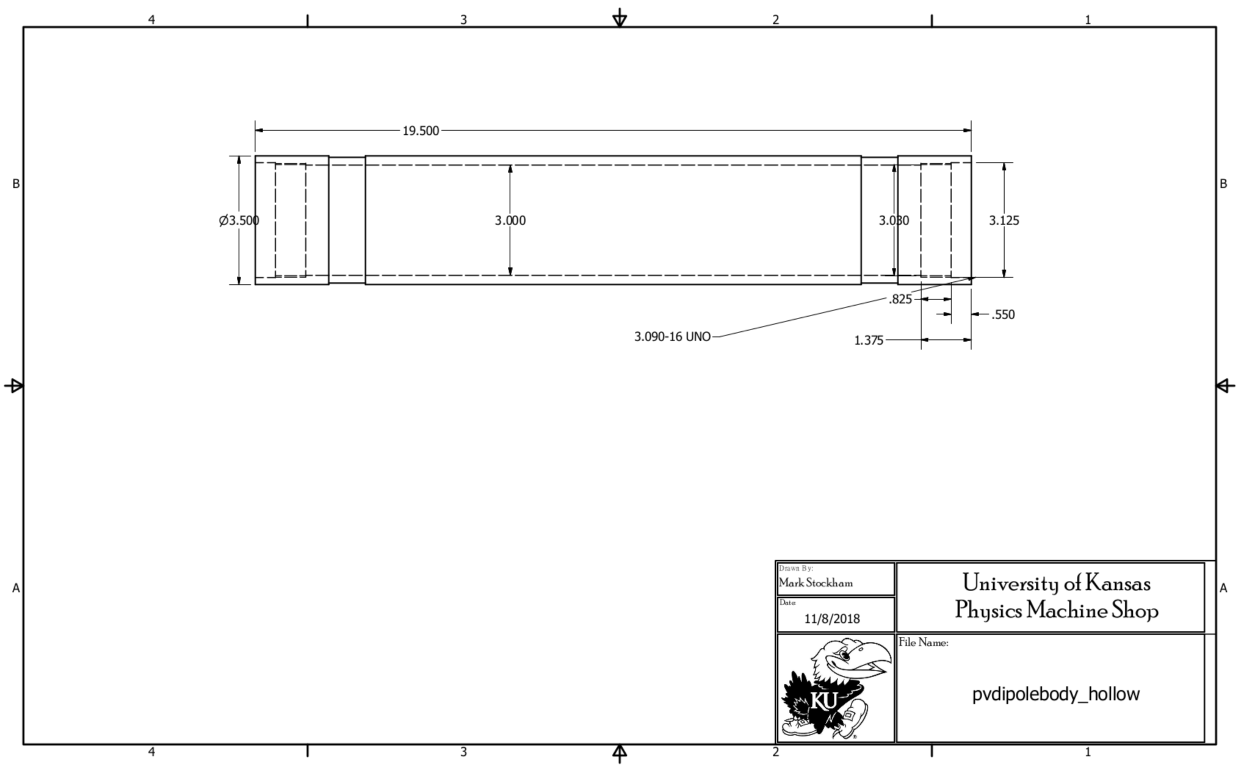


Figure B.3: *Aluminum PV/Antenna body.*

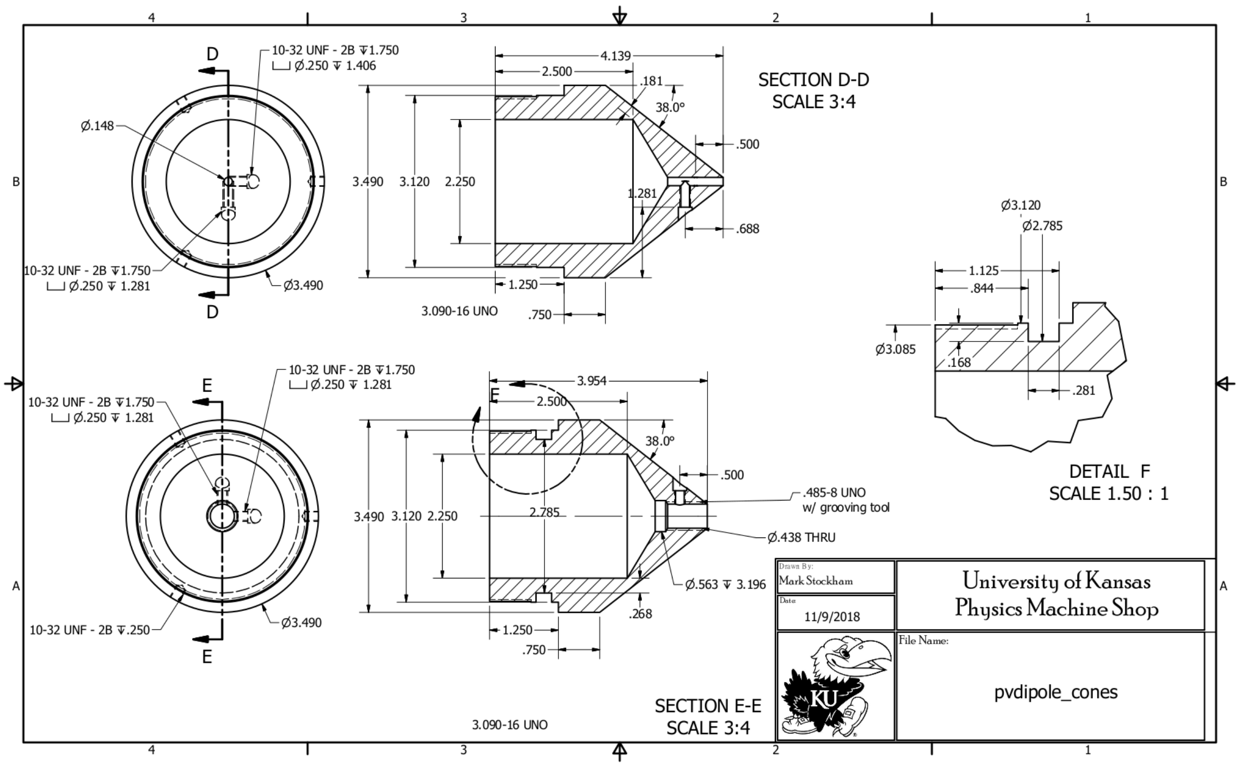


Figure B.4: *Aluminum PV/Antenna cone.*

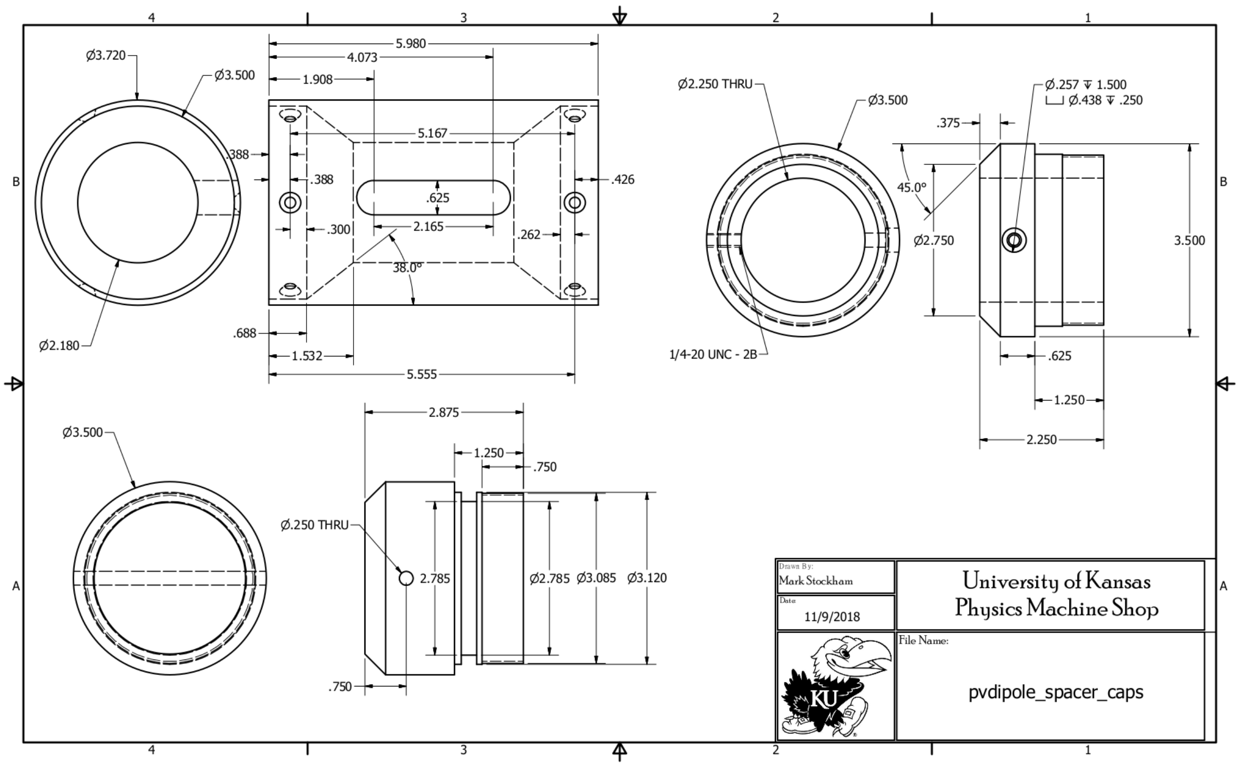


Figure B.5: *Aluminum PV/Antenna spacer and caps.*