MISSILE WORKS CORPORATION

Scratch Builders Supplement
Model RRC² - Rocket Recovery Controller

Overview

This document is targeted towards individuals who have had previous electronic prototyping and assembly experience. It is also assumed that you have familiarized yourself with the operation and operating precautions of the RRC² by thoroughly reading the User Manual and Operating Instructions included. Along with this supplement, you've received the RRC² preprogrammed MCU (U1) and the RRC² schematic. Through careful step-by-step assembly, the user can build up a custom rocket recovery control system to provide the exact level of functionality desired. You'll also have the satisfaction of building, testing, and ultimately flying with a recovery controller that you've scratch built yourself.

Handling Precautions

These components are sensitive to damage from ESD (electro-static discharge) and should always be handled in a properly grounded environment.

Parts List

Below is the complete list of parts and recommended parts suppliers to build up a fully functional RRC². This supplement will outline optional configurations for constructing the RRC² which do not require all of the parts listed below.

Digi-Key Corporation
701 Brooks Ave. South
Thief River Falls, MN 56701-0677
Tel: 800-344-4539 Fax: 218-681-3380

Part	Quantity	DigiKey #'s	RRC² part #'s
Transistor 2N3904	2	2N3904DICT-ND	Q4,Q5
1000uF 16V Cap	1	P5142-ND	C1
220uF 10V Cap	1	P5124-ND	C2
1 uF Tant 16V	2	P2105-ND	C3,C4
.1 mfd U1 Bypass capacitor	1	P4923-ND	U1 Bypass
100pF COG 50V	1	P4925-ND	C5
ZVN4306A FET	2	ZVN4306A-ND	Q1,Q2
LM340T-5.0 Reg	1	LM340T-5.0-ND	Q3
1N4004 Diode	1	1N4004DICT-ND	D1
T-1 LED RED	1	LT1139-ND	D2
4 Pos DIP Switch	1	CKN3066-ND	S1
10K Resistor 5%	6	10KEBK-ND	R2,4,5,8,14,15
10K Resistor 1%	4	10.0KXBK-ND	R16-19
3.3K Resistor 5%	1	3.3KEBK-ND	R13
3.3K Resistor 1%	2	3.32KXBK-ND	R9
1K Resistor 5%	2	1.0KEBK-ND	R1,6
300 ohm Resistor 5%	1	300EBK-ND	R10
100K Resistor 5%	2	100KEBK-ND	R3,7
61.9K Resistor 1%	1	61.9KXBK-ND	R11
130K Resistor 1%	1	130KXBK-ND	R12
LM385Z Voltage Ref	1	LM385Z-ND	U3
18 pin U1 socket	1	ED3118-ND	U1 socket
Terminal Block 2 Pos	3	277-1247	J1-J3

Allied Electronics Inc.
Tel: 800-433-5700

Part	Quantity	Allied #'s	RRC2 part #'s
Transistor 2N3904	2	858-8253	Q4,Q5
1N4004 Diode	1	858-0144	D1
4 Pos DIP Switch	1	676-7012	S1
LM385Z Voltage Ref	1	288-1350	U3
LM340T-5.0 Reg	1	288-1304	Q3
MPX5100A	1	858-4893	U2
Harris ICL7611DCPA	1	ICL7611DCPA	U4
Keystone 1291 9V batt clip	1	839-4055	9V BATT
Mallory Piezo PK-12N40P	1	854-6814	PA1

Radio Shack
1-800-THE-SHACK

Part	Quantity	Radio Shack #'s	Catalog Page	RRC² part #'s
Transistor 2N3904	2	267-2106	194	Q4,Q5
1000uF 16V Cap	1	272-958	201	C1
220uF 10V Cap	1	272-1017 or 272/956	201	C2
1 uF Tant 16V	2	272-1434	201	C3,C4
100pF COG 50V	1	272-123	201	C5
7805-5.0 Reg	1	276-1770	193	Q3
1N4004 Diode	1	276-1101	195	D1
T-1 LED RED	1	276-026	196	D2
4 Pos DIP Switch	1	RSU 11911955	191	S1
10K Resistor 5%	6	271-1335	200	R2,4,5,8,14,15
10K Resistor 1%	4	RSU 11346061	200	R16-19
3.3K Resistor 5%	1	271-1328	200	R13
3.3K Resistor 1%	2	RSU-11345857	200	R9
1K Resistor 5%	2	271-1321	200	R1,6
300 ohm Resistor 5%	1	RSU 11344744	200	R10
100K Resistor 5%	2	271-1347	200	R3,7
130K Resistor 1%	1	RSU 11346376	200	R12
Terminal Block 2 Pos	3	276-1388	190	J1-J3
9 Volt Holder & connector	1	270-326 & 270-325	184	9V BATT
18 pin U1 socket	1	276-1992	189	U1 socket
.1 mfd U1 Bypass capacitor	1	272-135 or 272-109	201	U1 Bypass
Piezo Beeper	1	273-065 or 273-078	181	PA1

Some additional notes on ordering components

The parts lists and suppliers listed herein are provided as a general guideline for purchasing the necessary components for this project. There is intentional part duplication between these suppliers. Some mail order suppliers have minimum dollar amounts for purchases, so you will have to decide which parts you purchase from which supplier to make the required order minimums.

There are other mail order or local electronics suppliers that can provide adequate components for your project. Call around and investigate all of your options.

Component Orientation and Pinouts
Please refer to Figures 1 through 7 for information regarding the orientation and pinout of all the devices used for the RRC². If possible, request copies of the component data sheets from your parts supplier.

Fabrication Methods
There are several methods that one could use to fabricate the electronics. Fiberglass prototyping boards with component holes on 0.1" centers are recommended. You might also consider investing in some pressure fit solder posts. These posts insert into the 0.1" center holes and allow you to solder the component leads on one side of the board, and to make all the interconnections on the opposite side. Wire wrapping is also an option. Try to keep the lenghts of all interconnection wiring as short as possible to improve the overall noise immunity of your unit. If you're real ambitious and have the resources, you could even design your own printed circuit board.

Whichever method you choose for fabrication, you should pay close attention to the overall size of the board required. Several factors will dictate the size requirements:

- The size of the rocket airframe and the payload section
- The amount of room required for all of the necessary components
- The relative locations of the components on the board to allow clearance in the airframe

It's a very good idea to layout the components on your board prior to actually fabricating the board to ensure there is adequate room and clearance for all the necessary components. Good soldering skills are also necessary for success, and having a good soldering iron helps as well. Do not attempt to fabricate your project with a high-wattage soldering gun, as you will very likely have sloppy connections or damage the components with excessive heat. Do not use acid core solder for this project. Rosin and rosin core solder is OK.

Fabrication Supplies

Radio Shack (catalog pg. 180)

Prepunch Perfboard	276-1395 (2.75" x 6")
30ga wire for wrapping	278-501 (red) / 278-502 (white) / 287-503 (blue)
Wire Wrapping tool	276-1570
Wire Wrapping posts	276-1987

Digi-Key (catalog pg. 453)		*Allied (catalog pgs. 885-888)*	
Vector Prepunch Board	V1043-ND (4.5" x 6.5")	Vector Prepunch Board	977-1212
Vector Klipwrap terminals	V1075-ND	Vector Klipwrap terminals	977-5060

Construction options
You have the option of building the RRC² in several different configurations, allowing you to tailor the final product to your exact needs. The assembly steps are organized to allow you to easily differentiate your component requirements for the various configurations of the unit. Here are the potential configurations you can consider for construction:

- ***Peak altitude altimeter with no recovery system***
  This configuration will record the peak altitude of your rocket flight and relies upon the motor ejection charge or other electronic methods to deploy your recovery system. Perform assembly steps 1-5.
- ***Dedicated redundant apogee mode or dedicated two stage recovery***
  You can eliminate some or all of the configuration switches if you wish to construct a unit with a dedicated recovery function. Refer to step 4 for specific details
- ***Single recovery stage electronics***
  If desired you may also eliminate either of the two recovery stages. Perform step 6 only for single stage apogee deployment, or step 7 for single stage 1000' or 500' AGL deployment.

Steps for Assembly
The following represents the recommended progression of assembly steps for easy and successful fabrication of the RRC². Although it's not absolutely necessary that these steps be followed, they are provided as a guide for methodical and modular construction.

Building and testing the unit using the steps provided will allow you to troubleshoot and isolate potential problems during the construction phase on a smaller and simpler level, rather than building the entire unit at once and potentially having to deal with several problems. All voltage measurements made in the following steps are referenced to ground.

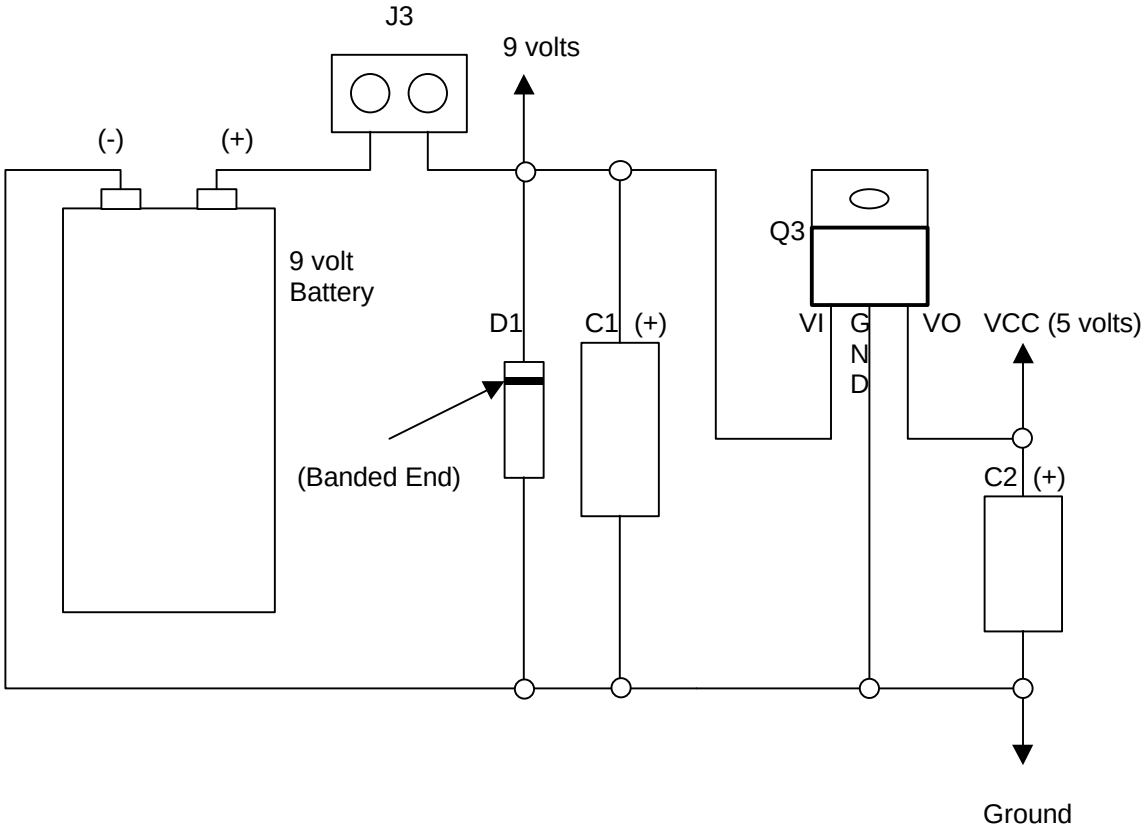
Step 1 – Power Supply (Figure 1)

Parts for this section
J3 External Switch Terminals
D1 1N4001 Diode
C1 1000 mfd capacitor
C2 220 mfd capacitor
Q3 7805 regulator

This section provides the necessary 5V power for the MCU. The 7805 regulator takes the 9V battery voltage and regulates it down to 5V. The capacitors act to stabilize the voltage output. The diode protects the circuit from accidentally connecting the battery backwards. Additionally you can add a terminal block to connect an external on/off switch.

After the power supply section is assembled, connect a 9V battery and measure the output of the 7805 regulator. It should read approximately 5V. This 5V is the VCC voltage depicted on the schematic.

Figure 1. Power Supply Physical Connection Diagram



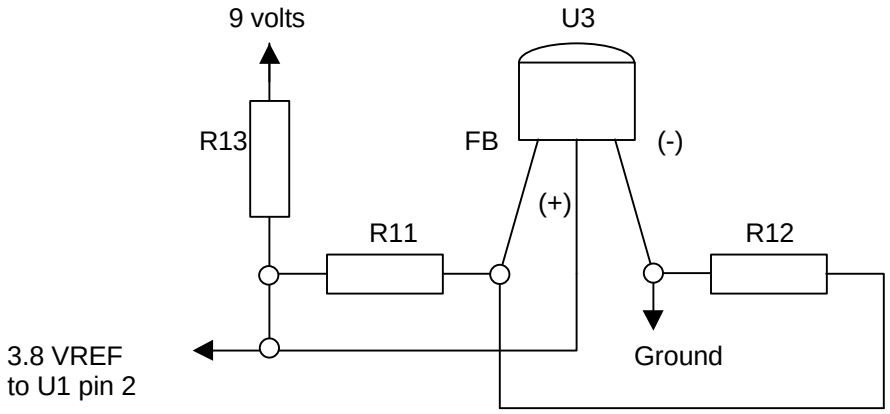
Step 2 – Voltage Reference (Figure 2)

Parts for this section
U3 LM385 Regulator
R11 61.9K ohm 1% resistor
R12 130K ohm 1% resistor
R13 3.3K ohm 5 % resistor

The voltage reference circuit provides the necessary operational reference of the A/D converter of the MCU. The reference voltage should provide approximately a 3.8V level. There will be some negligible variation in this voltage due to the tolerance of the parts, however this variation should not exceed 1%. The altimeter pressure table in the MCU assumes a reference voltage of 3.8V!

After the voltage reference circuit is assembled, connect a 9V battery and verify the 3.8V output of the LM385 regulator.

Figure 2. Voltage Reference Physical Connection Diagram



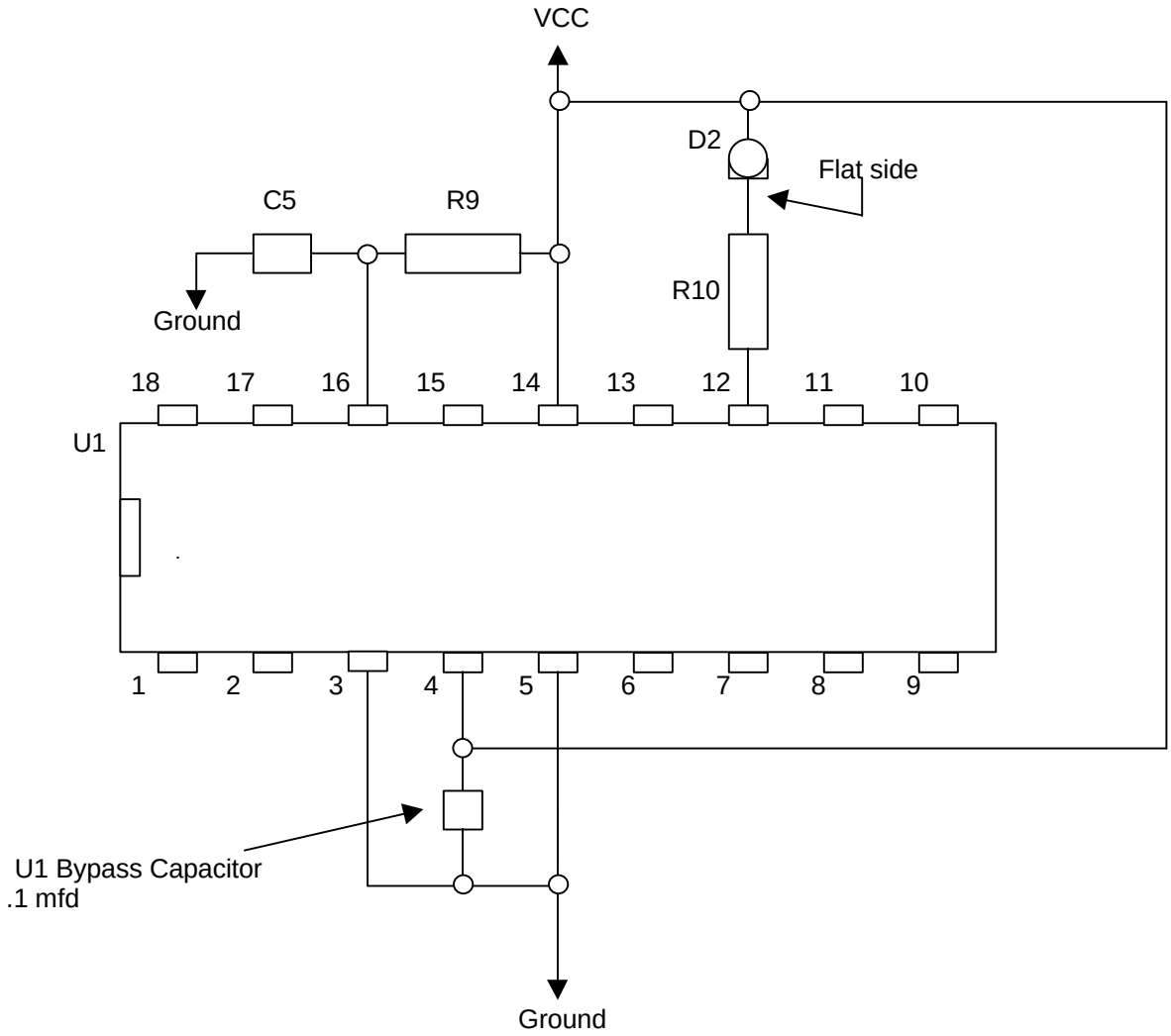
Step 3 – Clock / Status LED / MCU Power (Figure 3)

Parts for this section
C5 100 pf capacitor
R9 3.3K ohm 1% resistor
R10 300 ohm 5% resistor
D2 LED

Connect the clock timing components (C5 and R9) to the OSC input (pin 16) of the MCU. Also connect the LED and current limiting resistor (R10 and D2) to pin 12 of the MCU. Now that all of the necessary voltage sources are ready, it's time to connect them as well. The 5V VCC voltage connects to pins 4 and 14. The reference voltage connects to pin 2. Ground is connected to pins 3 & 5. Connect the status LED to pin 12.

Now power up the unit by connecting the 9V battery. If all is successfully connected, the LED will begin to flash at a rate of 5 times per second for 15 seconds, and then it will shut off (due to a sensor failure alarm as we have yet to connect it. Refer to the RRC² User Manual for specific operation of the LED).

Figure 3. Clock / Status LED / MCU Power Physical Connection Diagram



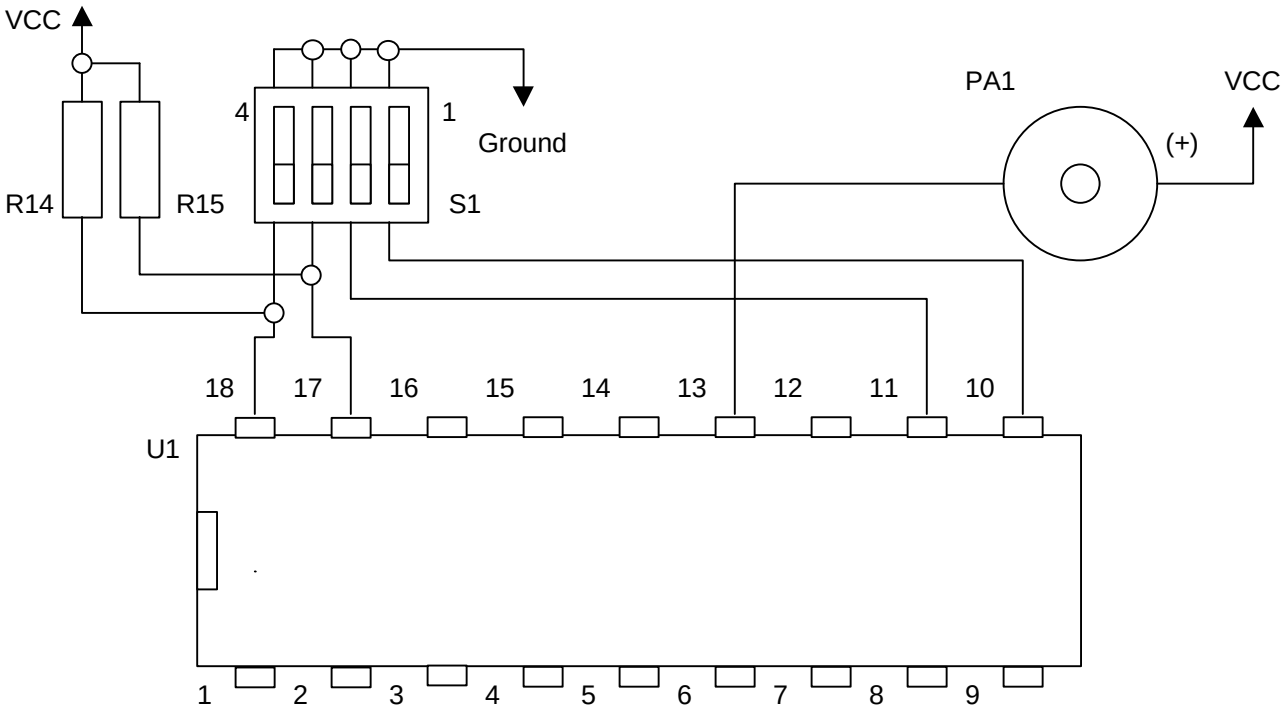
Important Note
Due to the variety of electronic prototyping techninques you may employ in the construction of you unit, we recommend the use of a bypass capacitor on the 5V power source of the MCU. This capacitor needs to be installed as close as possible to the MCU with the shortest length leads you can manage. Connection between pins 4 & 5 or between 4 & 14 are the best locations. Also wiring the MCU power and ground direct to the 5V regulator and battery ground will improve the overall noise immunity of your unit.

Step 4 – Switches and Piezo Beeper (Figure 4)

Parts for this section
R14 10K ohm 5% resistor
R15 10K ohm 5% resistor
S1 DIP Switch (4 pos)
PA1 Piezo Beeper

Now that you've verified the functional status of the MCU, you should now wire in the switch bank and the piezo beeper. After these items are connected, apply 9V battery power. You should be able to conduct the input test mode as outlined in the RRC² User Manual.

Figure 4. Switches and Piezo Beeper Physical Connection Diagram



Design Options
Depending on your personal preferences, you could eliminate some or all of the switches on the unit. The following section outlines the switch options:

- If you never plan on using the mach delay feature of the RRC², then switch 3 and 4 could be eliminated, along with R14 and R15. Instead wire the MCU pins 17 & 18 directly to the 5V VCC source.
- If you wish to build the unit as a dedicated apogee-only deployment device or as a dedicated two-stage recovery deployment device, then you could eliminate switch 2. Wire pin 11 of the MCU to the 5V VCC source for the dedicated redundant apogee only deployment device, or to ground for the dedicated two stage recovery deployment device.
- If you've chosen to build a dedicated apogee only deployment device, then switch 1 could be totally eliminated. Likewise if you have decided to build a two stage deployment device, you could eliminate switch 1 by permanently choosing a second stage deployment altitude. For 500' AGL deployment, wire pin 10 of the MCU to 5V VCC. For 1000' AGL deployment, wire pin 10 of the MCU to ground.

Note: Eliminating switches 1 and 2 will prevent you from exercising the input and output test modes of the RRC².

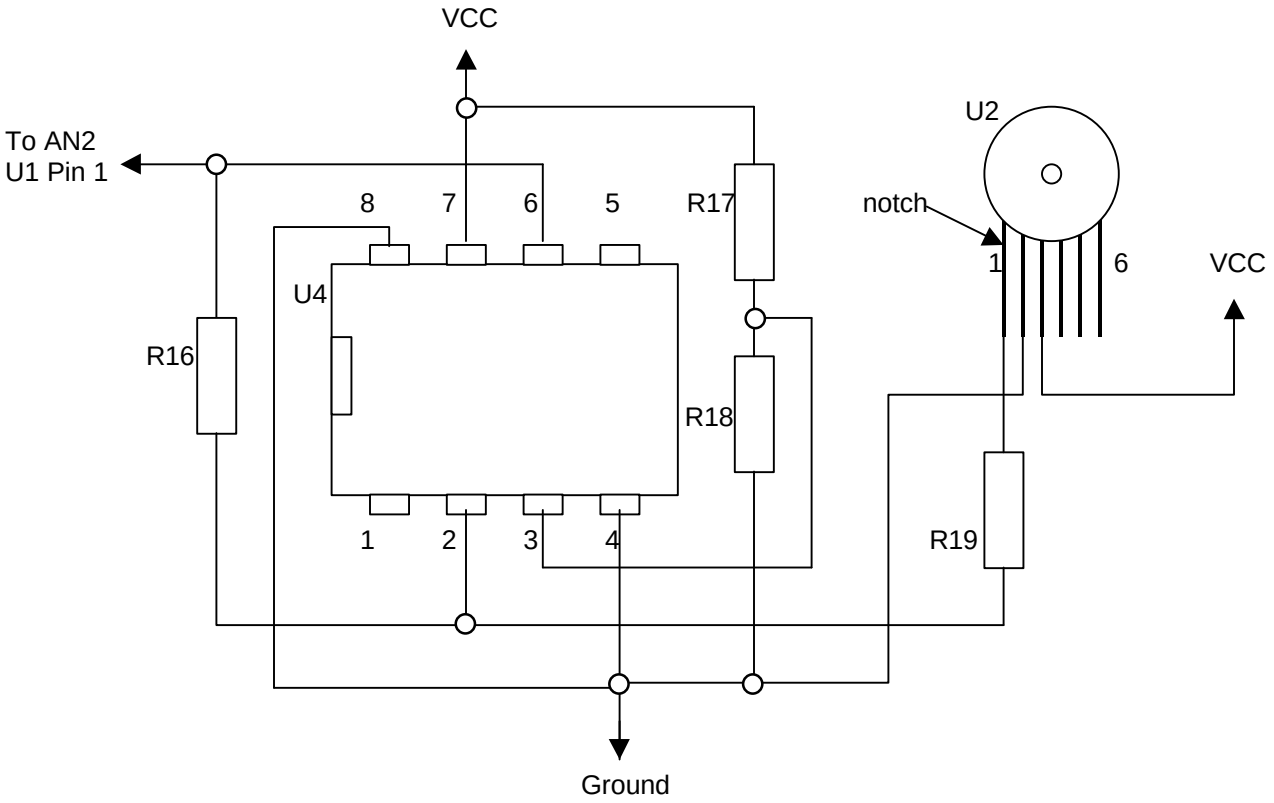
Step 5 - Pressure Sensor and Inverter Stage (Figure 5)

Parts for this section

U2	MPX-5100A Pressure Sensor
U4	7611 OpAmp
R16	10K ohm 1% resistor
R17	10K ohm 1% resistor
R18	10K ohm 1% resistor
R19	10K ohm 1% resistor

It's time to connect the pressure sensor and inverting amplifier stage. This pressure sensor signal is fed to pin 1 of the MCU. After this section is connected, you can verify the operation of the sensor and the inverter. Connect the 9V battery and then measure the output voltage of the pressure sensor on pin 1 of U2. Subtract this voltage from your 5V VCC voltage. The result should be fairly close to the voltage you measure on pin 1 of the MCU. If you wish you can actually pull a vacuum on the unit by placing it in a wide bottle and giving the bottle a "suck". Please refer to the RRC² User Manual for a description of the various modes of operation.

Figure 5. Pressure Sensor and Inverter Stage Physical Connection Diagram



Sensor Precaution

The sensor element is light sensitive and can operate adversely when exposed to any direct light source, even sunlight. It is recommended that you mount the sensor on your board assembly upside down, or that the static port on the stainless side of the sensor be covered. We recommend a small piece of Plastrut U channel affixed to the sensor with some CA glue.

Step 6 - Stage 1 Apogee Deployment Charge Firing and Test Circuit (Figure 6)

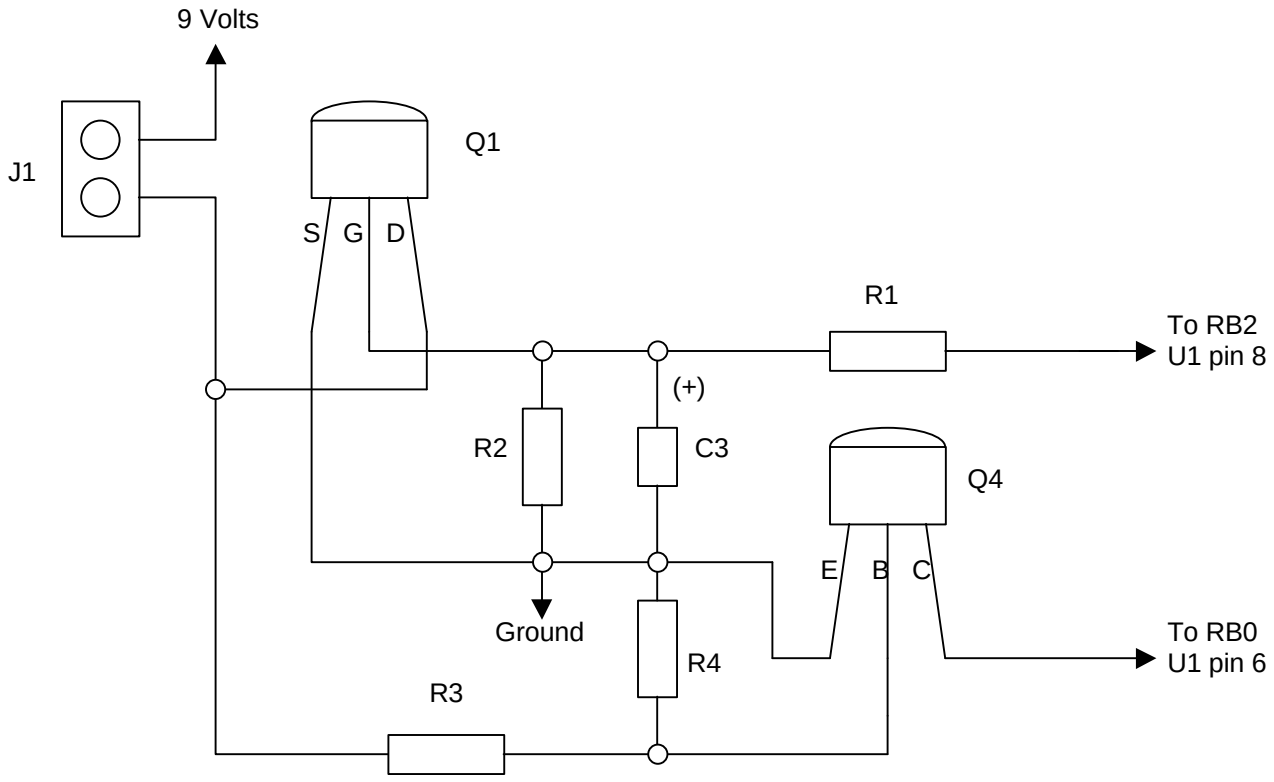
Parts for this section

R1	1K ohm 5% resistor
R2	10K ohm 5% resistor
R3	100K ohm 5% resistor
R4	10K ohm 5% resistor
C3	1 mfd capacitor
Q1	4306 N-channel FET
Q4	2N3904 NPN transistor
J1	Deployment charge terminals

This section controls the firing and continuity testing of the J1 apogee deployment charge. Pin 8 of the MCU controls the firing circuit, and pin 6 of the MCU detects continuity. When this section is completed, you can verify the operation of this circuit by using the output test mode with a lamp or LED as described in the RRC² User Manual.

Note: The Stage 1 circuit can be optionally removed if the user is building the unit with single stage recovery electronics for 1000' or 500' AGL recovery system deployment only. The Stage 1 circuit is not required for peak-altitude only configurations.

Figure 6. Apogee Deployment Charge Firing and Test Circuit Physical Connection Diagram



Step 7 - Stage 2 Apogee Deployment Charge Firing and Test Circuit (Figure 7)

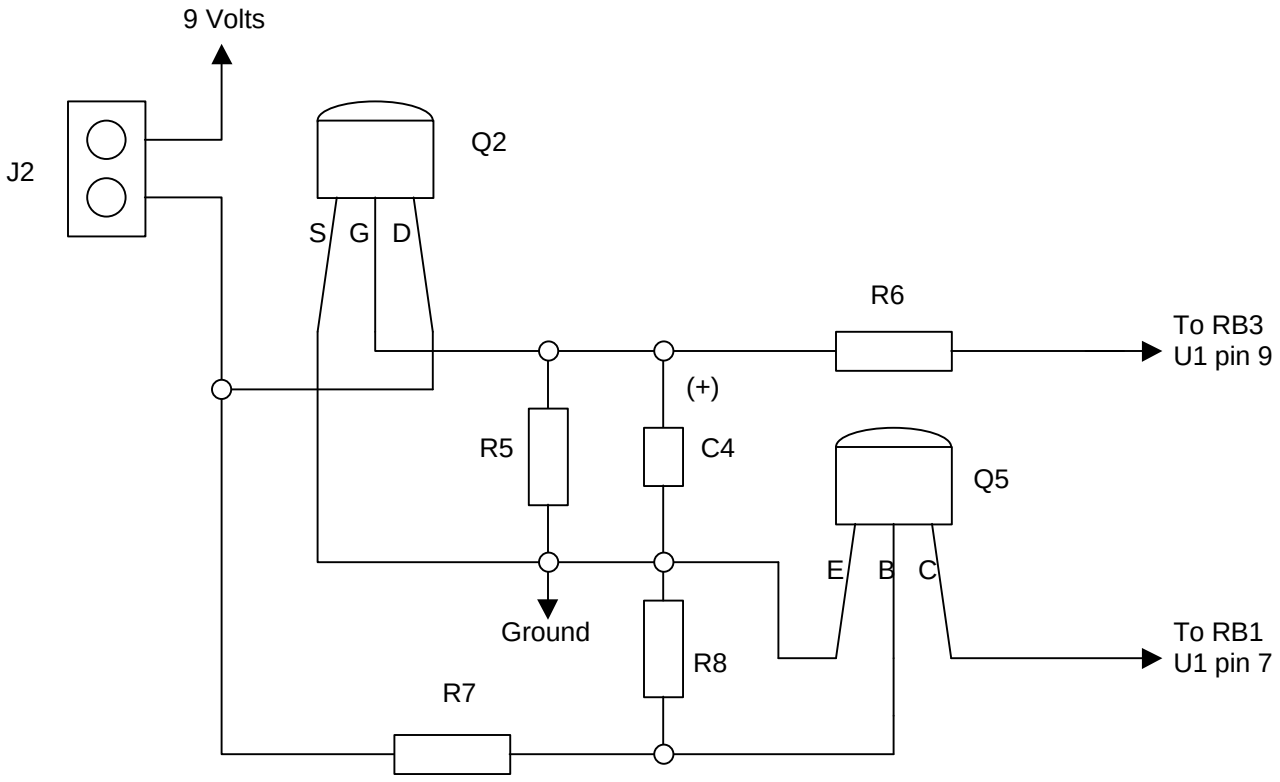
Parts for this section

R5	10K ohm 5% resistor
R6	1K ohm 5% resistor
R7	100K ohm 5% resistor
R8	10K ohm 5% resistor
C4	1 mfd capacitor
Q2	4306 N-channel FET
Q5	2N3904 NPN transistor
J2	Deployment charge terminals

This section controls the firing and continuity testing of the J2 second stage deployment charge. Pin 9 of the MCU controls the firing circuit, and pin 7 of the MCU detects continuity. When this section is completed, you can verify the operation of this circuit by using the output test mode with a lamp or LED as described in the RRC² User Manual.

Note: The Stage 2 circuit can be optionally removed if the user is building the unit with single stage recovery electronics for apogee recovery system deployment only. The Stage 2 circuit is not required for peak altitude only configurations.

Figure 7. Main Deployment Charge Firing and Test Circuit Physical Connection Diagram



Completion and Flight Testing

Congratulations! The unit is now complete and ready for test. You can simulate a rocket flight by using the bottle method as described in step 5. Satisfy yourself with the operation of the unit by this method and/or by use of the input and output test modes described in the User Manual.

Prepare and fly your rocket using the outlined methods and procedures in the RRC² User Manual.

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