A Homebrew PC Interface For The Celestron AS-GT Mount

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Introduction

This project owes a lot to previous efforts, notably Matthias Bopp's interface for other Celestron telescopes. The protocol used on the AS mount is different from that used on other Celestron mounts and circuits developed for them will not work with the AS mount. Celestron engineering was kind enough to provide the suggestions that allowed the user community to develop a circuit that will work with the AS mounts. The circuit presented here includes those suggestions and has been built and tested successfully by several AS mount owners. It will work with the Celestron firmware programmer as well as the only known PC program that can communicate directly with the mount, NexRemote. When NexRemote is used in this mode the hardware hand control is not needed at all. Other programs will typically connect to the serial port at the bottom of the hand control and would not need to use this interface. In fact, no other program known at the time of this writing can use this PC interface.

This project is not supported by Celestron so if you need help with it you should contact the owner of the website where you found this document or the author at celestron_AS@yahoogroups.com. You will have to join the Celestron_AS group on YahooGroups to post messages there but if you have an Advanced Series telescope or mount you will find the group to be an excellent resource.

This project does involve soldering CMOS integrated circuits so it is a bit more involved than simply soldering a cable together. Anyone with some experience with hobby electronics will have the skills necessary to complete it successfully. If you have never attempted anything of this nature before you may want to enlist the help of a friend or relative who has. This document assumes you have the required skills and it does not attempt to teach them. Please work carefully and double check your work since wiring errors could apply 12V signals to the 5V circuits in the mount and this could cause damage to the mount's electronics.

Parts List

The following parts should be obtained before starting the project. Prices (in US Dollars) and suggested suppliers are given for North American builders. People in other parts of the world are left to their own resources when it comes to locating sources for the parts. I will add sourcing information for other regions as and if it is reported to me.

(1) MAX232A RS232 interface IC, 16 pin DIP (DigiKey part # MAX232ACPE-ND, $5.50)
(1) 74HC125 Quad tri-state buffer IC, 14 pin DIP (DigiKey part # 296-12781-5-ND, $0.50)
(1) MC7805 Voltage regulator, 5V, TO220, (DigiKey part # 296-13996-5-ND, $0.50)
(6) 100nF (0.1 uF) metal film capacitors (DigiKey part # BC1621-ND, $0.10 each, $0.60 total) 5 x 1µF + 1 x 10µF
(1) Grid Style PC Board, 47mm x 72mm (RadioShack part # 276-150, $1.80)
(1) Project Enclosure, 3x2x1 inch (RadioShack part # 270-1801, $2.70)

(1) DB9 Female Connector (RadioShack part # 276-1538, $1.60)
(1) DB9 Connector Hood (RadioShack part # 276-1539, $1.60)
(2) 100k Ohm resistors, (RadioShack part # 271-1347, $0.99, this is a 5 pack you will only need 2)
(1) 6 wire phone cord with modular connectors on both ends (almost anywhere, $3.00)

The total comes to just about $20USD if you have to buy all the parts. You may have some of these parts already if you build many electrical projects and this will save money. Instead of buying the DB9 connector parts I found an old serial cable that was no longer needed at work. It had the proper connector on both ends so I cut it in half and used one half for this project.

Build The Cables

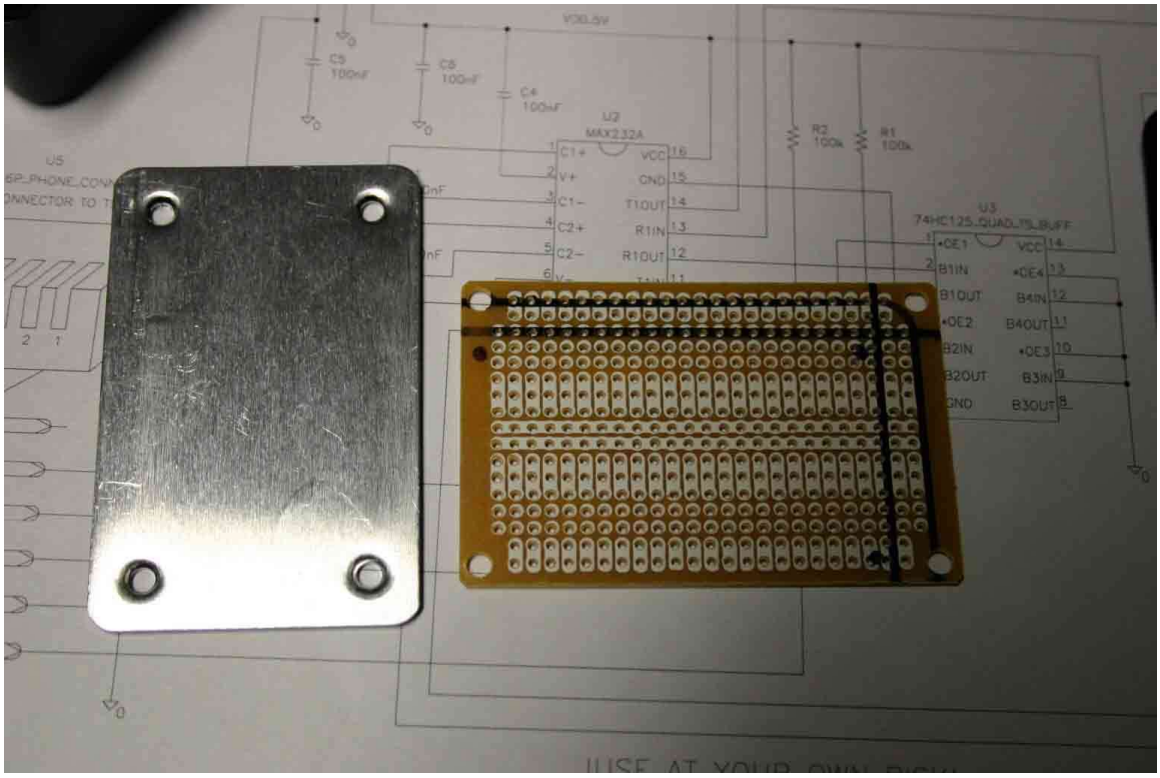
You will need two cables, one has a 6 wire phone connector on one end to connect to the telescope mount. The other has the DB9 connector on one end to connect to the serial port on the computer. The other end of both cables ends in wires which you will solder to the completed circuit. If you have the 6 wire phone cable, connectors, and a crimping tool you can make the cable to the mount yourself. If you don't, the easiest way to proceed is to buy a six wire phone cable as indicated above. Buy one in the total length you would like to use from the telescope to the computer. Cut one end to the length you would like to have from the telescope to the interface box and use the remainder to build the serial cable to the computer. Try to keep the phone cable between the mount and the interface box to a few feet (a meter or two) and run the balance of the length between the interface box and the computer. The 12V computer signals are less susceptible to interference so this will result in the most robust setup. For total lengths of 10 feet (3 meters) or less this is not too important. For longer lengths it becomes increasingly important.

For the serial cable you will need to solder wires to pins 2, 3, 5, 7, and 8 of the DB9 connector. Assembly of the connector and hood is fairly straightforward. The RadioShack connector contains a small metal strain relief that clamps to the wire to prevent mechanical stress from breaking the wires soldered to the connector. Make sure there is a slight amount of slack in these wires when the hood is assembled so that the strain relief can do its job. The schematic shows no color codes for either connector because these are not standard enough to be counted on. Once you have the cables assembled note which color of wire goes to which pin on the connector and write these down on the schematic. This will help you later when you solder the wires to the circuit. You can also strip back a couple of inches (a few cm) of the outer jacket on the cables to expose the wires at this time. Then strip a bit of insulation off each wire to prepare them for later assembly.

PCB And Housing

If you are using the RadioShack PCB (printed circuit board) and housing that are specified above you will find that the PCB is too big to fit the housing. It doesn't fit elegantly in any RadioShack housing. In order to make it fit you will have to cut it down and drill 3 holes in the corners. The board is brittle so it may be best to drill the holes first, then cut the board. I cut mine on a power bandsaw and this did a nice job if you have access to one. Cutting with a modeler's razor saw or a small hand saw should also work but cut as smoothly as you can to avoid chipping or breaking the board. The housing comes with two tops, an aluminum one and a plastic one. We will use the

plastic one to avoid shorting problems. The aluminum one can be used to mark the board for cutting and drilling.

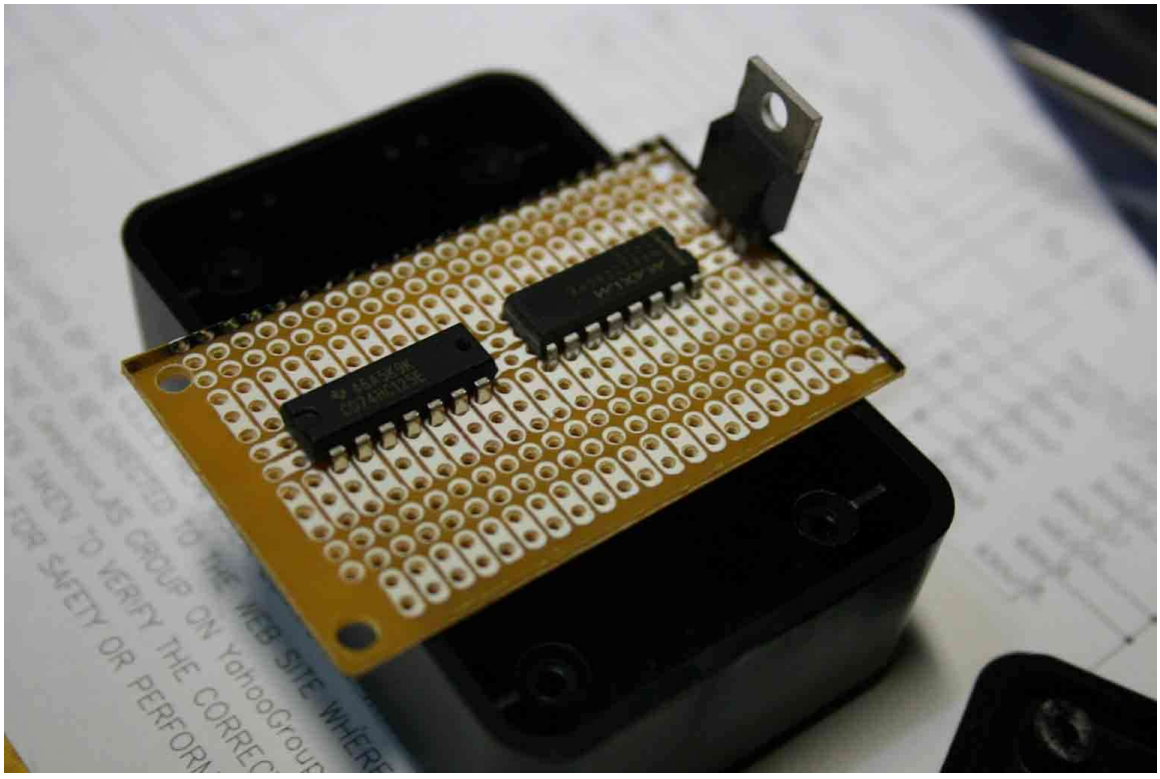


The photo above shows how I marked my circuit board. Lay the metal cover on the circuit board with one hole in the cover aligned with one hole in the circuit board. Now trace around the cover with a marker and put a dot on the board through the other three holes to mark their locations. You want to make the circuit board a little smaller than the cover. You can see the cut lines I drew on the board inside the outline of the cover. You do not have to cut off as much as I show above, just a little inside the cover outline will be enough, so the extra lines I drew are probably not necessary.

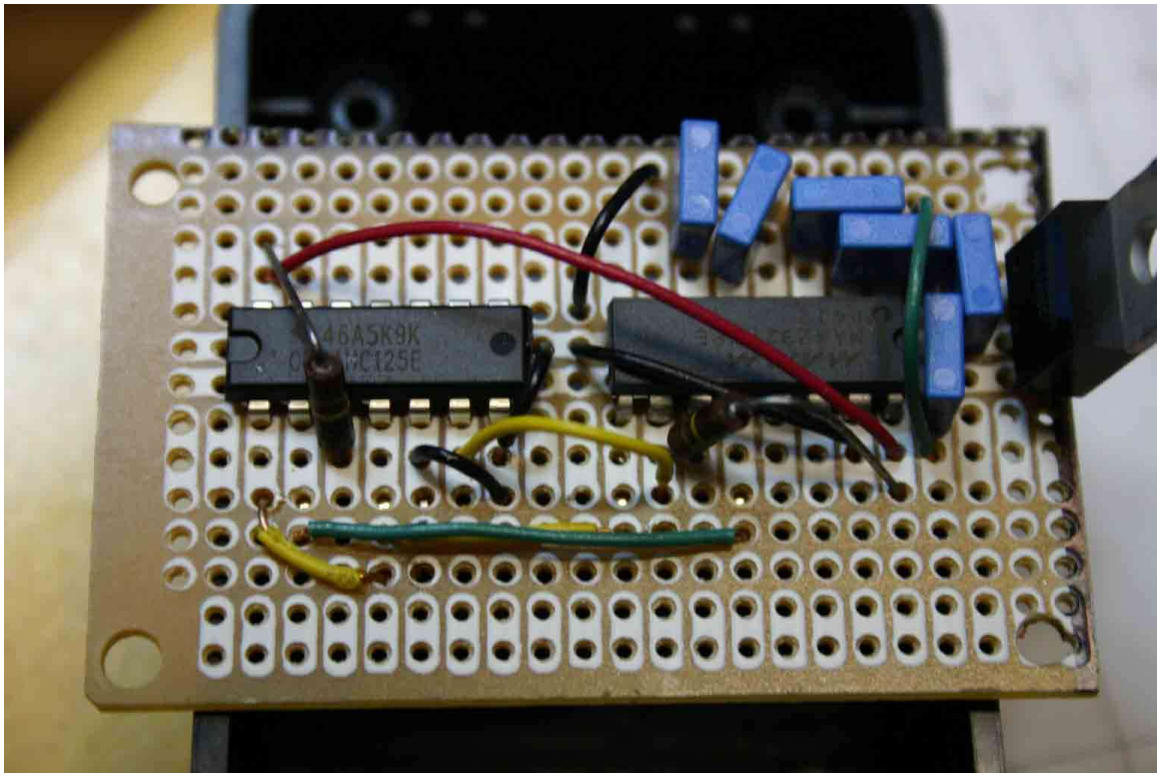
Once you have the PCB drilled and cut you can test fit it and the plastic cover in the box. You will find that the plastic bosses that stick down from the cover's screw holes will interfere slightly with the circuit board. This will prevent the cover from closing all the way. This isn't critical but trimming the bosses a little with diagonal cutters or sanding them down will fix the problem.

Adding The Components

The specified components are all through hole style and will fit nicely on the PCB. Since this is not a custom circuit board you will have to form the connections between components by bending the component pins over on the bottom side of the board where they are close enough or by adding connecting wires where they are not. Those who are comfortable with using surface mount capacitors will find that they work well in several instances.

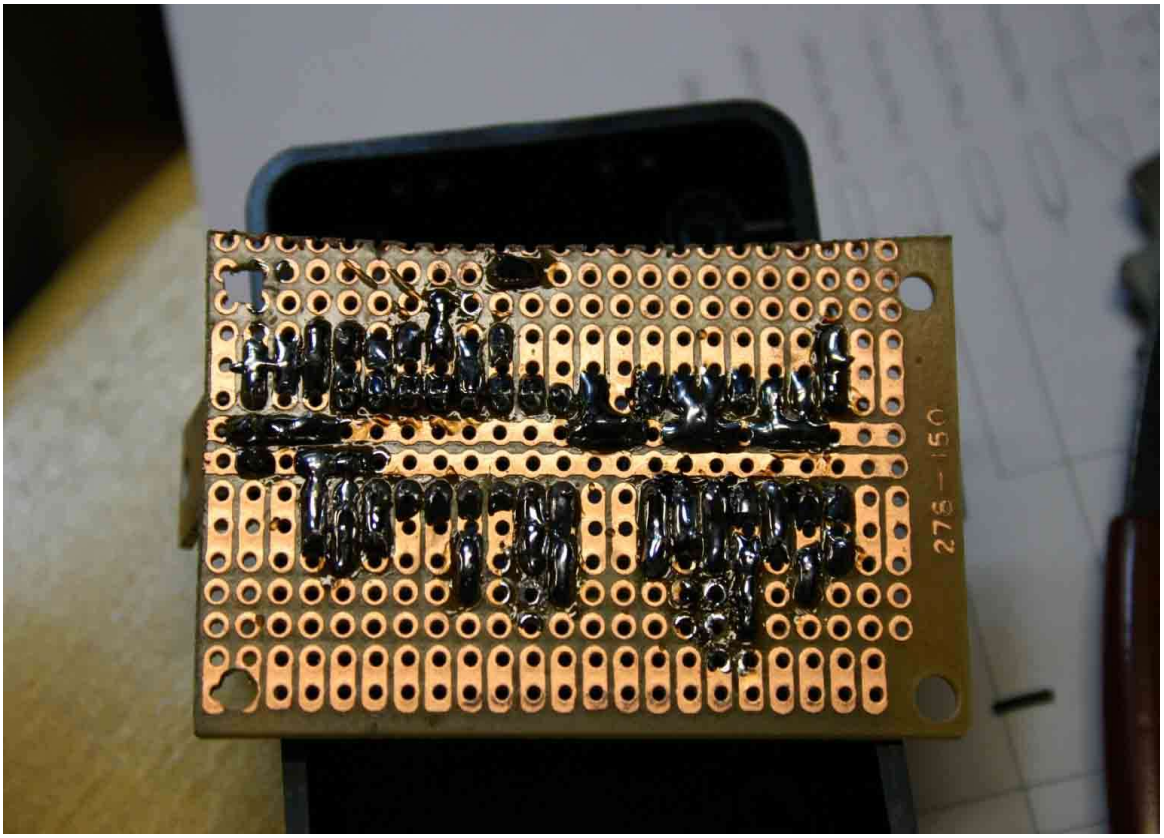


Shown above are the three integrated circuits inserted into holes in the circuit board. The tall one on the right end with the metal tab is the 5V regulator. The white ink on the top of the PCB matches the pattern of the copper traces on the back of the board. You can see that the input (left) pin of the regulator (12 Volts) goes in a trace that connects to two other holes. The ground (middle) pin connects to a trace that runs the length of the board under the other two IC's. The 5 Volt output (right) pin also runs the length of the board under the other two IC's. The leftmost IC is the 74HC125, the middle IC is the MAX232A. The schematic at the end of this document shows a semi-pictorial view of the IC's. It shows how the pins of the two flat IC's are physically laid out as seen from above. The end of the IC where pin 1 is located is marked with a semi circular notch or depression. Sometimes pin 1 is marked with a small circular depression next to it. I put the IC's in with pins 1 facing away from each other. This seemed to make it easiest to make connections as shown on the schematic but other arrangements will work too as long as the connections follow the schematic.



This photo shows the completed circuit, less the cable connections. The light blue boxes are the capacitors that I used. The brown cylinders are the two resistors. You can see that I stood up the resistors to make it easier to stretch one of their leads to other connection points without shorting to some other connection. You can also see the bits of wire that I used to make connections between distant points that needed to be joined. This photo is mostly illustrative. It would be hard to follow exactly what I did from the photo. There are drawings at the end of this document that show how the connections can be made efficiently. The drawings don't match the photo above exactly because as I made the drawing I saw several short cuts I missed when building the circuit.

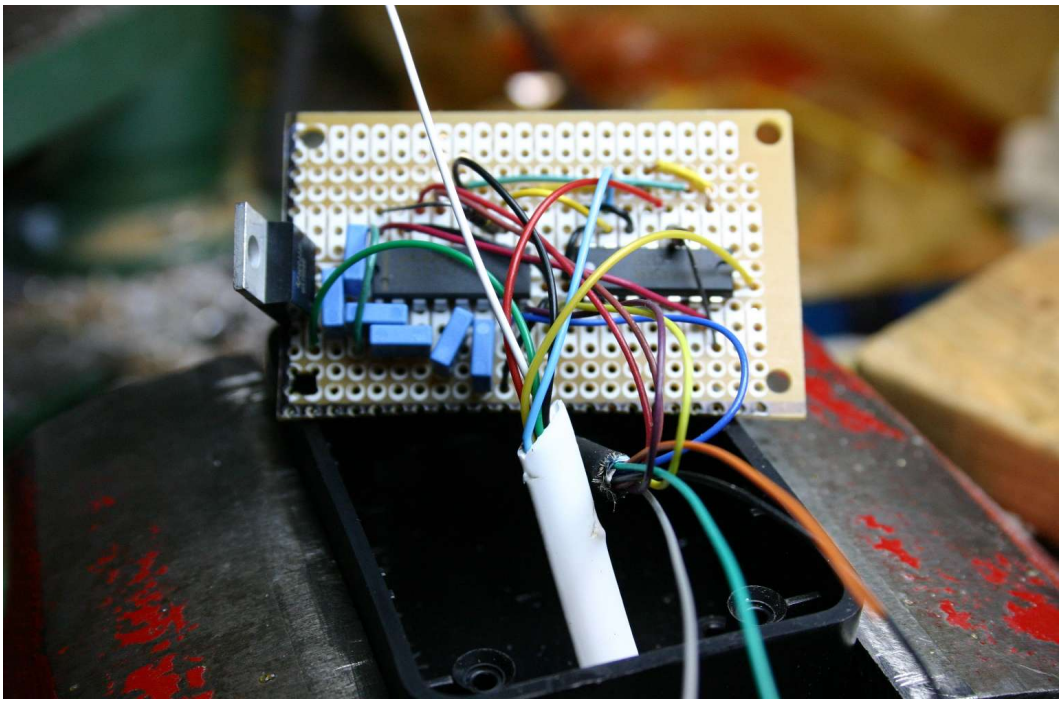
The photo below is potentially even less useful but it does show what the bottom of the circuit board will look like when you are done. As you might be able to tell from the photo a soldering iron with a pointed tip and small diameter solder will help to make the closely spaced connections without getting solder bridges between points that should not connect. The small copper braid known as solder wick can help to remove these bridges if they should occur. You might also want to get a lamp with a magnifying lens if you don't already have one. It will add to the cost of the project but you will find it very useful for many other projects too, especially as you age and your eyes lose their close focusing capacity. Don't ask how I know this.

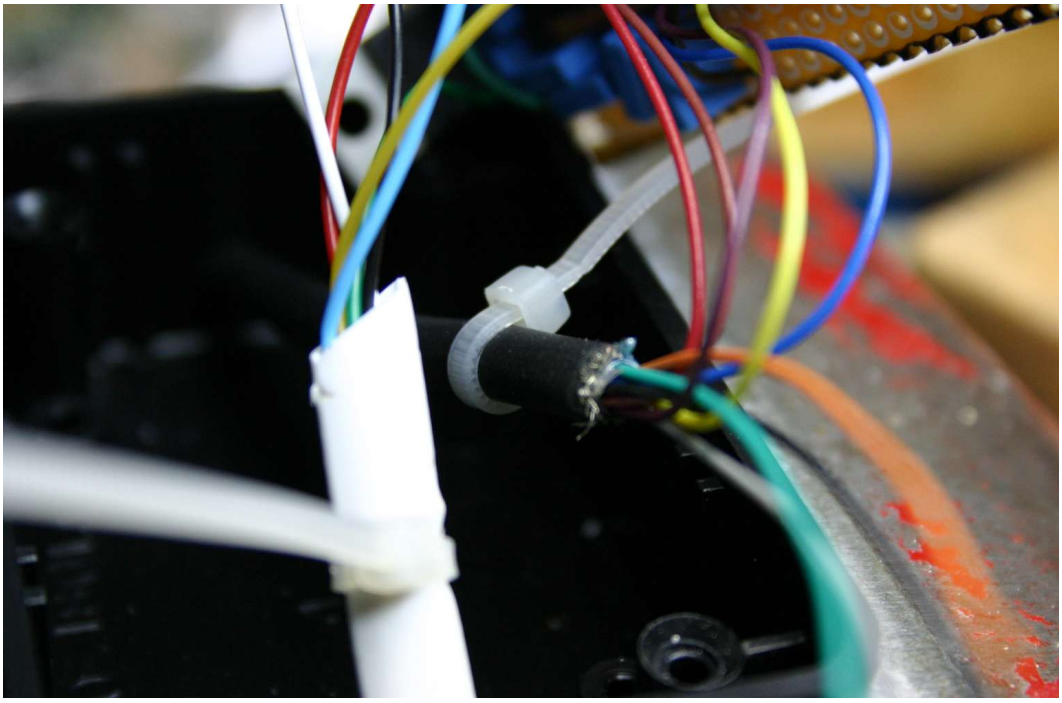


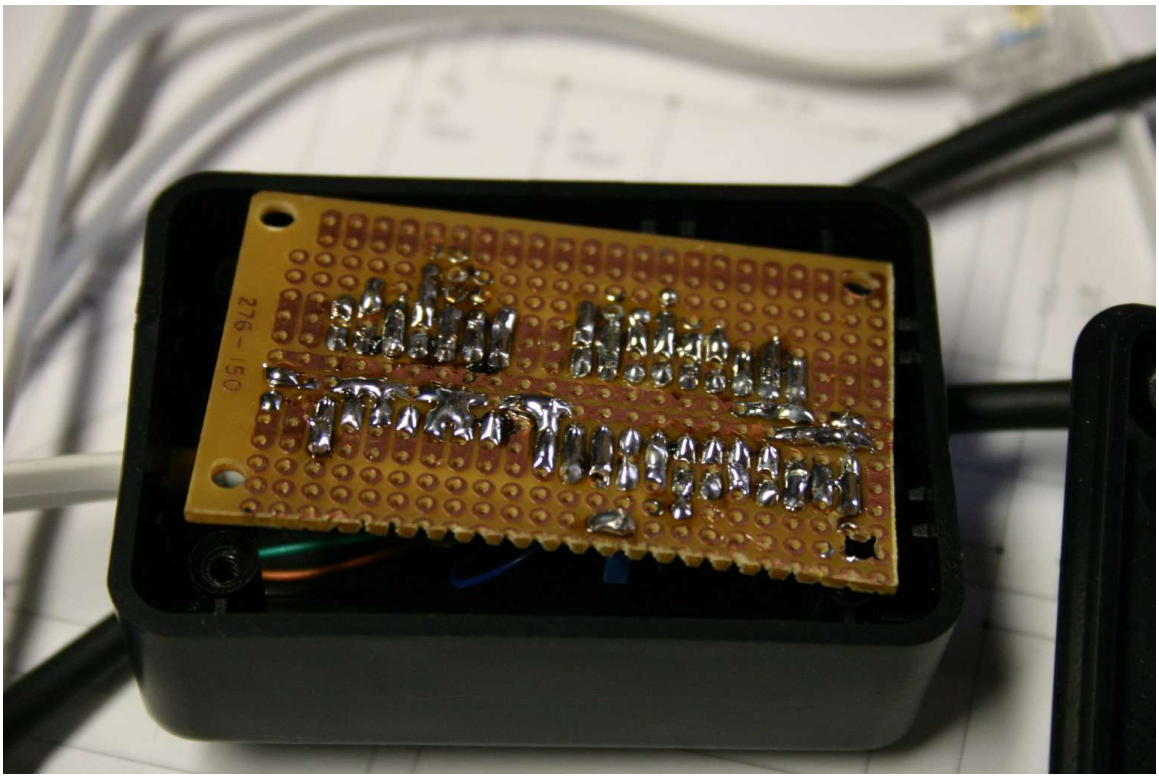
Adding The Cables, Do As I Say, Not As I Do

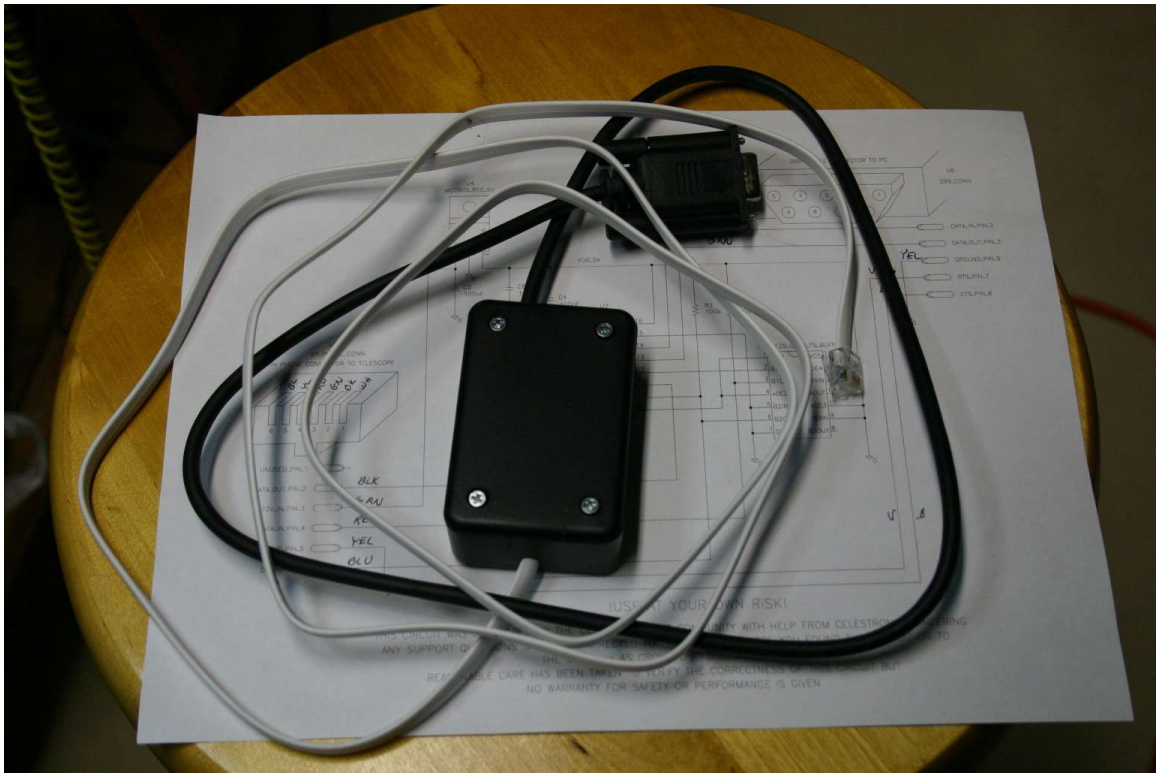
Before you solder on the cables you want to drill holes in the housing and feed the cables through them. Think this step through carefully. I drilled holes nicely centered on each end, one for each cable. You might recall that the tall voltage regulator IC is also nearly centered. What you can't tell is that when the circuit board is put in the box the top of the metal tab nearly touches the bottom of the box. This made it interfere with the cable I had just soldered carefully to the PCB. Instead of unsoldering and resoldering the cables I took the approach shown in the photo below, don't let this happen to you. Once the holes are drilled I slid the cable over and covered the rest with some black tape. Who's gonna see it in the dark? You will also want to put “tie wraps” on the ends of the cables just inside the holes in the box to strain relief them as shown in a photo below. Wrapping a few layers of tape around the ends of the cable will also do the job if tie wraps cannot be obtained.

The next few photos show the circuit board with the cables attached, some “tie wraps” (from a local hardware store or home center) put on the cables to strain relief the cables, the circuit board nesting in the box and the final product.






276-150


BLK
GRN
RED
YEL
BLU
USE AT YOUR OWN RISK!
NO WARRANTY FOR SAFETY OR PERFORMANCE IS GIVEN

Substituting Parts And Voltage Measurements

If you know what you are doing you may substitute parts other than the ones specified. There are many three terminal, 5 Volt regulators available. I choose the one in the power transistor package since it will need no heat sink at the small currents drawn by this circuit. Other RS232 chips could be used. Some will require electrolytic capacitors which are polarized. The correct polarity is shown on the schematic even though the capacitors specified for the MAX232A are not polarized and can be put in either way. Many RS232 chips will have the same pinouts and circuit diagram as the MAX232A but in some cases these will differ so follow the manufacturer's recommended circuit if you substitute. Other kinds of tri-stateable gates could be used, the builder is on his own to determine how they should be connected if a substitute for the 74HC125 is used.

The schematic also includes some voltage measurements if you would like to check the circuit before trying it. These are made with the hand control removed, the interface circuit plugged into the hand control port on the mount and with the mount power ON. The other cable should not be connected to the PC for these measurements. So far only one person has had any trouble getting this circuit to work and his trouble turned out to be the result of software problems with the Simplified Chinese version of Windows XP. So voltage measurements are probably not needed as long as you check your connections carefully.

Suggestions From A Fellow Beginner

Never built anything like this before and feeling a little bewildered? I'd like to say I feel your pain but not being a politician I just can't lie like that! I am an electrical engineer with 30 year's experience with doing things like this so it can be hard for me to see this project from the beginner's perspective. However another Celestron_AS member, Bruce (wd9aqs), who is a relative beginner posted these hints in message 10399. A photo of Bruce's version of the project follows his comments.

Good news, another successful DIY programming interface cable project was built and worked the first time without a problem!!!

I built the DIY programming cable board last night, then went over it today to double check I had all parts hooked up right. After that I added the cables. A couple things I did might help others who, like me, aren't real familiar with building solid state circuits.

I first printed out a copy of the schematic, then as I built I x'd off each connection as I put a part or wire on, and x'd each capacitor and resistor after each was soldered in at both ends. I started on Pin 1 of the MAX chip, worked my way down that side, finishing every connection that was off each pin on that chip, including extra wires and any parts.

When one pin was done I went to the next pin, in order around the chip until I was done with that chip. Next I started on other chip and finished up any remaining connections that one needed. Lastly I added any other connections left to do. When I was done every connection, capacitor, and resistor on the schematic had an x on it.

The next day I went over the board with a new printout of the schematic and went over it connection by connection, part by part, again x'ing off every connection and part as I had during building until done.

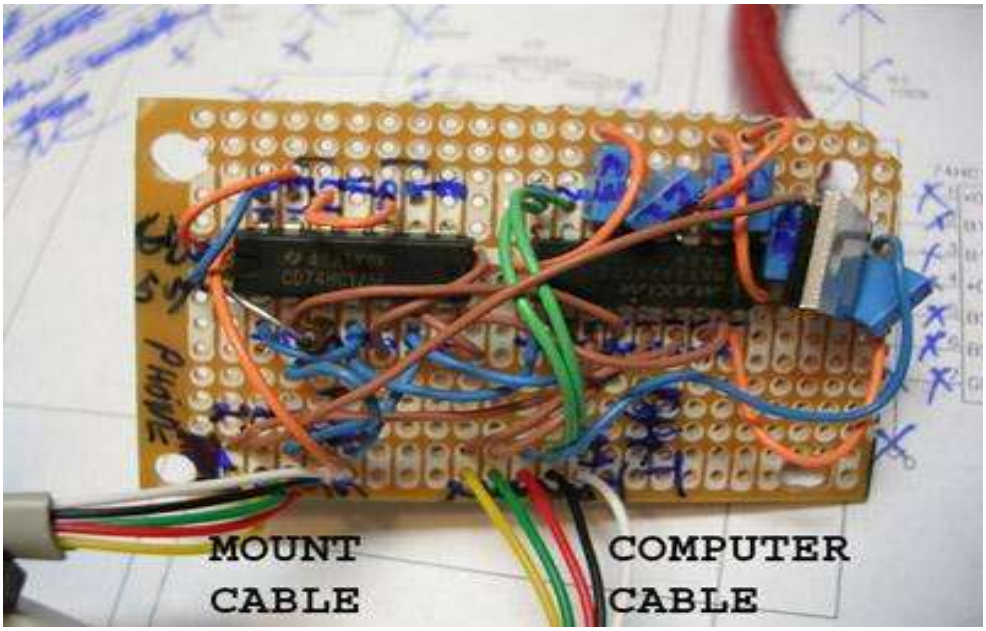
Instead of connecting the external cables directly where needed all over the circuit

board, I set up two groups of two hole foil sections on one side of the board as connection areas for the cables, with wires from the board going to one hole of each pair in a numerical order, one group for the phone plug mount end of the cable, the other for the DB-9 computer end of the cable. This made it real easy to connect up both cables when they were ready.

One thing to watch for, if you put the chips in so the pin 1 ends face in opposite directions, be sure you remember this when wiring as it is real easy to forget that they aren't facing the same way!

Last suggestions, take it slow, take your time, double check every step as you go, solder only when you're quite sure what you are about to solder is hooked up right. Then when you're done, wait until the next day or at least give yourself a good break, then go over the whole board again and check every connection all over again as if you were first building it.

The way I used the copy of the schematic and marked off each connection as I made it and part as it was fully installed is similar to how electronic or model kits are built. But without instructions detailing every step part by part like commercial kits have, which can be checked off as you go, it's even more important that you figure out some way to keep track of exactly what you have done, which also helps a lot in knowing what you have left to do.

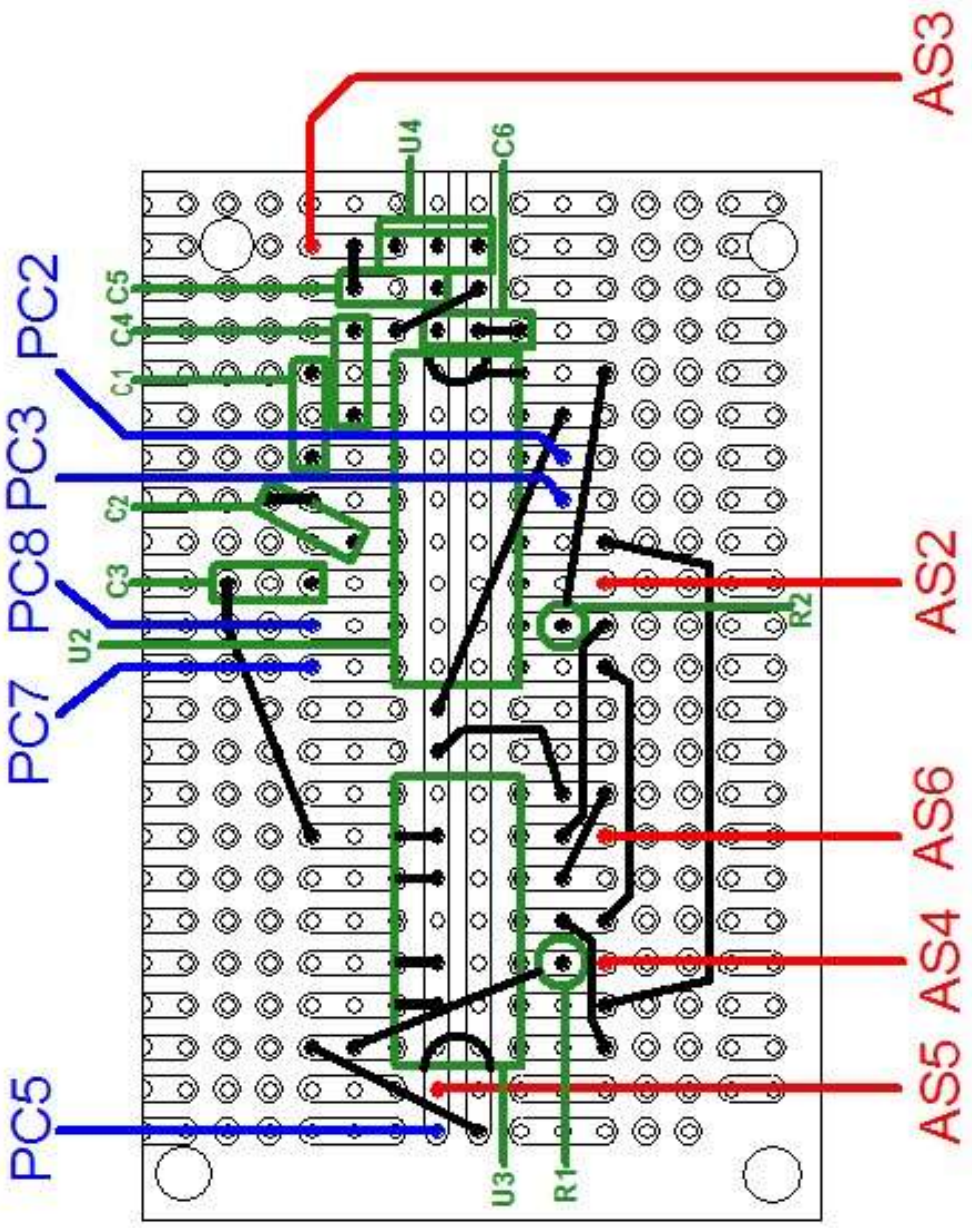


Using The Completed Cable

Another thing that Bruce pointed out is that it isn't clear how to use the cable once you are done. All the directions that come with the Celestron firmware programmer software and the NexRemote software refer to other telescopes and the Celestron auxiliary port expander for the AS mount. You can use this cable instead of the port expander to run those two pieces of software. In order to use the cable you must unplug the telescope's hand control. Now plug the phone cable connector on your home made interface cable into the hand control port on the AS mount. The DB9 connector should be plugged into the serial port on your Windows PC (as someone who primarily uses Macs it pains me

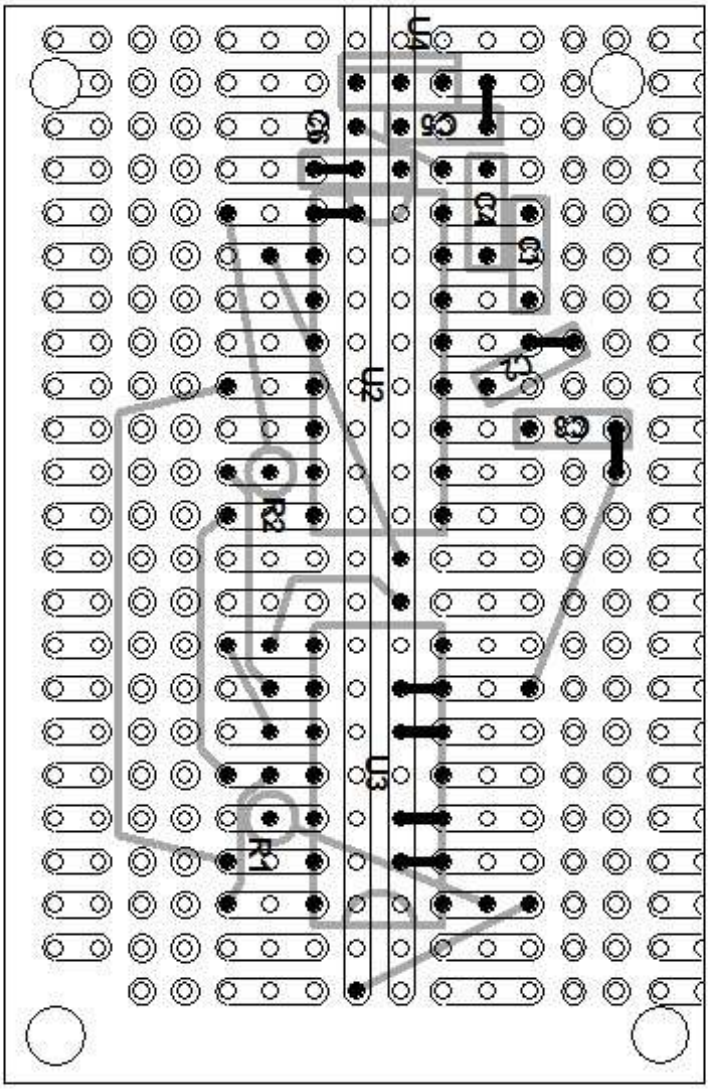
to say this but sorry, Celestron does not support the Mac in any way). If your PC has USB ports but no serial port you will have to purchase a USB to serial converter in order to use this cable. Once you have the cable connected to both the mount and the PC you are ready to turn both on and begin using either the firmware programmer or NexRemote. Detailed information on using the software can be had from Celestron, the Celestron_AS group, and Mike Swanson's website, www.nexstarsite.com.

I hope you have success with building this project and enjoy using it once you are done. Please do join us on the Celestron_AS group to share your experiences with this and anything else you do with your telescope/mount.



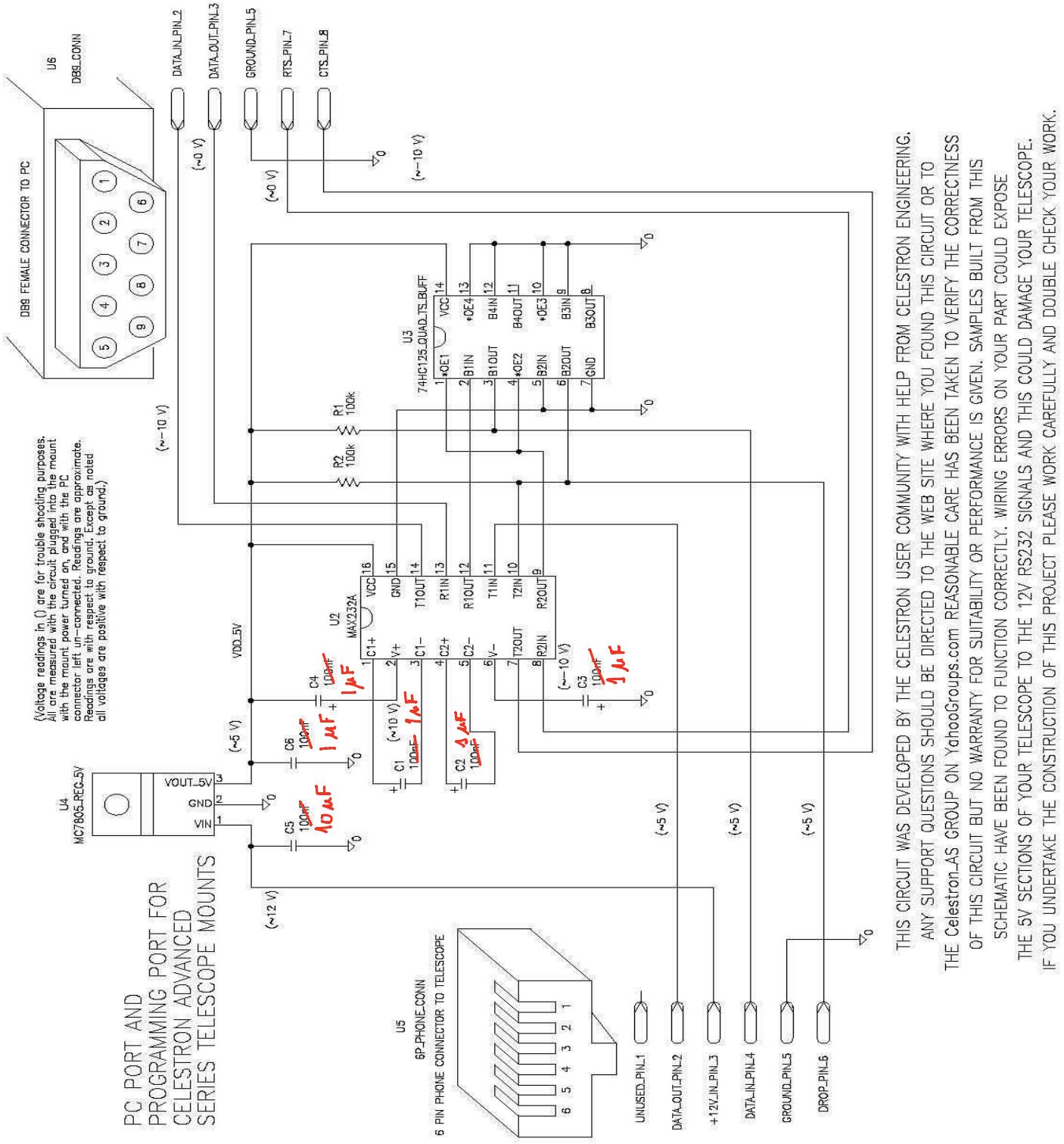
COMPONENT SIDE VIEW

This drawing illustrates one possible way to wire up the components on the circuit board. Wires between components and/or traces are shown as black lines. Black dots indicate solder connections. Blue lines and dots indicate the connections to the PC (DB9) connector. Red lines and dots indicate the connections to the telescope hand control port (phone) connector. The components are shown in green. Short black lines between two adjacent holes can be made by bending a component lead over.



SOLDER SIDE VIEW

This is a bottom view of the circuit board showing the same connections. The wires to the PC and telescope connectors are not show, The wires on the top side of the circuit board and the components are grayed out. This allows the connections made by bent over component leads to be shown more clearly. As you will be making these from the bottom side of the board, this drawing should make them easier to find since it shows everything in the correct orientation. The parts do not have to be arranged as shown in these drawings. Experienced builders are welcome to arrange things as seems best to them. Beginners may find these drawings helpful since it can be quite daunting to dive into this if you have never done something like this before. As long as all the connections are made correctly the physical arrangement of the parts does not matter.


PC PORT AND
PROGRAMMING PORT FOR
CELESTRON ADVANCED
SERIES TELESCOPE MOUNTS
DB9 FEMALE CONNECTOR TO PC
U6
DB9_CONN
DATA_IN_PIN_2
DATA_OUT_PIN_3
GROUND_PIN_5
RTS_PIN_7
CTS_PIN_8
(Voltage readings in () are for trouble shooting purposes. All are measured with the circuit plugged into the mount with the mount power turned on, and with the PC connector left un-connected. Readings are approximate. Readings are with respect to ground. Except as noted all voltages are positive with respect to ground.)
U4
MC7805_REG-5V
VOUT_5V
GND
VIN
VDD_5V
U2
MAX232A
U3
74HC125_QUAD_TS_BUFF
R1
100k
R2
100k
C1
100mF
C2
100mF
C3
100mF
C4
100mF
C5
100mF
C6
100mF
1 µF
1 µF
1 µF
10 µF
U5
6P_PHONE_CONN
6 PIN PHONE CONNECTOR TO TELESCOPE
UNUSED_PIN_1
DATA_OUT_PIN_2
+12V_IN_PIN_3
DATA_IN_PIN_4
GROUND_PIN_5
DROP_PIN_6
(~0 V)
(~10 V)
(~5 V)
(~12 V)
THIS CIRCUIT WAS DEVELOPED BY THE CELESTRON USER COMMUNITY WITH HELP FROM CELESTRON ENGINEERING.
ANY SUPPORT QUESTIONS SHOULD BE DIRECTED TO THE WEB SITE WHERE YOU FOUND THIS CIRCUIT OR TO
THE Celestron_AS GROUP ON YahooGroups.com REASONABLE CARE HAS BEEN TAKEN TO VERIFY THE CORRECTNESS
OF THIS CIRCUIT BUT NO WARRANTY FOR SUITABILITY OR PERFORMANCE IS GIVEN. SAMPLES BUILT FROM THIS
SCHEMATIC HAVE BEEN FOUND TO FUNCTION CORRECTLY. WIRING ERRORS ON YOUR PART COULD EXPOSE
THE 5V SECTIONS OF YOUR TELESCOPE TO THE 12V RS232 SIGNALS AND THIS COULD DAMAGE YOUR TELESCOPE.
IF YOU UNDERTAKE THE CONSTRUCTION OF THIS PROJECT PLEASE WORK CAREFULLY AND DOUBLE CHECK YOUR WORK.