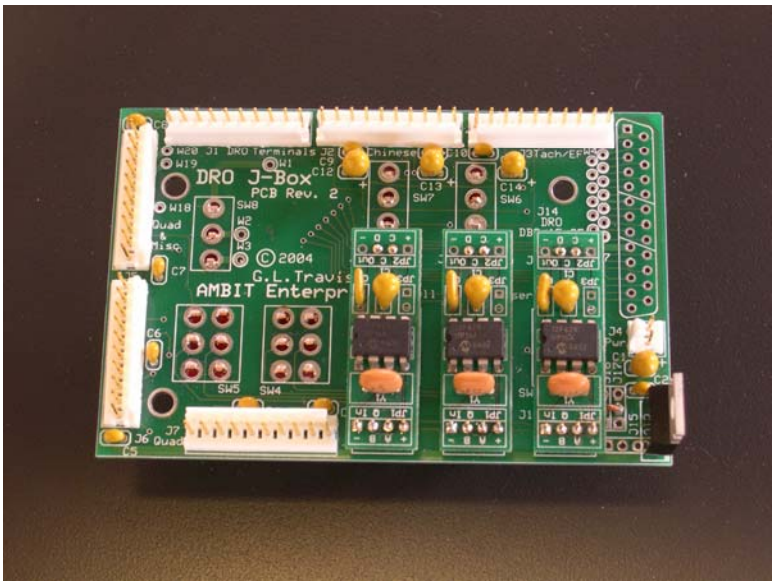
J-Box Construction Guide

Introduction

The J-Box was designed to allow easy routing of scale, encoder, and auxiliary input signals to Scott Shumate's DRO-350. It includes a regulated 5 volt power supply that provides adequate current to power multiple quadrature devices, 3 of ShumaTech's QCC-100s, and 3 auxiliary input devices (such as edge finders and tachometers).

The J-Box printed circuit board was designed to allow "flexible configuration." It can be built with or without switches, with or without an onboard voltage regulator, and with or without the ability to route power to the DRO-350.



The J-Box allows an increased number of scales, encoders and auxiliary devices to remain available for input to the DRO-350 without having to disconnect cables. When configured with a full complement of switches, 3 Chinese scales, 5 quadrature scales/encoders, and 3 auxiliary devices can remain connected to the J-Box; each of these inputs can be routed to the DRO-350 with a "flick of a switch" (or two).

The J-Box limits the number of cables that attach to the back of the DRO-350. In its "basic" configuration it decreases the number of cables from five to two. In its configuration with a "twist," the J-Box reduces the number of cables from five to one.

Please Note: This is not a "one size fits all" project. You will have to make some decisions about how you want your J-Box to work, and this will influence everything from laying out the holes on the enclosure to which scales you can use with your DRO-350. But that's not a bad thing – it's a good thing to have choices. And remember, you can always reconfigure your J-Box later.

I have described one "Basic Configuration" version of the J-Box, below. If you intend to use your J-Box just to power and connect two or three Jenix scales to your DRO-350, this is what you want. Or, if you are new to machining and/or the use of a digital readout, this might be the place to start. The "Basic Configuration" section is near the end of this Guide.

Some "Conventions"

On "major" header locations, **Pin 1** is the **square pad** on the PCB. This is important to remember when connecting power to J4, and when making all connections to J1 through J3, and J5 through J7. **J1 through J7** are considered the **"major" headers** on the J-Box.

When looking at each header location on the silkscreen side of the PCB (with the header location toward you), Pin 1 on **J1**, **J2**, **J3**, **J5** and **J6** is on the **right**. Pin 1 on **J4** and **J7** is on the **left**.

Chinese scales and QCC-100s are numbered 1, 2, or 3 (e.g., "Chinese scale 1", "QCC 3", etc.). The numbers 1, 2 and 3 identify which axes of the DRO-350 are connected to those devices (1 = X, 2 = Y, and 3 = Z). This same numbering applies to switches SW1, SW2 and SW3 (but not the other switches).

You don't have to use "headers" (like MTA or Phoenix headers) to connect to **J1** through **J7**. You can solder wires directly to the circuit board pads at those locations. Look at the section, "You can use direct solder connections" later in this Guide for information about how these connections are made.

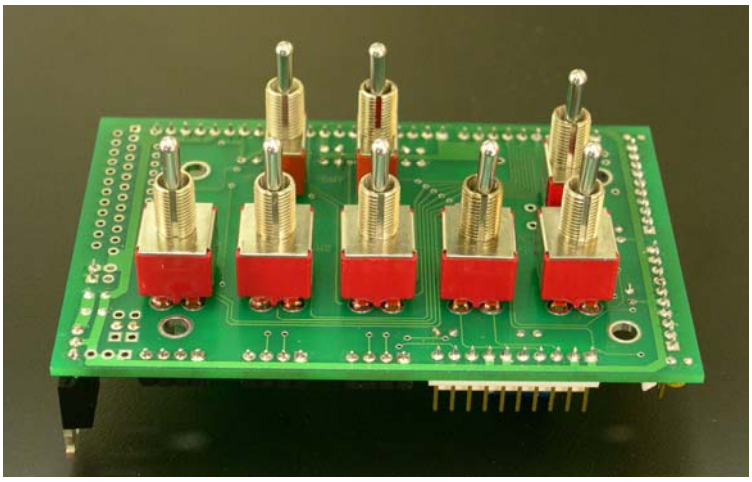
Getting Started

Before you do anything else, print the "**J-Box Bill of Materials**" and the "**J-Box Header Pin Assignments**" located at the end of this Construction Guide. Then, get your J-Box PCB out so you can refer to it as you read the sections below. As you read through the descriptions of the J-Box features, circle items on the **BOM** that you want to order for the features you choose to use.

Planning Your J-Box

There is a need to do some planning before you begin to construct the J-Box. The things that need to be considered appear in the following sections.

I. Deciding which switches to use:



To determine if you need to install switches on your J-Box, consider the following:

1.) The number and "mix" of scales/encoders you plan to use,

2.) The number of auxiliary devices you plan to use, and

3.) Whether you want a power switch. A power switch? Yes, a power switch!

Your answers to these questions will determine **which switches you need to install** on the PCB, if you need to install any switches at all.

If you want both a quadrature scale/encoder and a Chinese scale available to the same DRO-350 axis, you will need to install a DPDT switch in the part of the circuit that sends data to that axis. This feature was originally designed into the J-Box circuit board to aid in troubleshooting; it has been left in the circuit for that purpose, and for users who are in process of upgrading to quadrature scales/encoders. **SW1** is required to switch between them on the **X axis**, **SW2** is required on the **Y axis**, and **SW3** is required on the **Z axis**. **If you do not plan to use Chinese scales** in your J-Box setup, **you do not need SW1, SW2 or SW3**.

(Parts required for the above feature: SW1, SW2 and/or SW3.)

If you want two quadrature scales/encoders available to the Y axis or the Z axis, you will need to install a DPDT switch in the part of the circuit that sends data to that axis. **SW4** is required to switch between two quadrature devices on the **Y axis**, and **SW5** is required on the **Z axis**. Only one quadrature scale/encoder can be attached to the X axis. **If you only want one quadrature device** attached to the Y and Z axes, **you do not need SW4 or SW5**.

(Parts required for this feature: SW4 and/or SW5.)

If you plan to use two or three auxiliary devices with the J-Box and DRO-350 combination, you will need SW7 (to select between two) or SW6 and SW7 (to select between three devices). **If you intend to use a single auxiliary device** you can use a jumper wire in place of SW7; in that case **you do not need SW6 or SW7**.

(Parts required for this feature: SW7 alone, or SW6 and SW7.)

If you want a power switch for the J-Box you will need SW8. **If you do not want a power switch, you do not need SW8**.

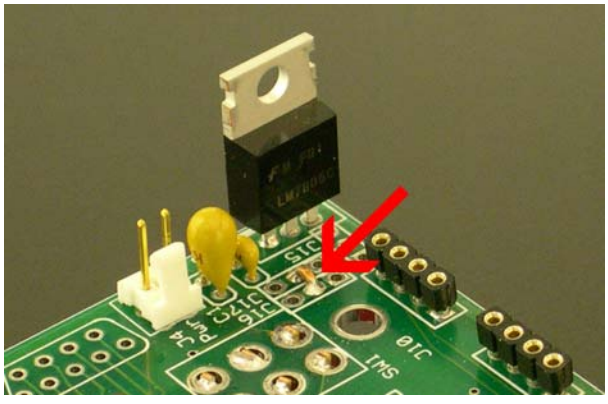
(Part required for this feature: SW8.)

II. Deciding How to Power the J-Box:

There are two alternatives for powering the J-Box, and then there's an extra "twist." You can build the onboard regulated 5 volt power supply, or you can power the J-Box with a regulated 5 volt supply or "wall wart."

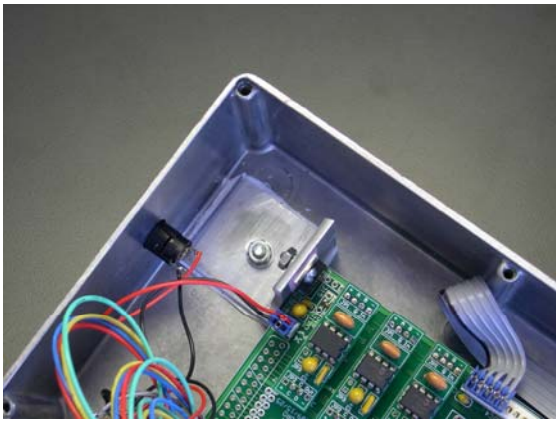
The extra "twist" is this. If you want to, you can add a second DC input jack to the J-Box enclosure. You can then wire this input jack to send the output of a second **9 volt power supply** through the "umbilical cable" from the J-Box enclosure **to the DRO-350**. Or, you can use a **single DC input jack**, and power **both the J-Box and the DRO-350** from an approximate **2.0 amp 9 volt supply**. You may wonder why you would want to do this. It's a matter of convenience, and it reduces the number of cables going to the DRO-350 to a single cable.

If you want to use the onboard regulated 5 volt power supply, you will need to install U1, C1 and C2 on the J-Box PCB. You will need to install a jumper wire between J16 and J17. You may choose to install a 2.1mm DC input jack on the enclosure. You may choose to install an optional 2 pin header at J4 and connect the DC input jack to that header using an optional 2 position MTA plug. You might also choose to wire the DC supply directly to an optional 2 pin Phoenix header soldered to J4. Whatever you choose to do, the "+" leg of the DC input connects to pin 1 of J4; the "-" side connects to pin 2.



When you mount your PCB in the enclosure, you will need to attach a **heatsink bridge** to the voltage regulator (**U1**). Say what? A **heatsink bridge**! Here's the reason. The voltage regulator reduces the voltage coming from the "wall wart" from about 9 volts to right at 5 volts. This voltage reduction

produces heat; the metal back and the tab that sticks up from the top of U1 are designed to dissipate this heat. U1 does a fair job of dissipating heat on its own. But to draw 1 amp of current through it without overheating, U1 has to be attached to a "heatsink," (typically a large piece of aluminum designed specifically to radiate heat into the air around it). Since the J-Box is in a large aluminum enclosure, it's enclosure can be used as U1's heatsink. The only problem is that you must somehow attach the metal back/tab of U1 to the J-Box enclosure to get this to work. To make a long story short, a scrap of 1.5" angle aluminum (.125" thick and 1" wide) makes a perfect "bridge" between the back/tab of U1 and the underside of the top of the enclosure.



(Parts required for this feature: U1, C1, and C2. Scrap of 1.5" angle aluminum. Optional parts: J4, P4 and/or J16a.)

If you want to use a regulated 5 volt supply or "wall wart" to power the J-Box, you will need to install C1 and C2 on the J-Box PCB. You will need to install a jumper wire between **J16** and **J17**. You will need to install an **insulated** jumper wire **between the left and right holes** on the silkscreen position for **U1** (ignore the middle hole). You may choose to install a 2.1mm DC input jack on the enclosure. You may choose to install an optional 2 pin header at **J4** and connect the DC input jack to that header using an optional 2 position MTA plug. You might also choose to wire the DC supply directly to an optional 2 pin Phoenix header soldered to J4. Whatever you choose to do, the "+" leg of the DC input connects to **Pin 1** of **J4**; the "-" side connects to **Pin 2**.

(Parts required for this feature: C1 and C2. Optional parts: J4, P4 and/or J16a.)

If you want to add a second DC input jack to route a separate source of power to the DRO-350 you will need to install **J16b** on the J-Box enclosure. Use of this feature requires substitution of a connector that has 11 or more pins for the DB9 connector (J14a) that is used in other J-Box configurations. (You **don't have to use** a DB-type connector. Any connector that has 11 or more pins should work fine so long as the connector is rated to handle as much as 1 amp of current, or so long as the connector has >12 pins and you can connect the + 9 volt wire to two of the pins, and the ground wire to two of the pins, to "share the load.")

Note: this separate source of power for the DRO-350 must be from a **9 volt supply** (the type of power supply normally used with the DRO-350). The **positive pin(s)** on the DRO-350's J-Box connector must be connected to the **"+"** pin of **JP6** on the DRO-350 PCB. The **negative pin(s)** on the connector must be connected to the **"-"** pin of **JP6** on the DRO-350 PCB (this is explained in the section, "Wiring the DRO-350 Connector," below).

One more thing: If you want to use a **single approximate 2.0 amp 9 volt power supply** to power both the J-Box and the DRO-350, install **just J16a** on the J-Box enclosure (if you want to use a DC input jack). Connect an approximate 24 gauge **red wire** to the **positive pin** of the jack. That wire should connect to the **positive pin** on **J4**. Connect an approximate 24 gauge **black wire** to the **negative pin** of the DC input jack. That wire should connect to the **negative pin** on **J4**.

Build the onboard regulated 5 volt power supply as described above.

Next, solder an approximate 10” long, approximate 26 gauge **red wire** to one of the holes on **J17**. Solder an approximate 10” long, approximate 26 gauge **black wire** to one of the holes on **J15**. Loosely twist these wires together along their lengths, so they form into a kind of two-wire cable. Solder the end of the **red wire** to **Pin 10** on the J-Box output connector. Solder the **black wire** to **Pin 11** of the output connector.

Remember, the power supply used for this type of power distribution must be an approximate 2.0 amp **9 volt supply**; if you use a lesser voltage, the displays on your DRO-350 may not illuminate very brightly.

[Parts required for this feature: ≥11 pin connector. Optional parts: J16b, approximate 2.0 amp 9 volt power supply.]

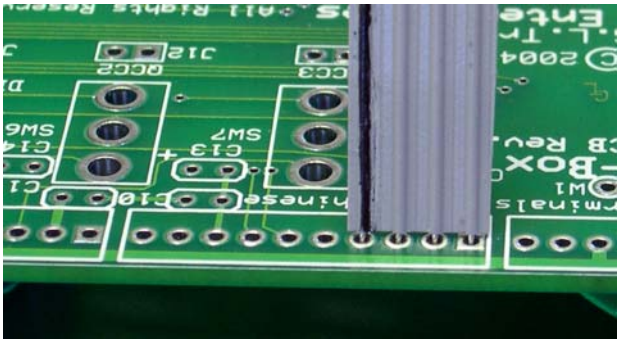
III. Connecting Scales and Auxiliary Inputs:

In the paragraphs of this section I describe three alternatives for connecting scales to the J-Box PCB. These include “direct solder connections,” “MTA headers and plugs,” and “Phoenix headers.” There are other alternatives, too. There are advantages and disadvantages to each method. Choose the one that seems to fit what you would prefer to do.

You can use direct solder connections for scales and auxiliary devices if you don’t want to install headers on your J-Box PCB. 10 conductor ribbon cable that has 26 gauge conductors spaced at .100” works well for this purpose (Digi-Key part number: WM10-06-ND). After you have drilled/milled your J-Box enclosure, temporarily mount the J-Box PCB in the enclosure. Temporarily mount the jacks and other connectors you plan to use in their respective locations on the enclosure.

Refer to the “**J-Box Header Pin Assignments**” near the end of this Guide. Cut lengths of ribbon cable long enough to attach each jack/connector to its respective header connections on the J-Box PCB; cut each piece of ribbon cable an extra inch long to be sure you have enough slack. Sets of conductors can be easily cut from the 10 conductor ribbon cable to make wire assemblies with 3, 4, 5 and 9 conductors. To do this, carefully cut through the plastic webbing between adjacent conductors with a sharp knife or a sharp pair of scissors.

To connect **Pins 1-7 and 9-10 on J1** to the **DRO-350 output jack** (J14a or another connector of your choosing) use a section of cable that includes 9 conductors. You will need to split the webbing about 1” between conductors 7 and 8 so the last two conductors can be soldered to Pins 9 and 10 on the **J1** header location (you do not connect a wire to Pin 8).



To connect **Pins 1-4 on J2** to **Chinese scale jack 1** use a 4-wire section of cable. To connect **Pins 5-8 on J2** to **Chinese scale jack 2**, use another 4-wire section of cable. **Pins 9 and 10 on J2** and **Pins 1 and 2 on J3** connect to **Chinese scale jack 3**. These connections can be made with a 4-wire section of cable, too. But it will need to be split about 1.5” between conductors 2 and 3 so it can bridge the gap between the end of J2 and the start of J3.

A 3-wire section of cable can be used to connect **Pins 3, 4, and 5 on J3** to the data connections on the three **auxiliary input jacks** (J15a, J15b and J15c). If you intend to use **two auxiliary inputs**,

connect a 2-wire section of cable to **Pins 3 and 4 on J3**. To use **one auxiliary input**, connect a single wire to **Pin 3 on J3**.

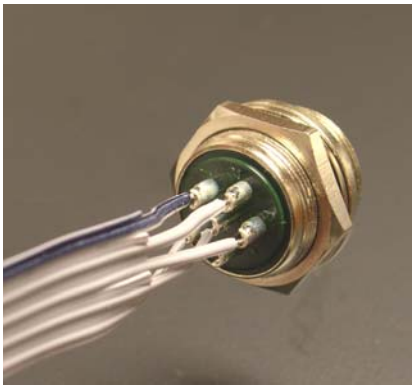
A piece of 24 or 26 gauge hook up wire (with black insulation) can be used to connect **Pin 6 on J3** to the ground pins of the **auxiliary input jacks**. The easiest way to do this is to run the wire from Pin 6 to the ground pin of the closest auxiliary input jack. After all of the auxiliary input jacks are mounted in the J-Box enclosure, loop the wire from the first auxiliary input jack to the ground pin of the next jack, and to the ground pin of the third jack.

A piece of hook up wire (with red insulation) can be used to connect **Pin 7 on J3** to the "+" pins of the **auxiliary input jacks**. The easiest way to do this is to run the wire from Pin 7 to the "+" pin of the closest auxiliary input jack, and, after mounting the other jacks in the enclosure, loop the wire to the "+" pin of the next jack, and to the "+" pin of the third jack.

Quadrature devices connect to their J-Box header locations with 5-wire sections of cable. **Quadrature jack 1** connects to **Pins 6-10 on J7** (remember, Pin 1 on J7 is on the left). **Quadrature jack 2** connects to **Pins 1-5 on J6** (Pin 1 is on the right on J6). **Quadrature jack 3** connects to **Pins 1-5 on J5** (Pin 1 is on the right on J5).

If you intend to use them, **Quadrature jack 4** connects to **Pins 1-5 on J7** (remember, Pin 1 on J7 is on the left). **Quadrature jack 5** connects to **Pins 6-10 on J6** (Pin 1 is on the right on J6).

Once you have your pieces of ribbon cable cut to length, strip approximately .250" of insulation from either end of each conductor. Remove the jacks/connectors from the enclosure, and solder the prepared ribbon cable assemblies to their respective jacks/connectors.



Pay close attention to the order of the conductors as you attach them to the jacks/connectors. You want to ensure that the order of the connections replicates the order that the wires connect to the header locations on the PCB. Refer to the "**J-Box Header Pin Assignments**." There you will see that, for Chinese scale 1 (attached to Pins 1-4 on J2), you connect the first wire of the 4-wire cable to the "ground" pin of the jack. You connect the second wire to the "data" pin, and the third wire to the "clock" pin. The fourth wire connects to the "+1.5 volts" pin of the jack. Refer to information that came with your encoders/scales to identify the "pin assignments" on their connectors.

After you have soldered the cable sections to the jacks and connectors, slip the free ends of the cable assemblies through the mounting holes in the enclosure, and mount each jack/connector securely.

Note: Do not complete the next step until you are ready to mount your J-Box PCB in the enclosure "permanently." If you have to remove the PCB from the enclosure after the cable assemblies are soldered in place, you will have to "de-solder" connections either at the PCB or the jacks/connectors to free the PCB from the enclosure.

Following the "**J-Box Header Pin Assignments**" carefully, insert the stripped ends of the cable assemblies into their respective holes of the header locations. Carefully solder each conductor to the PCB.

[Suggested parts for the above feature: Digi-Key part number: WM10-06-ND (5 pieces).
Required parts: J15a for one Auxiliary input, J15a and J15b for two Auxiliary inputs, or J15a, J15b, and J15c for three Auxiliary inputs; and jacks/connectors for scales.]

You can use MTA headers and plugs to connect scales/encoders and auxiliary devices to the J-Box PCB. You will want to install 10 pin headers at J1, J2, J3, J5, J6 and J7. The MTA headers specified on the BOM are the "friction lock" type. They have a vertical "leg" that sticks up from the header base; this vertical "leg" locks a MTA plug in place when it is connected to the header. You will want to mount the MTA headers so the "friction locks" are toward the middle of the PCB.

10 conductor ribbon cable that has 26 gauge conductors spaced at .100" works well in this method of making connections to the J-Box PCB. The Digi-Key part number for 6 inch sections of this cable is WM10-06-ND. After you have drilled/milled your J-Box enclosure, temporarily mount the J-Box PCB in the enclosure. Temporarily mount the jacks and other connectors you plan to use in their respective locations on the enclosure.

Refer to the "**J-Box Header Pin Assignments**" near the end of this Guide. Cut lengths of ribbon cable long enough to attach each jack/connector to its respective header connections on the J-Box PCB; cut each piece of ribbon cable an extra inch long to be sure you have enough slack. Sets of conductors can be easily cut from the 10 conductor ribbon cable to make wire assemblies with 3, 4, 5 and 9 conductors. To do this, carefully cut through the plastic webbing between adjacent conductors with a sharp knife or a sharp pair of scissors.

To connect **Pins 1-7 and 9-10 on J1** to the **DRO-350 output jack** (J14a or another connector of your choosing) use a section of cable that includes 9 conductors. You will need to split the webbing about 1.5" between conductors 7 and 8 so the last two conductors can be attached to Pins 9 and 10 on the 10 pin MTA plug. You do not connect a wire to Pin 8.

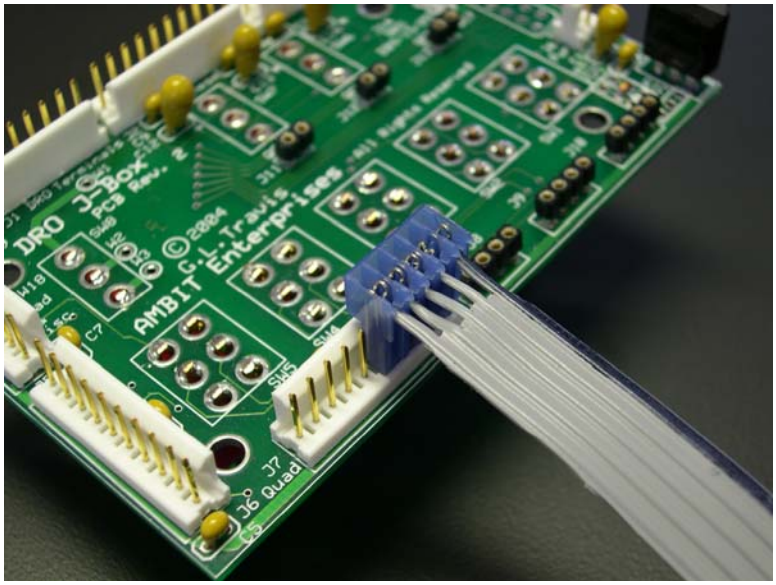
To connect **Pins 1-4 on J2**, and **Pins 5-8 on J2** to **Chinese scale jacks 1 and 2**, respectively, use 4-wire sections of cable. **Pins 9 and 10 on J2** and **Pins 1 and 2 on J3** connect to **Chinese scale jack 3**. These connections can be made with a 4-wire section of cable, too. But it may need to be split about 1.5" between conductors 2 and 3 so it can bridge the gap between the end of J2 and the start of J3.

A 3-wire section of cable or individual wires can be used to connect **Pins 3, 4, and 5 on J3** to the data connections on the three **auxiliary input jacks** (J15a, J15b, and J15c). If you intend to use **two auxiliary inputs**, connect a 2-wire section of cable or individual wires to **Pins 3 and 4 on J3**. To use **one auxiliary input**, connect a single wire to **Pin 3 on J3**. However, and this is a big however, if you use a piece of ribbon cable to connect two or three auxiliary input jacks to the PCB, mount the jacks permanently in the enclosure before you solder the ends of the ribbon cable to them. Otherwise, you'll have to "de-solder" the ends of the cable to mount the input jacks and, then, re-solder the connections. Déjà vu all over again!

A piece of 26 gauge hook up wire (with black insulation) can be used to connect **Pin 6 on J3** to the ground pins of the **auxiliary input jacks**. The easiest way to do this is to run the wire from Pin 6 to the ground pin of the closest auxiliary input jack. After all of the auxiliary input jacks are mounted in the J-Box enclosure, loop the wire from the first auxiliary input jack to the ground pin of the next jack, and to the ground pin of the third jack.

A piece of hook up wire (with red insulation) can be used to connect **Pin 7 on J3** to the "+" pins of the **auxiliary input jacks**. The easiest way to do this is to run the wire from Pin 7 to the "+" pin of the

closest auxiliary input jack, and, after mounting the other jacks in the enclosure, loop the wire to the "+" pin of the next jack, and to the "+" pin of the third jack.



Quadrature devices connect to their J-Box header locations with 5-wire sections of cable. **Quadrature jack 1** connects to **Pins 6-10 on J7** (remember, Pin 1 on J7 is on the left). **Quadrature jack 2** connects to **Pins 1-5 on J6** (Pin 1 is on the right on J6). **Quadrature jack 3** connects to **Pins 1-5 on J5** (Pin 1 is on the right on J5).

If you intend to use them, **Quadrature jack 4** connects to **Pins 1-5 on J7** (remember, Pin 1 on J7 is on the left). **Quadrature jack 5** connects to **Pins 6-10 on J6** (Pin 1 is on the right on J6).

Once you have your pieces of ribbon cable and other wires cut to length, strip approximately .250" of insulation from one end of each conductor. Remove the jacks/connectors from the enclosure, and solder the prepared ribbon cable assemblies/wires to their respective jacks/connectors.

Pay close attention to the order of the conductors as you attach them to the jacks/connectors. You want to ensure that the order of the connections replicates the order that the wires connect to the headers on the PCB. Refer to the "**J-Box Header Pin Assignments**." There you will see that, for Chinese scale 1 (attached to Pins 1-4 on J2), you connect the first wire of the 4-wire cable to the "ground" pin of the jack. You connect the second wire to the "data" pin, and the third wire to the "clock" pin. The fourth wire connects to the "+1.5 volts" pin of the jack. Information that came with your encoders/scales should identify the "pin assignments" on their connectors.

After you have soldered the cable sections to the jacks and connectors, prepare the free ends of the ribbon cable assemblies for connection to the MTA plugs. To do this, cut away the webbing between the conductors using a sharp pair of scissors. Cut the webbing back about .750". **Do not expose the conductors** as you cut back the webbing. You want to make sure you leave insulation surrounding the conductors because this makes it easier to push the conductors into the connections on the MTA plugs.

You might want to make your own punch-down tool to use to push the wires into the MTA plugs connections. Many ShumaTech Group members have made these tools by cutting slots in the blade of a small screwdriver. These slots can be cut easily with a hacksaw or with a thin cutoff wheel mounted in a Dremel Tool. In the "Files" section of the ShumaTech Group site is an entry entitled "MTA-100-Tool.pdf"; it includes a CAD drawing of the blade of the tool. I simply cut two slots in the end of a .1875" wide screwdriver. It seems to work fine.

Referring to the "**J-Box Header Pin Assignments**," connect a **10 position MTA plug** (P1) to the end of the 9 conductor cable section you attached to the **J-Box output jack** (J14a or another jack you chose). Remember, the last two conductors connect to Pins 9 and 10; you do not connect a conductor to Pin 8.

Connect a **4 position MTA plug** (P2a) to the end of the 4 conductor cable section you attached to the **Chinese scale jack 1**. Connect a **4 position MTA plug** (P2b) to the end of the 4 conductor cable section you attached to the **Chinese scale jack 2**.

The 4 conductor cable section used with **Chinese scale jack 3** connects differently. Connect a **2 position MTA plug** (P2c) to the first two conductors. Connect a **2 position MTA plug** (P3a) to the third and fourth conductors.

Connect a **3 position MTA plug** (P3b) to the end of the 3 conductor cable section (or the three wires) you prepared for the three **auxiliary input jacks**. If you intend to use **two auxiliary inputs**, connect a **2 position MTA plug** to the end of the 2 conductor cable section (substitute a 2 position MTA plug for P3b on the BOM – the number is the same as the one used for P3a). If you are going to use **one auxiliary input**, connect a **1 position housing and crimp socket** to the end of the single conductor cable section (substitute a housing and crimp pin for P3b – the numbers are the same as those used for P3c1 and P3c2).

Connect a **1 position housing and crimp socket** (P3c1 and P3c2) to the end of the piece of hook up wire you prepared for the **ground lead** (black wire) of the **auxiliary inputs**. Connect a **1 position housing and crimp socket** (P3d1 and P3d2) to the end of the piece of red wire you prepared for the **"+" lead** of the **auxiliary inputs**.

To install each housing and crimp socket, remove .250" of insulation from the end of the wire. Lightly solder the wire to the crimp area of the crimp socket. Carefully fold the crimp "wings" over the wire. Then, insert the crimp socket into the housing, making sure that the socket's "locking tab" is oriented to mate with the locking slot in the side of the housing.

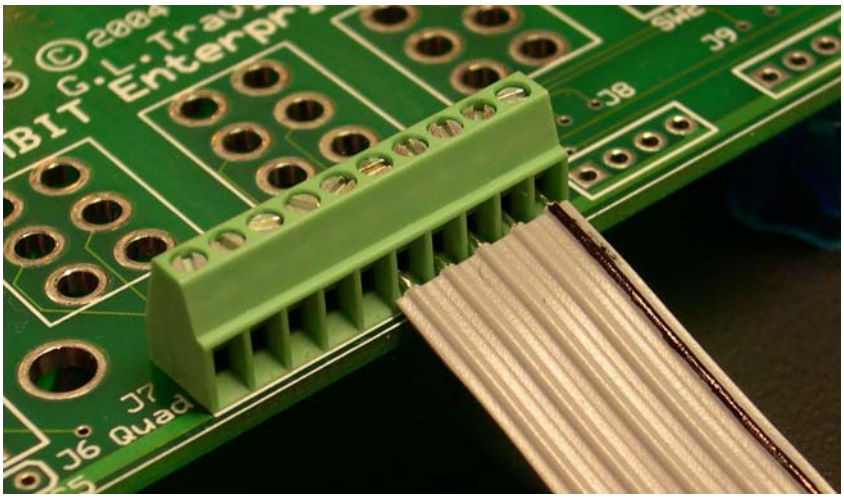
Now it's time to connect MTA plugs on the quadrature cable sections. Despite the fact that Pin 1 on J5 and J6 is on the right, and Pin 1 on J7 is on the left, **all of the MTA plugs** on the **quadrature cable sections** are installed with the **same pin assignments**. Well, almost. From left to right on the MTA plugs the order for the wires is: "ground" (for a shield wire), "ground", "B", "A" and "+ 5 volts". Connect a **5 position MTA plug** to the end of each 5 conductor cable section you have attached to a **Quadrature jack** (that's P7b, P6a and P5a, as well as P7a and P6b if you have chosen to use them).

Here's the "well, almost." "A" and "B" are reversed on Pins 8 and 9 of J7 (see the J-Box Header Pin Assignments" page). Instead of being next to "+ 5 volts" (Pin 10), "A" connects to Pin 8. "B" connects to Pin 9. So long as you get these wires soldered to the correct pins of the jack (and this is the jack for the X axis) you will not have a problem. The scale will still work even if you forget to "reverse" these connections on the jack. But the scale will seem to "read in reverse," compared to the movement of other scales on your machine. You can always go into the Setup Routine of your DRO-350 (Function "0") and change the direction that the scale reads; this will solve the problem if you forget to "reverse" these connections when you wire the scale jack.

After you connect all of the MTA plugs, thread the plugs and cables through the mounting holes for their jacks, and mount the jacks securely.

Before you try to circle parts to order on the BOM, go have a long cold drink of something. Then come back and follow the listing, below.

[Parts required for the above feature: Digi-Key part number: WM10-06-ND (5 pieces)
User-supplied jacks/connectors for scales
J1, J2, J3, J5, J6, J7
J14a or user-supplied ≥11 pin jack
J15a, J15b, J15c
P1, P2a, P2b, P2c
P3a, P3b, P3c1, P3c2, P3d1, P3d2
P5a, P6a, P7b, as well as P6b and P7a if used.]



You can use Phoenix headers to connect scales/encoders and auxiliary devices to the J-Box PCB. These headers are a "bird of a different color". Phoenix headers solder directly into header locations (like MTA headers). But their wire connections are made using their enclosed screw terminals, rather than plugs or some other attachment method. Wow! If you want to, you don't have to connect cables to jacks/connectors mounted on the J-Box enclosure. Instead, you can simply drill holes in the enclosure, and then shield the holes with rubber grommets. Scale and auxiliary cables can then be run through the grommet-shielded holes, and the cables can be connected directly to the positions on the Phoenix headers. This is definitely not what we are used to!

The Phoenix headers themselves are a little "pricey". But if you anticipate that you will be connecting and re-connecting cables rather frequently, they may be the way to go.

To use Phoenix headers, follow steps similar to those under the section, "You can use direct solder connections," above. Instead of soldering scale and auxiliary input cables to the PCB, simply attach them to the appropriate locations of the Phoenix headers. Piece of cake, huh?

(Parts required for this feature: Optional Phoenix headers J1, J2, J3, J4, J5, J6 and J7.
User-supplied rubber grommets.)

IV. Connecting the J-Box to the DRO-350:

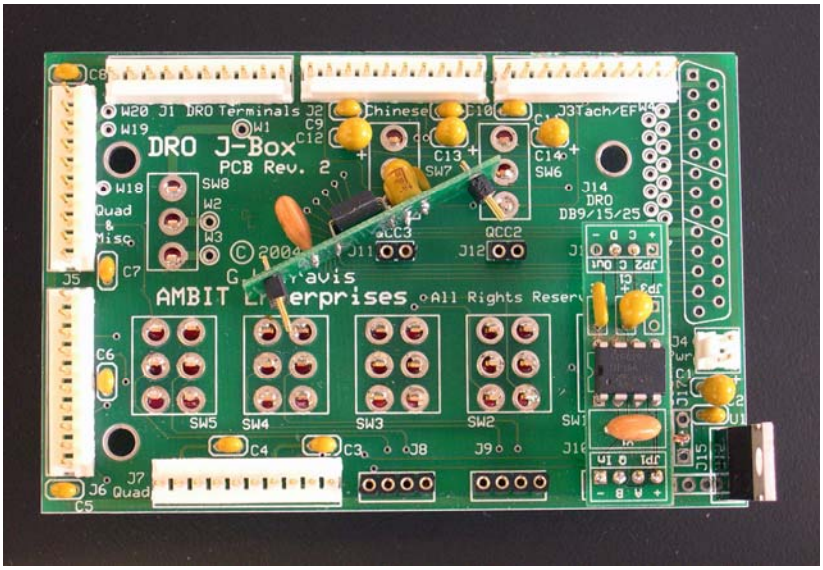
Another issue that must be decided is how you want to connect your J-Box to your DRO-350. You have to decide what kind of "umbilical cable" you want to use. Perhaps the easiest way to connect the J-Box to the DRO-350 is with a standard serial cable. To use this technique, mount a male DB-9 connector to the J-Box enclosure, and **wire the DB-9** to **J1** following the conventions on the "**J-Box Header Pin Assignments**." Remember, **Pin 8** of **J1** is **not used**; wire **Pin 9** of **J1** to **Pin 8** of the **DB-9** connector. Wire **Pin 10** of **J1** to **Pin 9** of the **DB-9** connector. Then, wire a female DB-9 connector on the back of the DRO-350 following the instructions in the section, "Wiring the DRO-350 Connector," below.

If you choose **to power the DRO-350** from the J-Box you will need to use a connector that has at least 11 pins. A **DB-25 connector is an alternative**, but you can use any connector that you want. Wire the connector to **J1** following the conventions in the paragraph above. Attach the positive wire that comes from the power supply to **Pin 10** on the connector. Attach the "ground" wire to **Pin 11**. Wire a matching/suitable connector on the back of the DRO-350 following the instructions in the section, "Wiring the DRO-350 Connector," below. When you choose to power the DRO-350 from the J-Box you may have to build a cable to connect the J-Box connector to the DRO-350 connector. A 12-wire cable (for example, 6 twisted pairs) should be adequate so long as the conductors are 26 gauge or larger. DB-25 cables are readily available if you choose to use DB-25 connectors; their cost is just a little more than a standard DB-9 serial cable.

Use of a Phoenix header at J1 is an alternative to using a DB-9 or other ≥ 11 pin connector. To wire a cable to the Phoenix header, drill a hole in the enclosure that is large enough to accommodate the cable you intend to use. Shield the edges of the hole with a rubber grommet. Run the cable through the hole, and connect the cable to **J1** following the conventions of the "**J-Box Header Pin Assignments**." You will need to attach an appropriate ≥ 11 pin connector on the back of the DRO-350 and wire it following the instructions in the section, "Wiring the DRO-350 Connector," below. Attach a mating connector to the end of the cable coming from the J-Box, and "plug and play."

V. Attaching QCC-100s to the J-Box PCB:

If you want to connect a quadrature scale or encoder to an axis of the DRO-350, you have to route its signal through a QCC-100. The J-Box can house up to three QCC-100s for easy connection of quadrature devices to any of the three axes on the DRO-350. The silkscreen locations for connecting QCCs to the J-Box are **QCC1** (**J10** and **J13**), **QCC2** (**J9** and **J12**), and **QCC3** (**J8** and **J11**). Remember, the numbers 1, 2 and 3 correspond to the DRO-350 axes X, Y and Z, respectively. If you want to use a quadrature device on the Z axis, for example, install a QCC-100 in location QCC3.



Decide which positions of your J-Box need to have a QCC-100 installed. To install a QCC-100 in one of the J-Box positions, use the Mill-Max headers/sockets included on the BOM as J8h-J13h and J8s-J13s ("h" stands for "header" and "s" stands for "socket"). For each QCC-100 that you want to install, cut a two-socket section and a four-socket section from the Mill-Max sockets strip. Then, cut a two-pin and a four-pin section from the headers strip.

(The Mill-Max strips seem to cut reliably with a razor knife or Exacto knife. Score both sides of the strip at the joint that you want to separate. Then apply firm pressure with the knife on the cut line as you rock the knife up and down. The joint will soon separate. The cut edges may need slight smoothing with the edge of the knife.)

Connect the two-pin socket and the two-pin header together (insert the header pins into the sockets). Connect the four-pin header and four-pin socket. On the silkscreen side of the J-Box PCB, insert the solder tails of the two-pin socket through the two-pin QCC location you want to use (J11, J12 or J13).

Insert the solder tails of the four-pin socket through the corresponding four-pin location (J8, J9 or J10). The header solder tails of both header/socket assemblies will be sticking up.

Next, hold the QCC-100 with the component or silkscreen side up. Slide the holes labeled JP1 on the QCC over the exposed pins of the four-pin header. Slide the holes labeled "C" and "D" of JP2 over the exposed pins of the two-pin header. (The header/socket assemblies will tilt inward slightly once the QCC has been lowered all the way.) Adjust the QCC PCB left or right to make the tilt of the header/socket assemblies approximately equal. Then, solder the pins of the headers to the QCC. Flip the J-Box PCB over (being careful to keep everything in place) and solder the exposed solder pins of the sockets to the J-Box PCB. Trim off excess leads with a sharp pair of diagonal cutters.

Remove the QCC-100 from the J-Box PCB and set it aside until you have completed the remainder of the J-Box assembly. To remove the QCC-100, gently pull up on both ends of the PCB at the same time to separate the Mill-Max headers and sockets.

Use the above technique to attach headers and sockets to each QCC location/QCC-100 PCB that you want to use on the J-Box.

(Parts required for this feature: J8h-J13h (<u>one</u> strip) and J8s-J13s (<u>one</u> strip); one QCC-100 for each QCC location used.

VI. Installing Filter Capacitors:

There are three "sets" of filter capacitors that can be installed on the J-Box. One set is in the power supply section. The second set is where quadrature encoders connect to the J-Box headers. The other set is where Chinese scales connect to the J-Box headers. You can see all of these capacitors in the photo on the previous page. Here are the guidelines for choosing which ones to install.

The filter capacitors in the **power supply section** include **C1** and **C2**. Install them, period!

The filter capacitors associated with the quadrature scales inputs are **C3 – C8**. Install the indicated capacitor from this group at each location where you intend to attach a quadrature encoder/scale. So, if you plan to install three quadrature scales (for example, one at each of the locations indicated in bold face type on the "**J-Box Header Pin Assignments**" page), install **C3**, **C5**, and **C7**.

C9 – C14 are the filter capacitors used in the power supply circuit for Chinese scales. Travis included these positions on the J-Box PCB in the hope that the capacitors could be used instead of having to solder capacitors to the printed circuit boards on the Chinese scale encoders. They may work well in "quieter" shop environments (i.e., where there are limited sources of RFI and EMI). It remains to be seen how well they will work in noisier environments.

Install **C9** and **C12** if you intend to attach a Chinese scale in the **X axis** circuit. Install **C10** and **C13** if you intend to attach a Chinese scale in the **Y axis** circuit. Install **C11** and **C14** if you intend to attach a Chinese scale in the **Z axis** circuit.

(Parts required for this feature: C1 and C2 in the power supply circuit – required!
C3 – C8, one each for every quadrature encoder/scale attached
C9 – C14, one "pair" per Chinese scale – see the text, above.)

Okay, you should have an idea of how you want to set up your J-Box. Order parts. Once you get the parts that you want to use, it's time to lay out the enclosure.

Laying Out the J-Box Enclosure

(Following is a general discussion of laying out holes for switches, jacks and standoffs on the J-Box enclosure. Before you attempt to lay out holes locations, make sure you know which switches, jacks and standoffs you intend to install. There are no switches used in the "Basic Configuration" described below. Make a note of what is specified for the assembly you plan to complete, and then return to this section.)

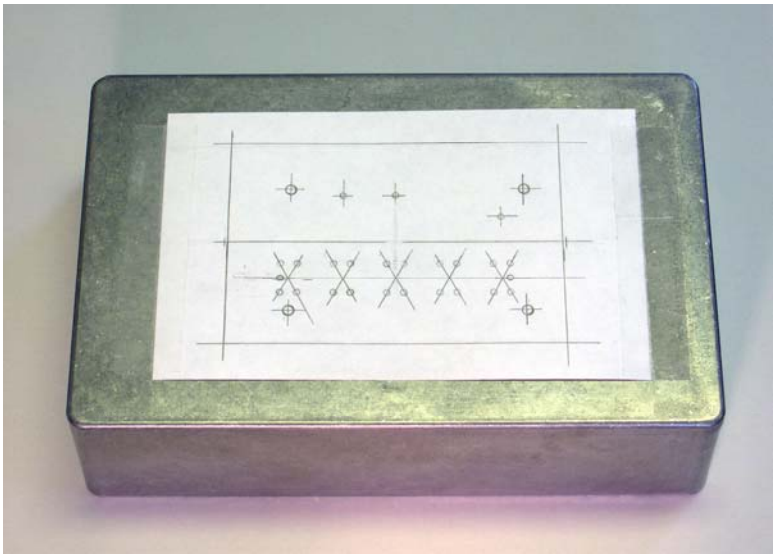
Before you begin construction of the J-Box circuit board, lay out the locations of holes for switches, jacks and circuit board standoffs on the J-Box enclosure. (You may choose to omit the standoffs in all but the "Basic Configuration," below.)

Note: the standoff holes are the four .150" diameter holes located in a rectangular arrangement near the corners of the PCB. They are sized to accommodate 4-40 screws/stand offs.

Once the enclosure has been drilled or milled, you can then mount the switches in their holes and slip the printed circuit board over their solder pins. When it is time (see below) you will want to solder the switch pins in place before you remove the printed circuit board/switches assembly from the enclosure.

Soldering the switches to the PCB in this manner will ensure that the switches are properly aligned with the holes drilled in the enclosure. After you've completed assembly of the other components on the circuit board, it will easily slip into place in the enclosure. If you try soldering the switches to the circuit board any other way, one or more of them may end up out of alignment. When you attempt to install the circuit board in the enclosure, the out-of-alignment switch(es) may stress the PCB to the point that one or more of the traces might crack. That would be a problem!

To lay out the switch or standoff holes locations on the face of the enclosure, first, cut a piece of paper just larger than the J-Box PCB. Then, tape the paper to the face of the enclosure covering the area where you want to drill the switch/standoff holes.



Place the J-Box PCB on the paper **with the silkscreen side down**. Use a square and ruler to position the PCB where you want it. Make sure you have the switch groups oriented the way you want them. Then, use a pencil and trace inside the standoff holes and the switch pin holes. When you remove the PCB you'll have all of the necessary "orientation" holes transferred to the piece of paper.

Next, note which switch/standoff holes you want to drill. If you are going to use the standoffs, center punch the middle of each standoff hole location. If you are going to install SW6, SW7 and/or SW8, center punch the middle pin hole for each switch you plan to use.

Finding the center holes locations for the DPDT switches (SW1 through SW5) may seem a bit challenging. Here's a trick that Travis suggested. Mark a diagonal line between the centers of the top left and bottom right switch pin holes for each DPDT switch you plan to use. Then mark a diagonal

line between the centers of the top right and bottom left holes. The center of the "X" identifies the location of the mounting hole for the switch. Center punch these locations (the middle of each "X" that you just drew).

Decide how you want to arrange scale and other connector jacks around the sides of the J-Box enclosure. As you look at the top of the enclosure (where the paper is still taped in place) orient the enclosure so the DPDT switches are closer to you, running left to right (this puts the location of SW8 at the top right). You may want jacks for quadrature scales/encoders on the end of the enclosure that is in your right hand; this keeps them close to their headers where they connect on the PCB. (The Jenix scales jacks require .750" holes for mounting.) I mounted my Jenix scales jacks on this end, oriented on 1.25" centers. The holes were drilled with a center-cutting .750" end mill turning at 350 r.p.m.

Now, roll the enclosure on its long side (the piece of paper should be toward your chest, and the marks for the DPDT switches (SW1 through SW5) should be at the bottom of the paper). Looking at this long side, you may want to locate the DB9/15/25 connector (for connecting the J-Box to the DRO-350) on the right end. Connectors for Chinese scales (if you are going to use them) might be arranged in the middle. You might want to arrange the auxiliary input jacks near the left end.

Roll the enclosure with its top up again (paper side up). You might want to mount the DC input jack on the end of the enclosure that is in your left hand. If you decide to use two DC input jacks (one for the DRO-350, too) there's plenty of room for the second jack on that end in your left hand.

You will notice I am not identifying hole sizes for jacks (other than the Jenix scales jacks). People are using a wide variety of jacks for connecting Chinese scales, auxiliary inputs, and DC. And, often, Digi-Key and Mouser seem to run out of items; specifying a certain hole size may cause a user to wait a long time for a backordered part to fit that hole. So, measure the parts when you get them, and lay out and drill hole sizes accordingly. There are no critical locations on the J-Box, except the locations of the switches. By following the procedure outlined above, even locating the switch holes turns into a "no-brainer."

A word of caution is in order. If you look inside the enclosure you will notice that there are "braces" of sorts in the middles of the long sides. Try to avoid locating a connector "on top" of one of these braces. It could lead to quite a mounting problem, and could weaken that side of the enclosure. Locate connectors with adequate space between the connectors and these center braces.

When you have your layout completed, center punch the enclosure where needed and drill away!

Soldering Switches to the J-Box Printed Circuit Board

Once you have decided which switches to use in your J-Box configuration, it is time to lay out your J-Box enclosure. Instructions for laying out the enclosure are detailed in the section above. Follow those instructions and drill the mounting holes for the switches before you attempt to solder them to the J-Box printed circuit board.

(NOTE: If you intend to install **SW2** but don't intend to install **SW4**, you must install jumpers at **SW4**. Similarly, if you intend to install **SW3** but don't intend to install **SW5**, you must install jumpers at **SW5**. Look at the section "Basic Configuration," below, and install/solder jumpers as shown in the **SW4** and/or **SW5** positions.

Similar to the above, if you intend to install **SW7** but don't intend to install **SW6**, solder a jumper between the center hole and upper hole of the **SW6** position.**)**

Remove the nuts (and other hardware) from the bushings of the switches you are going to install. (The "bushings" are the long, threaded collars that house the toggle handles.) Fit the switches in their mounting holes in the interior of the J-Box enclosure. Lay the enclosure face down on your work surface; prop up each corner of the enclosure about an inch so the switch handles don't contact the work surface as they protrude through their mounting holes. Make sure that the body of each switch fits approximately flat on the interior of the face of the enclosure. (Sometimes there are molding marks, logos, or other irregularities on the interior surface of the enclosure. You may have to file or otherwise level those irregularities to allow one or more of the switches to fit flat.)

When you have the switches in their mounting holes, lower the J-Box printed circuit board over the switches' solder tails. (The silkscreen side of the PCB should be facing up toward you as you lower it in place.) Once you have the PCB in place, solder each solder tail to its location. You will notice that the holes for the solder tails are, shall we say, "roomy." This allows them to accept a wide variety of switches, including switches with larger solder tails. As you solder the switches in place, use just enough solder to make a secure connection between the solder tails and their respective pads on the PCB; you don't have to "fill" the holes with solder.

When you have the switches soldered in place, remove the PCB from the enclosure and "populate" the silkscreen side of the board with headers, capacitors, and the other components required by your chosen J-Box configuration.

When all of the necessary components are installed on your PCB and it's ready to mount in the enclosure, thread a backup nut on each of the switch bushings. Locate them at about mid-position on the bushings. Temporarily install the PCB in the enclosure and check to see if the amount of bushing sticking up through the top of the enclosure is the height you want. Adjust the backup nuts either up or down until you get their heights about right – make sure there is enough thread exposed to install the outside nuts on the tops of the bushings!

Pull the PCB out of the enclosure one more time and place the edge of an approximate 6 inch ruler across the backup nuts. "Fine tune" their heights until each of them just touches the edge of the ruler. Why? When you install the PCB and begin to tighten the top nuts on the switch bushings, if one of the backup nuts is lower than the others, tightening its top nut may stress the PCB and break one or more of the board's traces. You don't want that to happen!

When you have the heights of the backup nuts adjusted, reinstall the PCB in the enclosure and install the top nuts. Tighten the top nuts equally (don't over-tighten them) and you're done with this step!

Wiring SW8

Before you begin to wire SW8, build the power supply section the way you have chosen (either with or without the voltage regulator). However, **do not install the jumper between J16 and J17**. Find the location of SW8 on the J-Box PCB. Decide if you want the power on when SW8 is in the up position or the down position. If you want **power on** in the **up position**, solder an approximate 26 gauge wire from one of the holes on **J17** to **W3** at SW8. Solder a similar-sized wire from **W2** at SW8 to **J16**. After you solder SW8 in place you're ready to go.

If you want **power on** in the **down position**, solder an approximate 26 gauge jumper wire from one of the holes on **J17** to **W1** at SW8. Solder a similar-sized wire from **W2** at SW8 to **J16**. With SW8 soldered in place, you're ready to go.

Do not, I repeat, **DO NOT** solder wires from J17 to both W1 and W3! If you do, the power will be on whether the switch is up or down – you might as well just use a jumper and save yourself the price of the switch.

Now, how do you switch **power** to the **DRO-350** and the **J-Box** at the same time **using SW8**? If you are using a single 9 volt wall wart for both the DRO-350 and the J-Box it's pretty easy, so long as the wall wart plugs in to the J-Box. If it plugs in to the DRO-350 you're out of luck. Here's how to make it happen.

Follow the above instructions for wiring SW8. Then, run another approximate 26 gauge wire from one of the holes of **J17** to **Pin 10** on the J-Box output connector. Connect another wire from **J15** to **Pin 11** on the connector (this provides access to "ground"). That's all there is to it.

Wiring the Connector on the DRO-350

Don't be intimidated by the thought of having to "do surgery" on your DRO-350. The way Scott designed connections to the three axes, this "surgical procedure" is pretty easy to do.

Open your DRO-350 case by removing the four screws from the back of the case. Set the front panel aside. Remove the six screws that hold the circuit board to the standoffs attached to the back of the case. Now, gently pull the circuit board away from the standoffs. Pull the MTA plugs from the programming jack (JP1), the auxiliary input jack (JP2), the three scales inputs (JP3, JP4 and JP5) and the power input (JP6). The back of the DRO-350 case should now be completely separated from the circuit board. Wrap the circuit board in an antistatic bag if you have it. Otherwise, set it in a place that is free from static electricity (a grounded anti-static work mat, for example, or somewhere other than on that overweight tabby cat that followed your kid home from school ten years ago – that would not be a good place!).

Find the connector that you intend to use to connect the DRO-350 to the J-Box cable. If your plan is to use a standard serial cable to connect to the J-Box, the connector that you mount to the back of the DRO-350 should either be a male or female DB-9. If you have mounted a male DB-9 to your J-Box enclosure, you will need a female DB-9 for the DRO-350 connector. Machine the hole in the back of the DRO-350 case for that connector; there are really no limitations about where to put the connector other than to avoid the DB-9 programming connector and any DRO-350 mounting hardware you may already have in place. **Don't permanently mount the connector yet!**

Refer to the "**J-Box Header Pin Assignments**" page. Look at the connections for **J1** of the J-Box (not the DRO-350). We are going to replicate those connections inside the DRO-350 case (well, almost). Look at the table on the next page for the pin assignments.

You have two (or more) choices to make at this point. You can either "re-use" the MTA plugs you just removed from the DRO-350 circuit board, or you can prepare new wires and MTA plugs to replace them. It's up to you. But here is something you need to be aware of. Scott's BOM for the DRO-350 specified inexpensive panel mount mini-DIN jacks for Chinese scale connectors. These connectors have approximate 6" wires attached to their four pins. You may have originally mounted those jacks in the back of your DRO-350 case after you attached 4 position MTA plugs to the ends of the wires. One easy way to make up the DRO-350 connector for the J-Box is to clip the leads from those mini-DIN jacks and use the wires to make connections to the DRO-350's J-Box cable connector. They already have MTA plugs attached. A bit of a labor and parts saving, eh?

DRO-350 DB-9 Connector Pin Assignments

Pin Number	Assignment
1 (yellow)	X axis, "Clock"
2 (blue)	X axis, "Data"
3 (yellow)	Y axis, "Clock"
4 (blue)	Y axis, "Data"
5 (yellow)	Z axis, "Clock"
6 (blue)	Z axis, "Data"
7	Auxiliary Input
8	Ground
9	+1.5 Volts

But here's the "rub" with that plan. The mini-DIN jacks use an unusual combination of wire colors. To make a long story short, the red wire is "ground" (we're used to black indicating ground), the blue wire is "data," the yellow wire is "clock," and the green wire is "+1.5 volts" (we're used to red being the "+" leg of the DC supply). The description below follows this unusual convention. Gulp! I'll try to keep it straight.

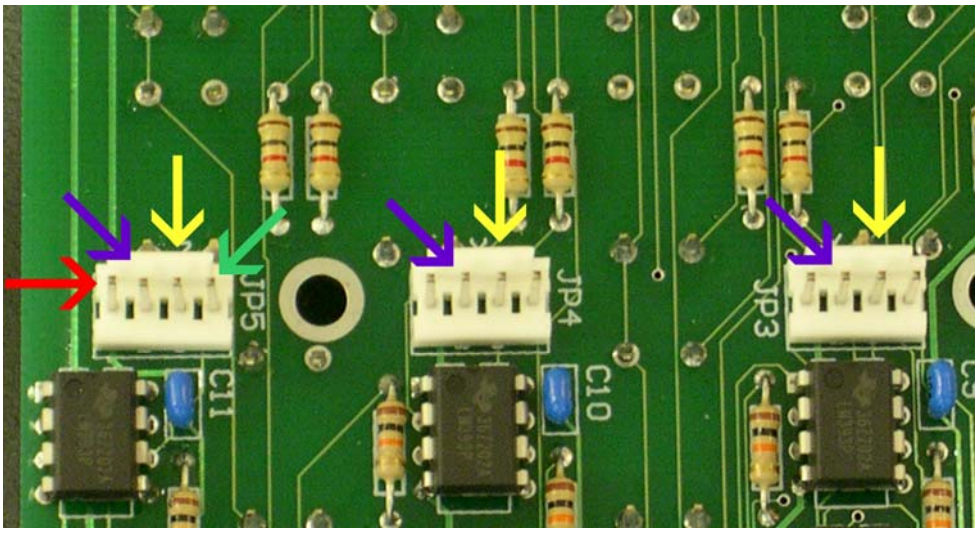
If you are not using the wires from your mini-DIN connectors, find some flexible stranded 26 gauge hook up wire (preferably two different colors, say blue and yellow). 24 gauge may work, but it is really too large for the type of MTA connectors we have been using.

If you are not using the wires from your mini-DIN jacks, cut three 9" pieces of both colors of wire you found. Remove .250" of insulation from one end of each blue and yellow wire (do the same if you are using the wires from your mini-DIN jacks). Make up pairs of blue and yellow wires; if you are reusing your mini-DIN wires, they are already "paired" together by the attached MTA plug. Solder the **yellow** wire from one pair to **Pin 1** of the connector and the **blue** wire from that pair to **Pin 2**. Solder another piece of **yellow** wire to **Pin 3** and the **blue** wire from that pair to **pin 4**. You guessed it, solder the last piece of **yellow** wire to **pin 5** and the **blue** wire from that pair to **pin 6**. These end up as the clock (yellow) and data (blue) wires for the X, Y and Z axes, respectively.

Unless you are reusing your mini-DIN wires, find three more colors of 26 gauge flexible stranded hook up wire; say red, green and orange. If you are reusing your mini-DIN wires, find a piece of orange or some other color of wire. Cut approximate 9" lengths of each type wire that you need. Remove .250" of insulation from one end of each wire you just cut. If you are **reusing your mini-DIN wires**, find the red and green wires that go with the wires attached to **Pin 5** and **Pin 6** of the connector; strip the ends of those red and green wires. Then, solder the **orange** wire to **Pin 7** of the connector. Solder the **red** wire to **Pin 8**, and the **green** wire to **Pin 9**. These are the "auxiliary signal," "ground," and "+ 1.5 volts" wires, respectively.

Okay, take another couple of gulps of that cold something that you have next to you and repeat after me….never mind.

Knock the cat off of your DRO-350 circuit board (you didn't see it get up there, did you? – just can't trust that cat!). Orient the board with the ICs toward you, with the **PIC** (**U1**) at the bottom and **U18** at the top. Look down 2.5" below **U18** and you will be looking squarely at **JP5** (on the left), **JP4** and **JP3** (on the right). These are the headers for the Z, Y and X axes, respectively. You can see their labels just above the headers. (See the photo on the next page for these details.)



The pins of those headers with the PCB in this position are, from left to right, “ground,” “data,” “clock,” and “+ 1.5 volts.” For the X and Y axes connections, if you are not reusing your mini-DIN wires, you can use either a 2 position or 4 position MTA plug to attach to the scale headers. Whichever you choose to use, you want to attach the wires to the MTA plugs so the blue wires connect to the “data” pins on the headers, and the yellow wires connect to the “clock” pins. If you use a **2 position MTA plug**, the **blue wire** goes in the **left** connection and the **yellow** goes in the **right**. You would then **connect** the MTA plugs **to Pins 2 and 3** of the headers (leaving Pins 1 and 4 disconnected).

If you use a **4 position MTA plug**, the **blue wire** goes in the **second connection from the left**, and the **yellow wire** goes in the **third**. When you connect the **4 position MTA plugs**, Pins 1 and 4 are left disconnected. Got it? (But that’s just on the X and Y axes!) If you are reusing your mini-DIN wires, you can **pull the red and green wires loose** from the **X and Y axis MTA plugs**; those red and green wires have not been soldered to the J-Box cable connector.

If you are not reusing your mini-DIN wires (which already have MTA plugs attached), grab the MTA plugs you want to use and connect the **blue** wire from **Pin 2** of your connector to the appropriate MTA plug connection. Connect the **yellow** wire from **Pin 1** to the connection **next to it**. Grab the next MTA plug and connect the **blue** wire from **Pin 4** of your connector to the appropriate MTA plug connection, and then connect the **yellow** wire from **Pin 3** to the connection **next to it**.

The MTA plug for the **Z axis** gets a **different** treatment. Here, a **4 position MTA plug is required**. If you are not reusing your mini-DIN wires, connect the **red** wire from **Pin 8** of the DRO-350 connector to the **first position on the left** of the 4 position MTA plug. Connect the **blue** wire from **Pin 6** to the **second position** from the left. The **yellow** wire from **Pin 5** of the connector goes to the **third position** on the MTA plug, and the **green** wire from **Pin 9** of the connector goes to the **fourth position** on the MTA plug. The addition of the red wire provides a common ground between the DRO-350 and the J-Box. The addition of the green wire routes 1.5 volts from the DRO-350 to the J-Box.

You are left with one unattached wire on the connector, the orange wire connected to **Pin 7**. This wire connects to the middle pin of **JP2** on the DRO-350, the auxiliary input jack. You can use either a 3 position MTA plug to make this connection, or a single crimp pin enclosed in a single-position housing. Whichever option you choose, be sure that the connection that you make with this wire goes to the middle pin of **JP2**.

Once you have attached the various MTA plugs to the wires on the DRO-350 connector, thread them carefully through the hole for the connector in the back of the DRO-350 case. Attach the connector to the back of the case securely. Then, attach the yellow/blue pair from **Pins 1 and 2** to the X axis

header (**JP3**). Attach the yellow/blue pair from **Pins 3 and 4** to the Y axis header (**JP4**). Attach the group of wires from **Pins 5, 6, 8, and 9** to the Z axis header (**JP5**). And finally, attach the orange wire from **Pin 7** to the **middle pin** of the auxiliary input header. Put the rest of the DRO-350 back together and you're good to go.

Note: If you have chosen **to power the DRO-350** from the J-Box you will need to use a connector that has at least 11 pins. A **DB-25 connector is an alternative**, but you can use any connector that you want. Wire the connector to **J1** following the conventions in the paragraphs above. Then, attach an approximate 6 inch long, approximate 26 gauge **red wire** to **Pin 10** on the connector. Attach an approximate 6 inch long, approximate 26 gauge **black wire** to **Pin 11** on the connector. Loosely twist these wires together along their lengths, so they form into a kind of two-wire cable.

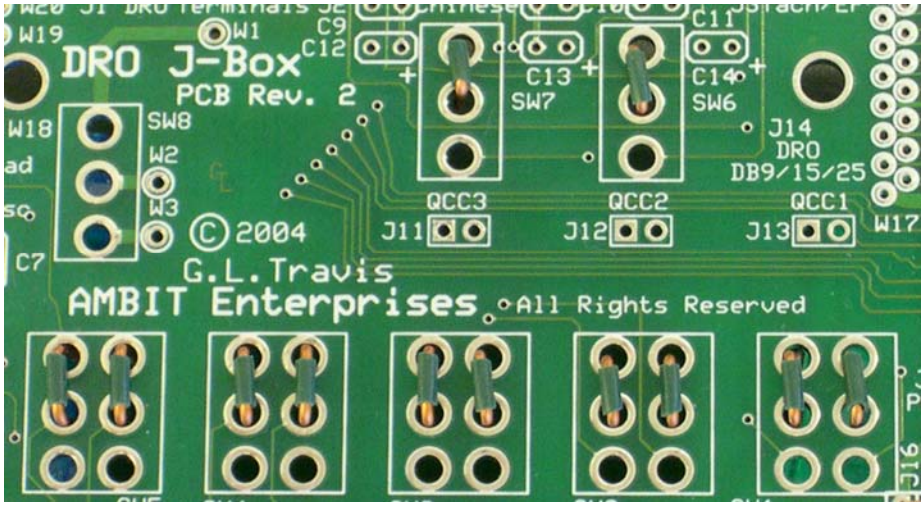
Find a **2 position MTA plug**. Attach the **black wire** to the **left** position of the connector. Attach the **red wire** to the **right** position of the connector. Attach the connector on the **JP6 header** on the DRO-350 PCB and you're done!

Basic Configuration

Here's the "quick and dirty" version. It **does not** allow use of Chinese scales. It limits you to **three quadrature scales/encoders** and it limits you to a **single auxiliary input**. But, after you read through the sections above, you will quickly see how you might modify this design to add "just a few nice touches" that you would really like to have.

First, lay out your J-Box enclosure following the steps outlined in the "Laying Out the J-Box Enclosure" section, above. Drill the enclosure to receive all four of the PCB standoffs. Drill the enclosure for three quadrature encoder/scale connectors, the DB-9 connector to connect the J-Box/DRO-350 cable (**J14a**), the auxiliary input jack (**J15a**) and the DC input jack (**J16a**).

Prepare a set of 11 jumper wires to connect between the middle and top holes of each switch pin location for **SW1 – SW5** and **SW7** (see the photo at right). Solder the jumpers into place using just enough solder to make a sound connection, but not so much that the switch pin holes get filled completely – you may want to remove the jumpers later and install switches. **Note:** you don't have to install a jumper in **SW6**; ignore the **SW6** jumper in the photo.



Prepare Mill-Max sockets and headers for attaching QCC-100s to **QCC1**, **QCC2**, and **QCC3**. Follow the instructions in the section, "Attaching QCC-100s to the J-Box PCB," above, and, when you're ready, solder those connections in place. Then, remove the QCC-100s and put them safely aside (watch that cat!).

Install the filter capacitors at **C3**, **C5** and **C7**. Install a jumper between **J16** and **J17**. Build the power supply consisting of **U1**, **C1** and **C2**. Fabricate and install the heatsink bridge (see the section, "If you want to use the onboard regulated 5 volt power supply," above).

If you want to direct solder cable sections to the PCB, follow the instructions in the section, "You can use direct solder connections," above, to attach cable sections to jacks for your quadrature encoders/scales. Do the same for the DRO output jack (**J14a**), the auxiliary input jack (**J15a**) and the DC input jack (**J16a**).

Attach the PCB standoffs inside the enclosure. Thread the cable sections through their respective connector/jack mounting holes, and fasten the connectors/jacks in their respective spots. Place the J-Box PCB inside the enclosure and, paying careful attention to the "J-Box Header Pin Assignments" page, solder the connector/jack cable sections to their header positions on the J-Box PCB. Attach the PCB to the standoffs; don't over tighten the screws!

Before you install the QCC-100s, plug the 9 volt wall wart into the DC input jack, and then plug it into the wall. Measure between **Pin 1** and **Pin 5** on **JP7** to see if you have approximately 5 volts. Put the "+" lead from your VOM on **Pin 1** and the "-" lead on **Pin 5**. If you have 5 volts, unplug the wall wart and skip to the next paragraph. If you don't have 5 volts, unplug the wall wart and check how you installed U1; its metal tab should be oriented to the outside edge of the PCB. Then check how you have wired the DC input jack to **J4**; the "+" lead from the input jack should attach to the square pad of **J4**. So long as you did install the jumper between **J16** and **J17**, there is little else that could go wrong.

When you have approximately 5 volts between **Pins 1** and **5** of **J7**, unplug the wall wart, and attach the QCC-100s to their respective positions. Then screw the lid on the J-Box enclosure.

Next, follow the instructions in the section, "Wiring the Connector on the DRO-350," above. When you have those steps completed, plug the various cables to their respective positions and apply power to both the DRO-350 and the J-Box. Remember to use the Setup Routines on the DRO-350 to set the "Counts per Inch" to match your quadrature encoders/scales. And set the "Filter Threshold" to "0."

Once all this is done, you should be good to go!

J-Box BOM

Part	Description	Digi-Key Number	Mouser Number
U1	5 volt 1 amp voltage regulator	LM7805CT-ND	512-LM7805CT
C1	10uF Tantalum capacitor	478-1840-ND	581-TAP106K020SCS
C2	.1uF ceramic capacitor	399-2127-ND	80-C315C104M5U
C3	.1uF ceramic capacitor	399-2127-ND	80-C315C104M5U
C4	.1uF ceramic capacitor	399-2127-ND	80-C315C104M5U
C5	.1uF ceramic capacitor	399-2127-ND	80-C315C104M5U
C6	.1uF ceramic capacitor	399-2127-ND	80-C315C104M5U
C7	.1uF ceramic capacitor	399-2127-ND	80-C315C104M5U
C8	.1uF ceramic capacitor	399-2127-ND	80-C315C104M5U
C9	.1uF ceramic capacitor	399-2127-ND	80-C315C104M5U
C10	.1uF ceramic capacitor	399-2127-ND	80-C315C104M5U
C11	.1uF ceramic capacitor	399-2127-ND	80-C315C104M5U
C12	10uF Tantalum capacitor	478-1840-ND	581-TAP106K020SCS
C13	10uF Tantalum capacitor	478-1840-ND	581-TAP106K020SCS
C14	10uF Tantalum capacitor	478-1840-ND	581-TAP106K020SCS
J1-J3	10 position MTA header	A24939-ND	571-16412150
J1-J3*	10 position Phoenix header*	277-1281-ND	651-1725737
J4	2 position MTA header	A24932-ND	571-6412152
J4*	2 position Phoenix header*	277-1273-ND	651-1725656
J5-J7	10 position MTA header	A24939-ND	571-16412150
J5-J7*	10 position Phoenix header*	277-1281-ND	651-1725737
J8h-J13h	64 positions header strip	ED7764-ND	575-101641
J8s-J13s	64 positions socket strip	ED7464-ND	575-113164
J14a	DB9 male solder cup	209M-ND	523-17S-DE09P
J15a	.125” miniature stereo jack	CP-43502PM-ND	161-7300
J15b	.125” miniature stereo jack	CP-43502PM-ND	161-7300
J15c	.125” miniature stereo jack	CP-43502PM-ND	161-7300
J16a	2.1mm DC input jack	CP-5-ND	163-4020
J16b	2.1mm DC input jack	CP-5-ND	163-4020
P1*	10 position MTA plug*	A19038-ND	571-16404420
P2a & P2b*	4 position MTA plug*	A19032-ND	571-6404424
P2c*	2 position MTA plug*	A19030-ND	571-6404422
P3a*	2 position MTA plug*	A19030-ND	571-6404422
P3b*	3 position MTA plug*	A19031-ND	571-6404423
P3c1*	1 position housing*	A26962-ND	571-7874992
P3c2 & P3d2*	crimp socket* (see Note 1)	A25970-ND	571-877567
P3d1*	1 position housing*	A26962-ND	571-7874992
P4*	2 position MTA plug*	A19030-ND	571-6404422
P5a*	5 position MTA plug*	A19033-ND	571-6404425
P5b*	5 position MTA plug*	A19033-ND	571-6404425

P6a*	5 position MTA plug*	A19033-ND	571-6404425
P6b*	5 position MTA plug*	A19033-ND	571-6404425
P7a*	5 position MTA plug*	A19033-ND	571-6404425
P7b*	5 position MTA plug*	A19033-ND	571-6404425
SW1	DPDT Toggle Switch, .4VA	CKN1010-ND	108-1MD1T1B1M2QE
SW2	DPDT Toggle Switch, .4VA	CKN1010-ND	108-1MD1T1B1M2QE
SW3	DPDT Toggle Switch, .4VA	CKN1010-ND	108-1MD1T1B1M2QE
SW4	DPDT Toggle Switch, .4VA	CKN1010-ND	108-1MD1T1B1M2QE
SW5	DPDT Toggle Switch, .4VA	CKN1010-ND	108-1MD1T1B1M2QE
SW6	SPDT Toggle Switch, .4VA	CKN1003-ND	108-1MS1T1B1M2QE
SW7	SPDT Toggle Switch, .4VA	CKN1003-ND	108-1MS1T1B1M2QE
SW8	SPDT Toggle Switch, 5.0 amp	CKN1004-ND	108-1MS1T1B1M2QE
Ribbon Cable**	10 wire, .100", 26ga, 6" len.**	WM10-06-ND	N/A
Stand Offs	.750" L 4-40 X .250" dia.	2204K-ND***	534-2204****
Enclosure	Cast Al. with Flanged Lid	HM577-ND	546-1590DFL
Wall Wart	9 volt, ≥1 amp.	(See Note 2)	412-109124
Heatsink Pad	T0-220 thermal pad .009"	BER175-ND	567-173-9-24OP

*****You can substitute 10 position Phoenix headers for J1 – J3, and J5 – J7. You can also substitute a 2 position Phoenix header for J4. If you use a full complement of Phoenix headers, delete all of the MTA-type headers and plugs from the **BOM**, above.

**Order 5 pieces.

***Sold in bags of 10; order 1 bag

****Sold individually; order 4.

Note 1: Digi-Key sells these crimp terminals 10 per bag; order 1 bag. Mouser sells these crimp terminals individually. Order at least two.

Note 2: At the time that this Construction Guide was being prepared, Digi-Key did not appear to have any 9 volt transformers available that were reasonably priced for use with this project.

J-Box Header Pin Assignments

Following are the corrected "pin assignments" for headers J1 through J7 on the J-Box printed circuit board. The pin assignments for the DRO-350 DB-9 connector appear on the next page. Chinese scales and QCC-100s are numbered 1, 2 or 3 (e.g., "Chinese scale 1", "QCC 3", etc.). The numbers 1, 2 and 3 identify which axis of the DRO-350 is connected to those devices (1 = X, 2 = Y, and 3 = Z). This same numbering applies to switches SW1, SW2 and SW3 (but not the other switches).

When output from a device is switch selectable, the position of the switch handle that connects the device to the DRO-350 is noted (e.g., SW7 down). If more than one switch is involved, all related switch positions are noted.

Bold face listings identify recommended connections for single quadrature connections to a QCC.

J4 Power Input (2 pin header)

Pin 1 "+" (Positive voltage)
Pin 2 "–" (Ground)

J1 DRO Output (10 pin header)

Pin 1 Clock, X axis
Pin 2 Data, X axis
Pin 3 Clock, Y axis
Pin 4 Data, Y axis
Pin 5 Clock, Z axis
Pin 6 Data, Z axis
Pin 7 Auxiliary
Pin 8 + 5 volts
Pin 9 Ground
Pin 10 + 1.5 volts (from DRO-350)

J2 Chinese Scales Input (10 pin header)

Pin 1 Ground
Pin 2 Data (Chinese scale 1, SW1 up)
Pin 3 Clock (Chinese scale 1, SW1 up)
Pin 4 + 1.5 volts
Pin 5 Ground
Pin 6 Data (Chinese scale 2, SW2 up)
Pin 7 Clock (Chinese scale 2, SW2 up)
Pin 8 + 1.5 volts
Pin 9 Ground
Pin 10 Data (Chinese scale 3, SW3 up)

J3 Chinese scale 3 continued, Auxiliary, 5 volts (10 pin header)

Pin 1 Clock (Chinese scale 3, SW3 up)
Pin 2 + 1.5 volts
Pin 3 Auxiliary input 1 (SW7 down)
Pin 4 Auxiliary input 2 (SW6 down, SW7 up)
Pin 5 Auxiliary input 3 (SW6 up, SW7 up)
Pin 6 Ground
Pin 7 + 5 volts
Pin 8 Ground
Pin 9 + 5 volts
Pin 10 Ground

J5 Quadrature Input (10 pin header)

Pin 1 + 5 volts
Pin 2 "A" (to QCC 3, SW3 down, SW5 down)
Pin 3 "B" (to QCC 3, SW3 down, SW5 down)
Pin 4 Ground
Pin 5 Ground
Pin 6 unassigned
Pin 7 unassigned
Pin 8 unassigned
Pin 9 + 5 volts
Pin 10 Ground

J6 Quadrature Input (10 pin header)

Pin 1 + 5 volts
Pin 2 "A" (to QCC 2, SW2 down, SW4 down)
Pin 3 "B" (to QCC 2, SW2 down, SW4 down)
Pin 4 Ground
Pin 5 Ground
Pin 6 + 5 volts
Pin 7 "A" (to QCC 3, SW3 down, SW5 up)
Pin 8 "B" (to QCC 3, SW3 down, SW5 up)
Pin 9 Ground
Pin 10 Ground

J7 Quadrature Input (10 pin header)

Pin 1 Ground
Pin 2 Ground
Pin 3 "B" (to QCC 2, SW2 down, SW4 up)
Pin 4 "A" (to QCC 2, SW2 down, SW4 up)
Pin 5 + 5 volts
Pin 6 Ground
Pin 7 Ground
Pin 8 "A" (to QCC 1, SW1 down)
Pin 9 "B" (to QCC 1, SW1 down)
Pin 10 + 5 volts