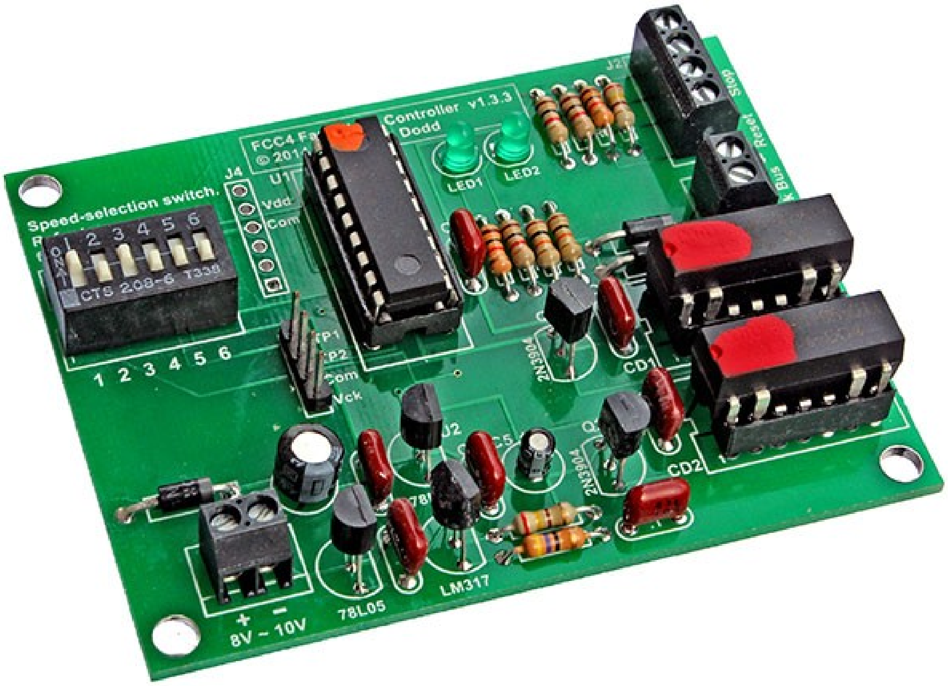
FCC4 Fast Clock Controller

User Manual



by

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Table of Contents

Introduction

Congratulations! You're just a few hours away from operating your model railroad more realistically with a fast clock.

This manual describes how to use the Model FCC4 Fast Clock Controller to operate Quartex Q80 clock movements at fast-time speeds. It also tells how to assemble the FCC4 kit, and how to modify Q80 movements to work with the FCC4.

Features and benefits

Here's what you get when you add the FCC4 to your railroad:

- ***New!*** More clock speeds. Now 16 switch-selectable speeds between 1:1 and 16:1.
- ***New!*** 16 additional switch-selectable "fractional" speeds between 2½:1 and 7¾:1 to fine-tune your railroad's fast time.
- ***New!*** More clocks. You can have up to 15 fast clocks, compared to 10 with the previous model.
- ***New!*** Longer clock "bus" cable. Connect clocks along a single 2-wire cable up to 180' long, compared to two 75' cables with the previous model.
- A Run/Stop switch, so you can stop the clocks without powering-down the controller.
- A clock reset button that advances the clocks at high speed to the original starting time, and then stops them. Press the button and walk away – soon all clocks will be ready for the next operating session.
- A fast-forward switch to run the clocks ahead at high speed. Useful for advancing all clocks on the layout at once to a new time.
- Movements are a standard size, and snap into most commercial clocks. Or you can install a modified movement in *any* clock using the supplied nut and washer.

  This gives you tremendous control over the appearance of your fast clocks. Perhaps you have a replica of an old railroad-style clock that would look great in the crew lounge. Just install a modified movement and connect it to the FCC4's clock bus cable. Easy clock movement modification.
- Movements are easy to modify, should you choose to do that yourself.

Finding your way around the user manual – read this

Navigating with hyperlinks

Throughout this manual, “hyperlinks” to figures, tables, and other sections (or websites) are shown in **bold blue** (unless the target is on the same page). Click the mouse pointer on a link to go directly to that location. For example, clicking this link: **Clocks and clock movements – read this** takes you directly to that chapter starting on page **10**. So does clicking the blue **10**.

You also can click a headings or page number in the table of contents to jump directly there.

PDF reader programs have various ways to return to the page you were on when you clicked a hyperlink. Try holding the **Alt** key and pressing the left-arrow key (←).

Usually you can add a "Back" (also known as "Previous View") button to your PDF reader's toolbar. If you're using *Adobe Reader,* right-click on the toolbar, click **Navigation**, then click **Previous View**. A left-arrow button should appear on the toolbar.

In *Foxit Reader,* click the **View** menu, then **UI Options,** then **Customize Toolbars.** Scroll through the list and check the box next to the **Previous View** item in the **View** group. A left-arrow button should appear on the toolbar.

User manual road map

This manual covers a lot of ground, so it can be puzzling about what to read, and in what order. Many chapter headings include "read this," and you should read those chapters

in addition, many chapters have a "**Next:**" link at the end that suggests the next logical chapter to read. So if you're just getting started reading about power supplies, you probably need to read about clocks and clock movements next. Just click the link to jump directly to that topic.

All chapters dealing with the FCC3 <u>kit</u> apply *only* to the kit, and may be skipped if you purchased an assembled and tested FCC4.

The same applies to modifying clock movements. If you purchased modified and tested movements, skip the chapter on modifying them.

Optional reading is contained in appendices. There is nothing there that you need to connect and operate the FCC4, assemble the FCC4 kit, or modify movements.

Basic information

Using the FCC4

Everyone needs to know how to use the FCC4, so that chapter is near the front of the manual, on page **5**.

Power supply

You can't use the FCC4 without a power supply, so this important topic starts on page **7**.

Clocks and clock movements

Everyone also needs to learn about choosing clocks for the layout, and how to install modified movements in them. This information begins on page **10**.

Beyond those basic chapters, I recommend the following road map, depending on whether or not you need to assemble an FCC4 kit and/or modify clock movements.

The steps on the road map assume you have read about using the FCC4, power supplies and clock movements, so they don't mention this basic information again.

My FCC4 is a kit

1. Identify the components, using the table starting on page **17**.
2. Inventory the parts that came with the kit, and check them against the list on page **22**.
3. Read about soldering and installing electronic components on page **25**.
4. Look over the component layout on page **27** to become familiar with the FCC4 circuit board.
5. Assemble the FCC4, following the instructions starting on page **24**.
6. Perform initial testing, page **33**.
7. Perform operational testing, starting on page **36**.
8. Go to page **40** for information about installing and using the FCC4.

My FCC4 is already assembled

Your assembled FCC4 was fully tested prior to shipment, so all you need to do is choose a power supply, perform a quick functional check, and install fast clocks on your railroad.

1. Perform operational testing, starting on page **36.**
2. Go to page **40** for information about installing and using the FCC4.

I need to modify my clock movements

1. Choose the right movements for your clocks; see page **10**.
2. Read about soldering on page **25**.
3. Modify clock movements according to the instructions starting on page **41**.

Warranty

Please read the warranty information on page **62**, so you know what to do if something doesn't work right.

Additional information

Optional appendices near the back of this manual contain information that you might find interesting.

- **Appendix G – Digging into the Q80 movement** shows how to disassemble and clean a Q80 movement that has begun to run erratically. Doing this can restore a flaky movement to like-new condition.
- There is a block diagram of the FCC4 on page **51**.
- If you want to install the FCC4 and its control switches in a plastic case, you can print and use the suggested front panel on page **52**.
- There is a list of "helper services" I offer on page **50**.
- You can learn how the FCC4 works on page **53**.
- Finally, page **54** relates how the FCC4 evolved after Klockit could no longer supply suitable clock movements for the former model.

Operating the FCC4 – Read This

The FCC4 is simple to use. First, please read about the power supply on page **7**, about optional control switches on page **37**, and about installing the FCC4 on **40**. Then come back here to learn how to use the FCC4.

- Turn on the power. With no switches connected to J2, the clock runs at the speed selected by S1. If you have a **Run/Stop** switch connected to J2, flip it to the **Run** position to start the clock. Flip it to the **Stop** position to stop the clock.
- Refer to the speed switch setting tables on page **38** to learn how to set the fast-time speed you want.
- **Fast Forward**. Flip the Fast Forward switch to the **fast-forward (FF)** position while the clock is running to advance it rapidly. Be sure to notify crews operating your railroad if you do this, to avoid surprises.
- **Reset.** With the **Run/Stop** switch in the **Stop** position, momentarily press the **Reset** pushbutton to command the FCC4 to advance the clock rapidly until it reaches the starting time. This is handy at the end of an operating session so you don't have to reach behind every clock to manually set it for the next session. ***The clock must be stopped (Run/Stop switch in the Stop position) for Reset to operate.***

  Table 7 shows how long it takes to reset clocks to the starting time, based on the length of the operating session (i.e., how many hours they have run at fast-time.

  Do not turn off the power at the end of the session if you want to reset the clock. Stop the clock with the **Run/Stop** switch, then press the **Reset** button. The clock will run at a speed of 17:1 until it reaches the starting time, and then it will stop. Turn off power ***after*** the reset operation completes.

  Leave the Run/Stop switch in the Stop position while resetting. If you switch it to the **Run** position, the reset operation will complete, but then the clocks will begin running again at fast-time speed.. If your goal is to reset your clocks to the starting time, you want them to stay there.

  Remember: Leave the **Run/Stop** switch in the **Stop** position during reset, and turn off power after the reset operation completes.

Troubleshooting

What should you do if your FCC4 doesn't work correctly? Table 1 below lists common problems and things to check.

First ask yourself if something has changed since it ran the last time. Did you move anything? Did you do any layout wiring that might have disturbed the connections to the FCC4 or to your clocks? If so, begin looking there for the source of the problem.

Symptom	Possible Cause
Clocks don't run; no lights flash on FCC4.	1. Power not connected, or connected backward. Check wiring. 2. Power supply bad. Measure 8V to 10V (9V nominal) on J1 terminals. 3. Run/Stop switch in Stop position. Flip switch. 4. Run/Sop switch defective, or wires shorted together. Disconnect Run/Stop wires at J2. 5. Microprocessor U1 has failed due to static electricity or nearby lightning strikes. Email me at mike@mdodd.com to order a replacement.
FCC4 lights flash, but no clocks run.	1. Clock bus is not connected to J3, or it is connected but the wires are shorted together. 2. Perform the voltage checks on page **34**, looking for brief positive pulses on J3. If pulses are not present on both terminals, email me at mike@mdodd.com.
Clocks won't stay synchronized.	1. Clock minute hand is too long, causing the movement to run erratically. The maximum recommended minute hand is 3½", for a 7" time ring. 2. Defective clock movement. Some movements simply won't run well at higher speeds. Clean the gears as described on page **59**, or try a different movement. 3. The clock movement has reached the end of its useful life; replace it.
Clocks don't run at desired speed.	1. Speed switch S1 is incorrectly set. Verify the setting in **Table 5** and **Table 6**. 2. Switch #5 on S1 is incorrectly set. Turn off the switch for the speeds in **Table 5**, and turn it on it on for the fractional speeds in **Table 6**.

Table 1: Troubleshooting

Next: control switches, page 37, or Speed switch settings, page 38 (Click the page number)

Power supply – read this

The FCC4 requires a DC power supply capable of providing 9 volts direct current (9VDC), with a minimum of 8VDC and a maximum of 10VDC, at a current of 200 milliamps.

☐ ***Measure the power supply's output voltage now, before connecting it to the FCC4.***

Suggested power supplies

Here are some suggested power supplies:

Fig. 1: 9V @ 600mA power supply.

- All Electronics **#PS-961**, 9V @ 600mA (Fig. 23). (http://www.allelectronics.com/make-a-store/item/PS-961/9-VDC-600MA-REGULATED-POWER-SUPPLY/1.html)
- All Electronics **#PS-912**, 9V @ 1A. (http://www.allelectronics.com/make-a-store/item/PS-912/9VDC-1A-SWITCHING-DC-SUPPLY/1.html)
- All Electronics **#PS-920**, 9V @ 2A. (http://www.allelectronics.com/make-a-store/item/PS-920/9VDC-2A-POWER-SUPPLY/1.html)
- All Electronics **#PS-10**, switchable 3, 4.5, 6, 7.5, 9 or 12 volts @ 1A. (http://www.allelectronics.com/make-a-store/item/PS-10/SELECTABLE-MULTI-OUTPUT-POWER-SUPPLY-1-AMP/1.html) Set the switch for 9V and measure the output with a voltmeter. If it is higher than 10V, switch to the 7.5V setting and measure again.
- Radio Shack **#273-316**, switchable 3, 4.5, 6, 7.5, 9 or 12 volts @ 1A. (http://www.radioshack.com/product/index.jsp?productId=3875403#) Set the switch for 9V and measure the output with a voltmeter. If it is higher than 10V, switch to the 7.5V setting and measure again.

Can I use a 9V battery?

You can use a 9V battery, but this is not recommended. Even though the current drain is small (especially with just a few clocks), there is no way to predict when the battery will discharge to the point where the clocks won't remain synchronized, or won't run at all. The middle an operating session is no time to discover a weak battery!

Preparing the power supply to connect to the FCC4

☐ If the power supply comes with a connector on the end of the output cable, cut it off, strip 1/4" of insulation from each wire and tin the bare wires with solder.

☐ Do not connect the power supply to the controller yet. Connect a voltmeter to the stripped and tinned wires and turn on the power supply. Identify which wire is positive and which is negative. Often the wire with a stripe is negative (Fig. 2), but not always. Measure to be sure, and mark the wires for reference later – don't depend on your memory.

Fig. 2: Identifying power supply wires.

Do not connect your power supply to the FCC4 if the voltage is higher than 10 volts!
Use a power supply that produces between 8VDC and 10VDC.

A regulated power supply is best; the output from an unregulated power supply can vary greatly. Switching power supplies, such as the All Electronics examples above, are regulated, and produce a steady voltage.

Checking your power supply with the FCC4

Here you will connect your power supply to the FCC4, and confirm that it is properly connected, and that the FCC4's internal power circuits are functioning correctly.

You will need a voltmeter capable of reading up to 10 volts DC to check-out your power supply before connecting it to the FCC4, and for troubleshooting if the FCC4 does not operate properly. An inexpensive multimeter such as All Electronics # DVM-810 http://www.allelectronics.com/make-a-store/item/dvm-810/economy-digital-multimeter/1.html is suitable.

What you'll need

- The power supply you chose above, with the output cable prepared to connect to J1 on the FCC4.
- A voltmeter capable of reading up to 10 volts DC. An inexpensive multimeter such as All Electronics # DVM-810 http://www.allelectronics.com/make-a-store/item/dvm-810/economy-digital-multimeter/1.html is suitable.

Measuring voltages on the FCC4

The following checkout steps require your voltmeter's negative probe to be connected to a common point on the PCB. Locate the pin labeled **Com** on J5, and connect your voltmeter's **negative** probe to it, and leave it there. ***Be extremely careful that the probe does not also touch the adjacent Vck or TP2 pins.***

If necessary, you may use needle nose pliers to gently bend the **Com** pin about 45° to provide additional clearance, as seen here. The J5 pin header is not needed for anything else, so bending the pin is okay.

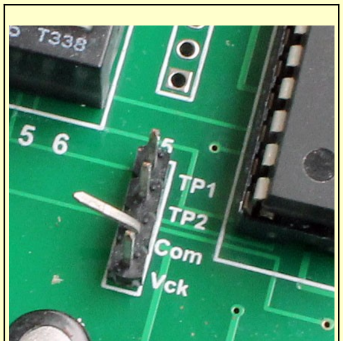


Fig. 3: J5 Com pin bent for clearance.

Important! The Com point on J5 is ***not*** the same as the Com point on J2, which is the terminal block for control switches. Connect the voltmeter's negative probe to J5-Com, not J2-Com.

When you are asked to touch the voltmeter's positive probe to a point on the PCB, take care that it touches *only* that point, and that it makes good contact. If you don't see the desired reading, check the contact point before assuming that something is wrong.

After connecting your voltmeter's negative probe to J5-Com, follow these steps to connect your power supply to the FCC4, and check it out.

☐ Turn off the power supply.

☐ Connect the **negative** power wire to the [–] pin of J1. Insert the wire into the [–] hole in J1 and tighten the screw to hold the wire securely, but do not over-tighten.

☐ Connect the **positive** power wire to the [**+**] pin of J1. Insert the wire into the [**+**] hole in J1 and tighten the screw to hold the wire securely, but do not over-tighten.

☐ Apply power**.** Touch the voltmeter's positive probe to the lead on diode D1 that is marked with a bar and soldered to the square pad.

☐ The voltage here should be about 0.7V less than the power supply's output you measured above. So, if you measured 9V on your power supply, now the voltmeter should read about +8.3V on diode D1's banded lead.

☐ ***Remove power immediately if the voltage is zero.*** If the voltage is zero, check these possible causes:

- The power wires are reversed in J1.
- There is a short circuit between the pins of J1, or between the banded lead of D1 and the [**–**] pin of J1. Touch diode D1. If it is warm or hot, the banded lead is shorted to the [**–**] pin of J1.
- Capacitor C1 is installed backward or is defective. Touch C1. If it is warm or hot, it is installed backward or is defective. Contact me for a replacement or replace it with a 47 µF 16V electrolytic capacitor, with the long (positive) lead in the hole in the square pad.
- D1 is installed backward. Check that the banded end is soldered to the square pad.
- D1 is defective (open circuit). To check, turn on the power and touch the positive voltmeter probe to the [**+**] pin of J1, then to the banded end of D1. If there is positive voltage on J1 [**+**], but none on the banded end of D1, D1 is defective. Contact me for a replacement or replace it with a 1N4001 diode.

☐ With voltage present on the banded end of D1, we know that the power is connected correctly, and the diode and some capacitors are installed properly. Touch the voltmeter's positive probe to the pad labeled **Vdd** in the J4 outline**.** The voltage there should be +5V. If not, replace U2, the 78L05 voltage regulator.

☐ Touch the voltmeter's positive probe to the pin on J5 labeled **Vck**. The voltage there should be +1.5V. If there is no voltage, replace U3, the LM317 voltage regulator. If the voltage is not +1.5V, confirm that resistors R1 (240 ohms) and R2 (47 ohms) are installed in their correct locations, and are the correct values.

Power supply verified

If the preceding voltages are correct, remove power. Your power supply and the FCC4's internal power circuits are working correctly.

Next: Clocks and movements, page 10, or Operating the FCC4, page 5 (Click a page number)

Clocks and clock movements – read this

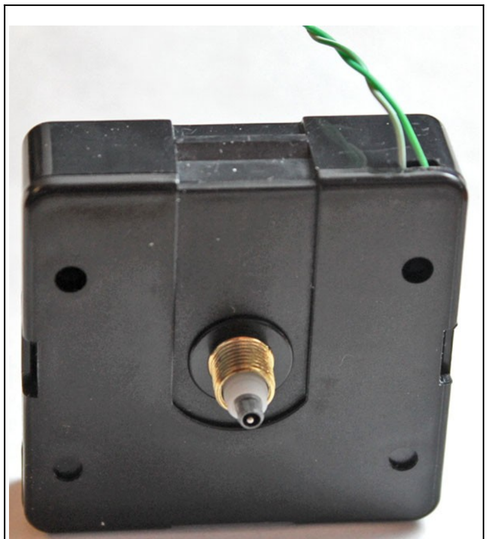


Fig. 4: Modified Q80 clock movement.

You will need one or more clocks, each with a Quartex brand Q80 movement that has been modified to operate faster than normal. Also please read the helpful information on page **55** about keeping your clocks running accurately.

Q80 movements are available from Klockit (http://www.klockit.com/products/dept-157__sku-AAAVV.html) or you may order them from me (http://electronics.mdodd.com/fastclock.html#movements) with the parts needed to perform the modification, or already modified and tested. Instructions for modifying a movement begin on page **41**.

Many clock styles, from plain to fancy, are available in stores and online. Some modelers choose inexpensive plastic clocks, while others prefer ornate wooden clocks reminiscent of railroading's glory days. Whatever you choose, replacing the factory movement with a modified Q80 movement is easy. Most commercial clocks have a snap-fit holder for the movement, and the Q80 fits this holder perfectly. If a clock does not have such a holder, the Q80 can be attached with the supplied nut and washer on the movement's threaded bushing.

You might decide to make your own clocks with a computer-printed face glued to a dial made from plastic, hardboard (Masonite), or plywood.

Choosing your clocks and clock parts

Here are some suggestions for selecting and buying clocks and parts to make your own clock.

Procure your clocks first

Buy clocks to be transformed into fast clocks *before* ordering the Q80 movements. You need to know the dial thickness to select a movement bushing length, and the "time ring" diameter to choose clock hands. See **Choosing clock hands**.

Measure the clock dial thickness

Q80 movements must be ordered with a bushing sized for a specific dial thickness. Bushings are available for dials 1/8", 3/16", ¼", 3/8", ½", and ¾" thick. *(The vast majority of movements I've sold have the bushing for 1/8" dials.)*

Bushing lengths are specified for the maximum dial thickness, and are slightly longer than that to leave a few threads for the mounting nut. In other words, a 1/8" bushing fits dials up to 1/8" thick, and still has threads for the nut.

Dials may be *thinner* than the specified bushing length, because the threads run all the way to the base. Nothing prevents you from using a movement with a ¾" bushing on a 1/8"-thick dial.

But be careful about using long bushings with thin clock dials. A long bushing elevates the hands well above the clock face – unlikely to be an attractive feature. Also, if your clock has a clear glass or plastic cover, the shaft or hands scrape against it.

Your best bet is to choose a movement with a bushing length sized for your clock dial thickness. Most plastic clocks sold at big-box stores accept a movement with a 1/8" bushing.

Clock hands

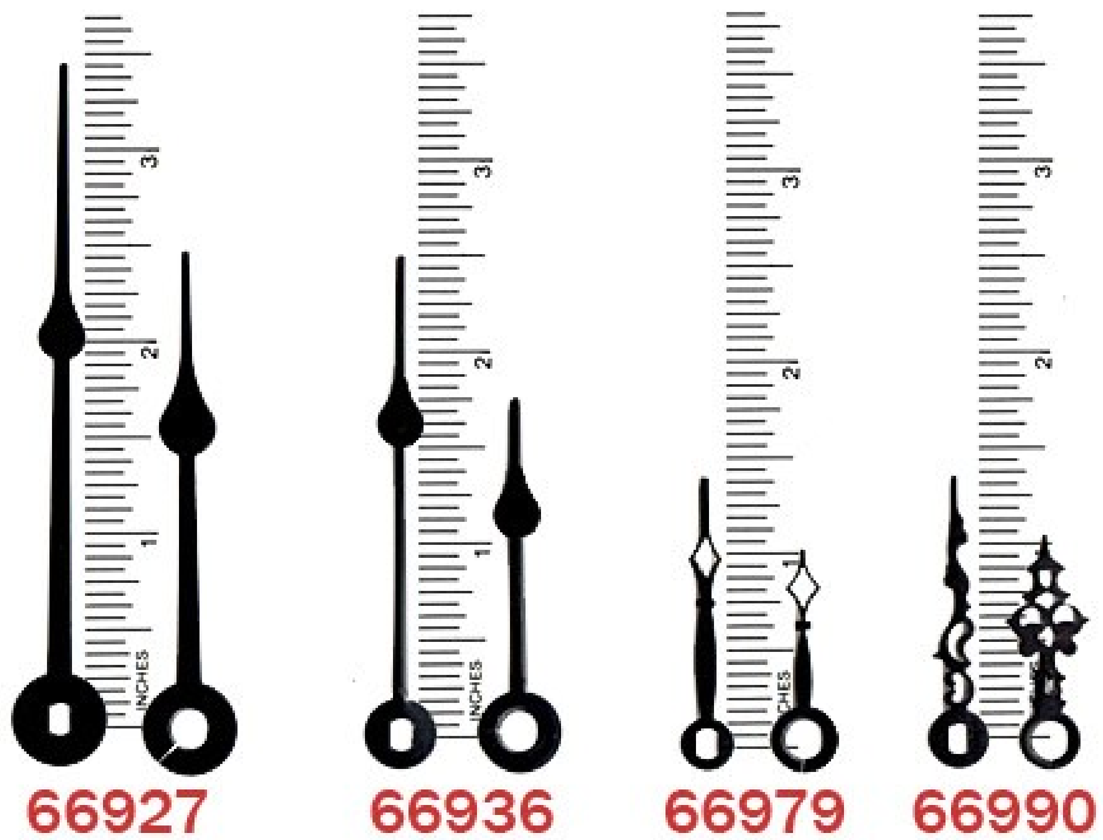


Fig. 5: Clock hand sizes (actual size).

Each Q80 movement comes with one minute hand and one matching hour hand at no extra charge. Klockit offers a wide range of styles and lengths, and I offer the four shown in Fig. 5. These hands will print actual size if you turn off all scaling, such as "fit to page" or "fit to margins" in your PDF reader's Print dialog.

It is important to use the supplied Klockit hands for several reasons:

- They fit the Quartex Q80 movement. Hands on many inexpensive clocks attach to the movement's shafts differently, and can't be used on a Q80 movement. The Klockit minute hand's hole has two flat sides (see Fig. 5) to fit the flatted shaft on the Q80 movement.
- They are lightweight metal, and modified movements can move them at high speed. Thicker plastic hands found on some commercial clocks have too much mass, even if they could be made to fit the Q80 movement.
- You can't use a second hand. The movement doesn't have enough power to rotate a second hand at high speed. This is not a consideration when buying a Q80 because you don't get a free second hand from Klockit or from me. But frequently commercial clocks have a second hand, and it might be tempting to use it on your fast clock. ***Don't.***

Choosing clock hands

For best appearance, the minute hand should extend to the "time ring" where the tick marks are printed. Usually the numerals are inside this ring, so the minute hand extends past the numerals.

The maximum recommended length of the minute hand for fast-time use is 3½". A minute hand longer than this can cause the modified movement to operate erratically.

This means that the clock's time ring should be no more than 7" in diameter. The clock face itself can be larger (and most are), but the time ring should match the minute hand length. You can snip off the end of the minute hand if it's too long for your clock's time ring.

You need a Quartex Q80 movement

Plan on replacing the movement in every clock you buy. The FCC4 is designed and tested to operate modified Quartex Q80 movements at high speed. Commercial clocks often have another brand movement. Even if the movement has the Quartex name, there is no way to tell if it is a Q80.

If you buy a commercial clock, replace the movement with a modified Quartex Q80.

If you buy a Klockit clock, ask if the movement in it is a genuine Quartex Q80. If so, it probably is suitable. If not, or the sales person doesn't know, order a separate Q80 at the same time.

Order one or two spare Q80 movements to have on hand if any should behave erratically or if you want more fast clocks.

I have a pendulum clock

If your clock has a pendulum that you want to keep, order Klockit item 20071 http://www.klockit.com/products/product.aspx?sku=20071. This is a shell that surrounds the Q80 movement, and has its own battery and mechanism to swing the pendulum. This way, the pendulum swings independently of the fast clock (even when the fast clock is is not running).

Miscellaneous

Each Q80 movement comes with mounting hardware consisting of:

- A large rubber washer to place between the movement and the rear of the clock dial.
- A large brass nut and washer to fasten the movement to the clock dial.
- A tiny brass "cap" nut, closed on one side, to fasten the minute hand to its shaft. I recommend using this nut for better appearance, since it hides the open end of the hollow minute-hand shaft.
- A second tiny brass nut, but open on both sides, to fasten the minute hand to its shaft. This nut is used when a second hand is used on the movement. Since fast clocks can't use a second hand, you can discard this nut unless you don't mind looking at the hollow minute-hand shaft end.

The order of assembly starting with the clock movement is: Rear – movement, rubber gasket, clock dial. Front – large brass washer, large brass mounting nut, hour hand, minute hand, tiny brass nut.

When hanging your clock on a wall or installing it in the layout fascia, be sure to allow easy access to the time-setting knob on the rear of the movement.

Installing clock hands

It is important to Install clock hands correctly, so the modified movement will operate smoothly.

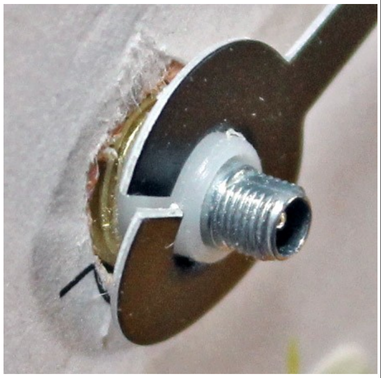


Fig. 6: Hour hand hub split wrong.

- ☐ First support the back of the movement, and press the hour hand onto its shaft with a twisting motion.
  - ○ Work carefully. The hour hand's hub is split, and sometimes it bends upward at the split, as seen in Fig. 6. If this bent end it too high, the minute hand will drag on it.
  - ○ If the hub split is too high, press down on it with your thumb as you rotate the hour hand. It should slide down the plastic shaft. Ideally, both sides of the split will be on the same plane, but as long as neither protrudes above the top of the plastic shaft, it is fine.

Fig. 7: Hour hand hub split OK.

- ☐ Leave about about 1/8" clearance between the hour hand and the clock face. The hour hand should be parallel to the clock face; don't let it bend downward and drag on the clock face. If it bends upward, the minute hand might hit it, stalling the clock.
- ☐ Ensure that the flat sides on the minute hand's hole are aligned with the flats on the shaft. Thread the small cap nut onto the shaft carefully – it is easy to get it cross-threaded.
  - ○ Hold the minute hand securely against the clock face while tightening the nut. If the hand moves, the internal gears can "strip." This can damage the gears so the movement runs unreliably.
  - ○ When properly fastened, the minute hand should be secure on the shaft. If the minute hand "flops around" when you shake the clock, the nut is cross-threaded , and not tightened securely. Remove it and try again.
- ☐ Check that the minute hand's hub is not dragging on the hour hand's hub at the split, as discussed **above**. Fig. 8 shows proper hub clearance. Notice also how close-together is the hour hand hub at the split. If it were like **Fig. 6**, the minute hand would drag on it.

Fig. 8: Hub clearance.

- ☐ Check hand clearance. Hands should not drag on the clock face or interfere with each other. With both hands installed, use the time-setting knob on the back of the movement to rotate the minute hand several times around the clock. The minute hand should pass the hour hand without striking it. If it strikes, check the following:
  - ○ Does the minute hand run into the hour hand because the hour hand is too high on its shaft? If so, remove the minute hand and press the hour hand further onto its shaft.
  - ○ The hour hand might not be square on its shaft, and the resulting tilt allows it to interfere with the minute hand.
  - ○ If the hour hand is square on its shaft and not too high, bend it down closer to the clock face. Don't let it drag on the clock face.
  - ○ Bend the minute hand slightly away from the clock face to provide more clearance above the hour hand.

- ○ Be sure that the minute hand doesn't drag against the clock's front glass or plastic. ***Any*** drag will cause the clock to run erratically at high speed. Also check that the cap nut securing the minute hand doesn't touch the clock's clear cover. If it does, replace the closed cap nut with the thinner nut that is open on both sides.

☐ If the hands are too long for your clock's time ring, you may snip a fraction of an inch from the end of them. Color the bare metal end with a black permanent marker or thin black paint to hide the cut. Use your judgment about how much to cut off. The minute hand should end approximately at the time ring, and the hour hand should be long enough to make it obvious which number it's pointing at. Consider appearance *and* functionality. Not only should your clocks look nice, you should be able to read the time at a glance, without being confused by oddly-sized hands.

☐ Synchronize the hour and minute hands before closing the clock case, while you still have access to them.

- ○ Rotate the time-setting knob on the back of the movement until the minute hand points directly at the 12.
- ○ Gently rotate the hour hand on its shaft until it points directly at any number (e.g., 9 for 9:00 o'clock). The clock hands are now correctly synchronized.

Installing movements in your clocks

The Q80 movement is a standard size that will snap into most commercial clocks with battery-powered quartz movements. If you built your own clock, or are modifying a classic clock, the Q80 can be installed using the supplied nut and washer on its threaded brass bushing.

Installing the Q80 in a commercial plastic clock

☐ If you are using a commercial plastic clock, first remove the clear plastic front cover. Usually this can be accomplished with a thin screwdriver or a table knife. Insert the tool between the clear cover and the clock case at the 12, 4, and 8 positions, then pry gently inward while pulling upward. Once the cover begins to move, it is easy to continue prying until it comes off.

☐ Remove the factory hands and discard them all; they will not fit the modified Q80 movement.

☐ Remove the factory movement from the rear by gently prying open the plastic tabs that hold it in place.

☐ Snap the modified Q80 movement into the bracket that held the factory movement. The large rubber washer included with the Q80 usually is not needed, but if you do use it and the movement doesn't snap easily into the shell, remove the rubber washer.

☐ Install the flat brass washer and large brass nut on the movement's threaded bushing. Even though the movement is held in place with the clips on the shell, the washer and nut hold the face flat and hide the hole in it, for a more finished appearance.

Installing the Q80 in a homemade or other clock

☐ Place the large rubber washer over the movement's bushing so it lies flat against the front of the movement.

☐ Position the movement on the back of your clock face with the threaded bushing in the center hole.

☐ Install the flat brass washer and large brass nut on the movement's threaded bushing, and tighten securely.

Installing the hands

- [ ] Please read **Installing clock hands** on page **12** for details about installing Klockit metal hands on a Q80 movement.
- [ ] Install the hour and minute hand and synchronize them, then close the case.

How about a fast-time model clock tower?

Over many years of selling fast clock controllers, people have asked me if it's possible to have a fast clock in the clock tower of a large building, such as a city train station.

Now the answer is "maybe." Even though the clock movement case measures almost 2¼" square, the actual movement inside is considerably smaller. The photos below show a movement alongside a ruler, so you can judge whether it would fit in your model. The photos are not actual size.

The 1-3/8" #66979 1-3/8" hands (http://www.klockit.com/products/sku-FANCY.html) or 1¾" #66741 (http://www.klockit.com/products/sku-SPADE.html) could be cut shorter to fit a model clock dial. The central hubs are a bit large, and can't be reduced.

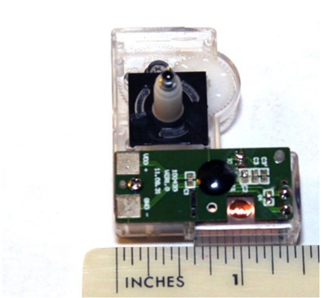


Fig. 9: Motor side.

Fig. 10: Motor end.

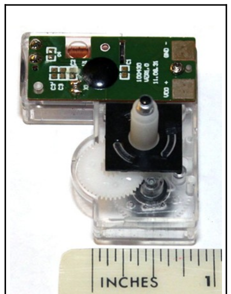


Fig. 11: Gearbox end.

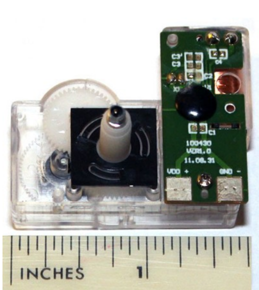


Fig. 12: Gearbox side.

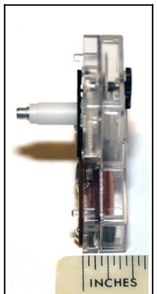


Fig. 13: Edge.

Table 2: Movement dimensions.

Connecting the clocks

Wiring your fast clocks to the FCC4 is straightforward. J3 has two screws to connect a two-wire cable called a "bus." This single output is capable of powering up to 15 clocks over a cable up to 180 feet long. Tap onto this bus cable anywhere you need a clock, as with the clocks shown in **Fig. 14**.

The bus wires can be almost any type, such as telephone cable, one twisted pair from an Ethernet cable, or even selected wires in a complete four-pair Ethernet cable.

Connect the ends of bus wires to the J3 screws, and run the cable to clock locations around your layout.

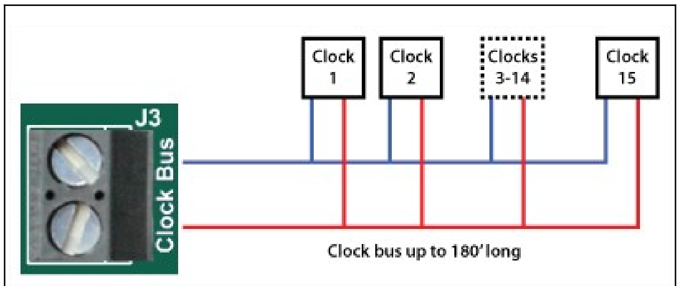


Fig. 14: Clock connections.

- ☐ Refer to Fig. 15. The brown twisted-pair of wires is the clock bus, and the green pair goes to a clock. A and B show the connection choices described next.
  - ○ At each clock location, cut around the insulation on each wire, and push it back, exposing about ¼" of bare wire. Work carefully to avoid nicking the wire. Solder the two wires from a modified movement to the two exposed wires (A in the photo).
  - ○ If you can't easily cut around the insulation and push it back, just snip the wires . Strip ½" of insulation from the ends, and twist the bare ends of the same wire together along with one wire from the clock, then solder(B in the photo).
  - ○ Wrap plastic electrical tape around each soldered joint to prevent them from touching each other or anything else.

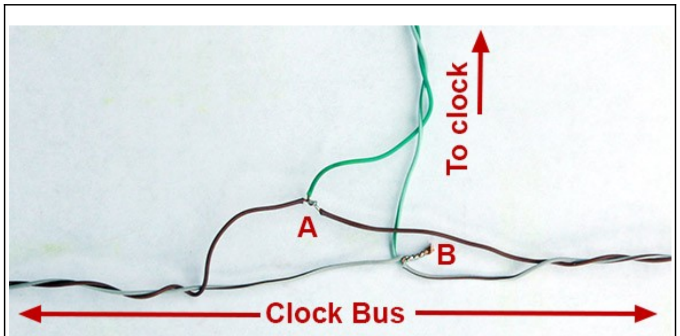


Fig. 15: Clock wire connections.

When running the cable to your fast clocks, try to avoid routing it near (within an inch of) AC power cords or other high-power wiring (e.g., DCC track-power cables) that might introduce extraneous electrical "spikes" into the cable.

Run a final test when all clocks are connected.

Movement sounds

Do not become concerned if a clock movement's ticking is barely audible, Most modified movements operate with a quiet but distinct ticking sound, but some are nearly silent. It's easy to conclude that a movement that's quieter than others is defective. Probably not. The proof is whether the clock hands move correctly.

Next: Initial testing, page 33, or Modifying clock movements, page 41 **(Click the page number)**

Kit Components

Identifying the components

Take an inventory to be sure you have all parts before beginning assembly. The parts list on page **22** lists all the components. This table describes the parts, and includes photos to help you identify them. If an item is noted as “polarized,” pay extra attention to its orientation when you insert it into the PCB, and be sure to orient it exactly as directed.

Note: The term "DIP" is an abbreviation for "Dual Inline Package," the style of integrated circuits ("chips") used in the FCC4.

Static-sensitive components

Components that can be damaged by static electricity are shipped in a piece of black protective antistatic foam. DIP sockets and the Z1 speed switch also are shipped in this foam to prevent damage to their pins.

This photo shows the general arrangement of the components in the foam. Take special care to locate the five three-pin transistors and voltage regulators. These tiny black components can be hard to see against the black foam.

See the note on page **29** to make it easier to read the markings on transistors and voltage regulators.

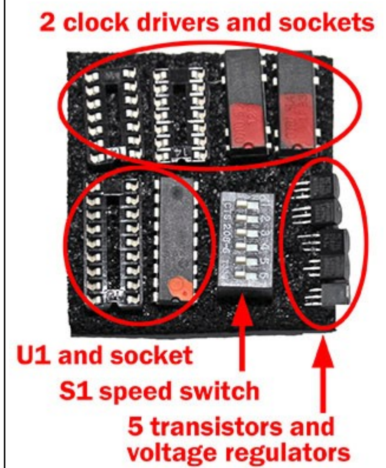
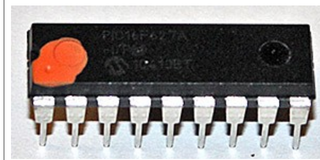
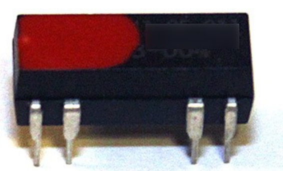
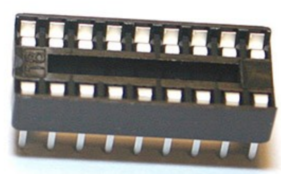
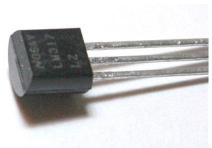
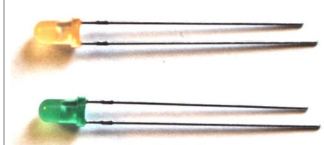
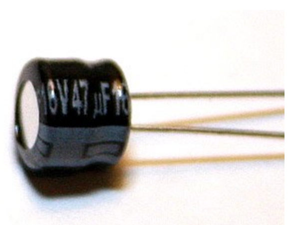
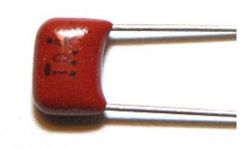


Fig. 16: Static-sensitive components.

Component	Description	Photo	Notes
Microprocessor “chip”	Rectangular package with two rows of pins on the bottom.		This device is the heart of the FCC4, and can be destroyed by static electricity, so keep it in its black conductive foam until ready to insert it into the socket on the PCB. Before handling it, touch your hand to a metal object to discharge any static electricity. Polarized. Insert into its socket with the notched end (painted orange) oriented as printed on the PCB and shown on page **27.**
Clock driver "chip"	Rectangular package with two rows of pins on the bottom.		Polarized. Insert into their sockets with the notched end (painted red) oriented as printed on the PCB and shown on page **27.**
Socket for "chips"	Plastic body with two rows of pins on the bottom, and metal contacts on the top. This is an 18-pin socket. There also are two shorter 14-pin sockets.		Polarized. install on the PCB with the notched end oriented as printed on the PCB and shown on page **27.**

Component	Description	Photo	Notes
Voltage regulator, transistor	Black, semi-circular device with three leads on the bottom. Marked **78L05**, **LM317**, or **2N3904**.		These devices can be destroyed by static electricity, so keep them in their black conductive foam until ready to solder them on the PCB. Before handling one, touch your hand to a metal object to discharge any static electricity. Polarized. Install with the flat side as as printed on the PCB and shown on page **27.** ***important!*** The identifying numbers on these devices are *extremely small.* See the note on page **29** to make it easier to read the markings. Be absolutely sure you have the correct part when assembling the kit.
LED (light-emitting diode)	Yellow or green transparent body with two leads on the bottom. One lead is longer than the other, and the bottom flange on the body has a (barely visible) flat side. In this photo, the flat sides are facing upward.		LEDs are polarized. Orient the flat side to match the flat on the PCB outline. This places the longer lead in the hole in the *square* pad on the PCB. It makes no difference if you receive yellow or green LEDs, or one of each color.

Component	Description	Photo	Notes
Resistor	Small cylinder with colored bands that identify the resistor's value.		Resistors are not polarized, but some people choose to install them with the same orientation (e.g., the gold bands all in the same direction) for aesthetics. Use care identifying the colored bands. Installing the wrong resistor will result in improper operation or no operation at all. To read the color code, position the gold band to the right, then read from left-to-right. This 10K resistor's color code is **brown-black-orange**. The gold band is ignored.
Capacitor	There are two types of capacitors. An *electrolytic* capacitor is a black cylinder and has its value and other symbols printed on its case. One lead is shorter than the other, and is marked with a white bar on the black case. The short lead is the negative lead. A *ceramic* capacitor has two leads on one edge, and is marked with numbers (usually "104") to indicate its value.	 ***Electrolytic capacitor***  ***Ceramic capacitor***	Electrolytic capacitors are polarized. Insert the longer (positive) lead into the hole in the *square* pad on the PCB. Ceramic capacitors are not polarized.
Diode	Black cylinder with a band on one end. Marked 1N4001.		Polarized. Install with the banded end as printed on the PCB and shown on **page 27.**

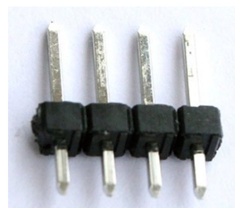
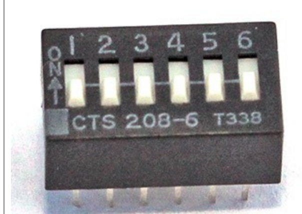
Component	Description	Photo	Notes
Terminal block	Rectangular plastic block with holes along one side, screws along the top, and pins on the bottom. This photo shows a 2-position connector block. There also is a 4-position block.	 	Install with the side holes facing *outward* from the PCB. See the note below. **Note:** If the terminal block style shown above is unavailable, terminal blocks will have the wire holes on *top* and the screws on the *side,* such as this one. Install these with the screws facing *outward* from the PCB.
4-pin header for J5	Plastic body with four square pins protruding from the top and bottom		Install on PCB with ***short*** pins in holes, leaving long pins sticking up. This is used for **J5.** A pin header is ***not*** included for J4, so those holes remain empty. See page **31**.
DIP switch	Black plastic block with six slide switches on the top, and pins on the bottom.		Polarized. Install with the switch numbers 1-6 as printed on the PCB and shown on page **27**.
Quartex Q80 clock movement (not part of FCC4 controller kit)	You will need one modified Q80 clock movement for each clock on your layout.		Purchase Q80 clock movements separately from Klockit, or from me at http://electronics.mdodd.com/fastclock.html.

Table 3: Kit parts identification.

Parts list

The fast clock controller kit contains these parts. Please check the kit contents against this list to verify that all components are present. Refer to the table starting on page **17** for details about identifying the components.

Item	Component Designation	Total Quantity	Identification
Capacitor, 47µF	C1	1	47µF, 16V
Capacitor, 1µF	C5	1	1µF, 50V
Capacitor, 0.1µF	C2, C3, C4, C6, C7, C8, C9	7	Marked 104 or .1
Resistor, ¼W, 240 ohms	R1, R3	2	Red-yellow-brown
Resistor, ¼W, 47 ohms	R2	1	Yellow-violet-black
Resistor, ¼W, 1K ohms	R4, R5, R6, R7, R9	5	Brown-black-red
Resistor, ¼W, 10K ohms	R8, R10	2	Brown-black-orange
Diode, 1N4001	D1, D2, D3	3	Black cylinder with banded end
Transistor, 2N3904	Q1, Q2	2	2N3904
LED, green or yellow	LED1, LED2	2	
Microprocessor chip	U1	1	Orange paint
Voltage regulator, 5V, 78L05	U2, U4	2	78L05
Voltage regulator, LM317	U3	1	LM317
Clock driver chip	CD1, CD2	2	Red paint
Switch, 6-position	S1	1	
Terminal block, 2-pin	J1, J3	2	
Terminal block, 4-pin	J2	1	
Pin header, 4-pin	J5	1	
DIP sockets for U1, CD1, and CD2		3	18-pin for U1, 14-pin for CD1 and CD2.
Recommended Additional Items			
Quartex Q80 clock movements	Dial thickness in parentheses: Klockit 10043 (1/8") Klockit 10002 (¼") Klockit 10082 (3/8") Klockit 10003 (½") Klockit 10004 (¾").	1 for each clock	You may purchase movements from Klockit or from me. Each movement comes with one set of hands. I include with each movement everything needed to modify it for fast-time.
AC-to-DC adapter, 9 volts DC nominal (8VDC to 10VDC) at 200 milliamps minimum		1	See **Suggested power supplies** for more information.
SPST or SPDT toggle switch	Optional control switches	1 or 2	See **Control switches – read this** for more information.
SPST normally-open momentary pushbutton	Optional Reset button	a	See **Control switches – read this** for more information.

Table 4: Kit parts list.

KIT ASSEMBLY

The fast clock controller is built on a high-quality printed circuit board (PCB) with plated-through holes. Plated-through holes have metal walls, so the solder readily flows into the hole and out onto the soldering pad on the opposite side of the PCB.

What you'll need

you will need these basic electronics tools to assemble and test the FCC4 kit.

- Needle nose pliers. (All Electronincs #PLR-55 http://www.allelectronics.com/make-a-store/item/plr-55/5-mini-long-nose-pliers/1.html).
- Wire cutters, (All Electronics #FC-14 http://www.allelectronics.com/make-a-store/item/fc-14/5-flush-cutter/1.html).
- Soldering iron, 30-45 watts, tip temperature of 700° to 800°. ***I strongly recommend a temperature-controlled soldering station,*** such as one of these. You can adjust the tip temperature, and the tip is isolated from the power plug to prevent household voltage from destroying sensitive electronics components as you solder them to the PCB.
  - Weller WTCPT (HMC Electronics: http://www.hmcelectronics.com/cgi-bin/scripts/product/1980-0217/?gclid=CPaA2vaMuZ4CFchn5QodJ2l0pg).
  - All Electronics IR-361 (http://www.allelectronics.com/make-a-store/item/ir-361/60w-temperature-controlled-solder-station/1.html).
  - All Electronics IR-50 (http://www.allelectronics.com/make-a-store/item/ir-50/temperature-controlled-solder-station-50w/1.html).
- 60/40 rosin-core solder (All Electronics #TS-110 (7' in dispenser) http://www.allelectronics.com/make-a-store/item/ts-110/60/40-solder/1.html or #SOL-564 (½-pound spool http://www.allelectronics.com/make-a-store/item/sol-564/60/40-solder-1mm-1/2-lb-roll/1.html).
- **Use only rosin-core solder to assemble the FCC4, and for all electronic soldering.** If you insist on using liquid or paste flux, check and double-check that it is ***rosin*** flux. If it doesn't say “rosin” it is not rosin. ***Never*** use acid flux to solder electronics.
- You will need a voltmeter capable of reading up to 10 volts DC to check-out your power supply before connecting it to the FCC4, and for troubleshooting if the FCC4 does not operate properly. An inexpensive multimeter such as All Electronics # DVM-810 http://www.allelectronics.com/make-a-store/item/dvm-810/economy-digital-multimeter/1.html is suitable.

About soldering

You need to know how to solder electronic circuits to assemble the kit and modify Q80 clock movements. If you are unfamiliar with soldering techniques, you can find a good tutorial on the Web, such as this one at http://www.aaroncake.net/electronics/solder.htm

You can purchase a solder practice kit, such as this one: http://www.makershed.com/ProductDetails.asp?ProductCode=MKEL2 It definitely is a good idea to hone your skills before assembling the FCC4.

Soldering electronic components requires the use of a low-wattage soldering iron, about 35 to 45 watts. Ideally, use a temperature-controlled soldering station, as listed above.

Use only rosin-core solder to assemble the FCC4. If, despite this warning, you insist on using liquid or paste flux, check and double-check that it is ***rosin*** flux, not ***acid*** flux. ***Never*** use acid flux to solder electronics.

Getting started

You may solder components such as resistors and diodes from the *front* side of the PCB. This eases assembly because you can press the component against against the PCB while soldering.

Some components such as capacitors, terminal blocks, and integrated circuit sockets can be soldered only from the back side. Bend the leads of capacitors slightly to hold them against the front side, and press sockets and terminal blocks firmly against the front side while soldering on the back side.

Resistors and diodes used on the fast clock controller PCB have 0.4” hole spacing. The parts kit includes a 3D-printed jig (Fig. 17) to help you bend bend axial component leads consistently. Place a resistor or diode between two notches, then bend the leads downward to 90°. The third pair of notches from the end are for a diode. They are slightly wider and closer together to accommodate the diode’s larger wires.

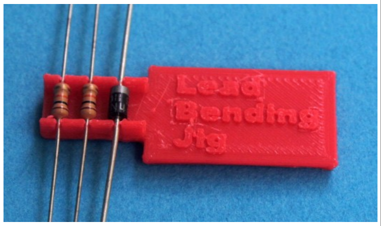


Fig. 17: Component lead-bending jig.

Refer to **Identifying the components** on page **17** as you install the components in each step.

Solder/cool procedure

Some components can be damaged or ruined by excessive heat, so follow this two-step procedure for each lead wherever you see **solder/cool** in the instructions.

1. Solder one lead. Solder quickly to not overheat the component.

2. After soldering, blow gently on the solder joint for one or two seconds to cool it, then turn the board over and blow gently on the component itself for one or two seconds.

Repeat steps 1 and 2 for each lead on the component. Solder and cool each lead. Do not solder all the leads at once without cooling.

Don't overheat other components

Even if the instructions don't say **solder/cool**, you can employ a soldering technique that minimizes heat damage to components such as resistors, capacitors, and plastic components such as sockets, plastic switches, and terminal blocks.

Similar components usually are installed together. Insert all components listed in a single step into their holes, then begin soldering.

Solder one lead one each component in turn, then come back and solder another lead. This gives each component time to cool before you come back to solder the next lead.

Take care to solder every lead. They are easy to overlook when using this round-robin technique. Double-check your work.

Component layout

Refer to this component layout and the printed circuit board (PCB) itself while assembling the FCC4 fast clock controller. The front side of the PCB is shown here; the reverse side is referred to as the "back" side in the assembly instructions on the following pages.

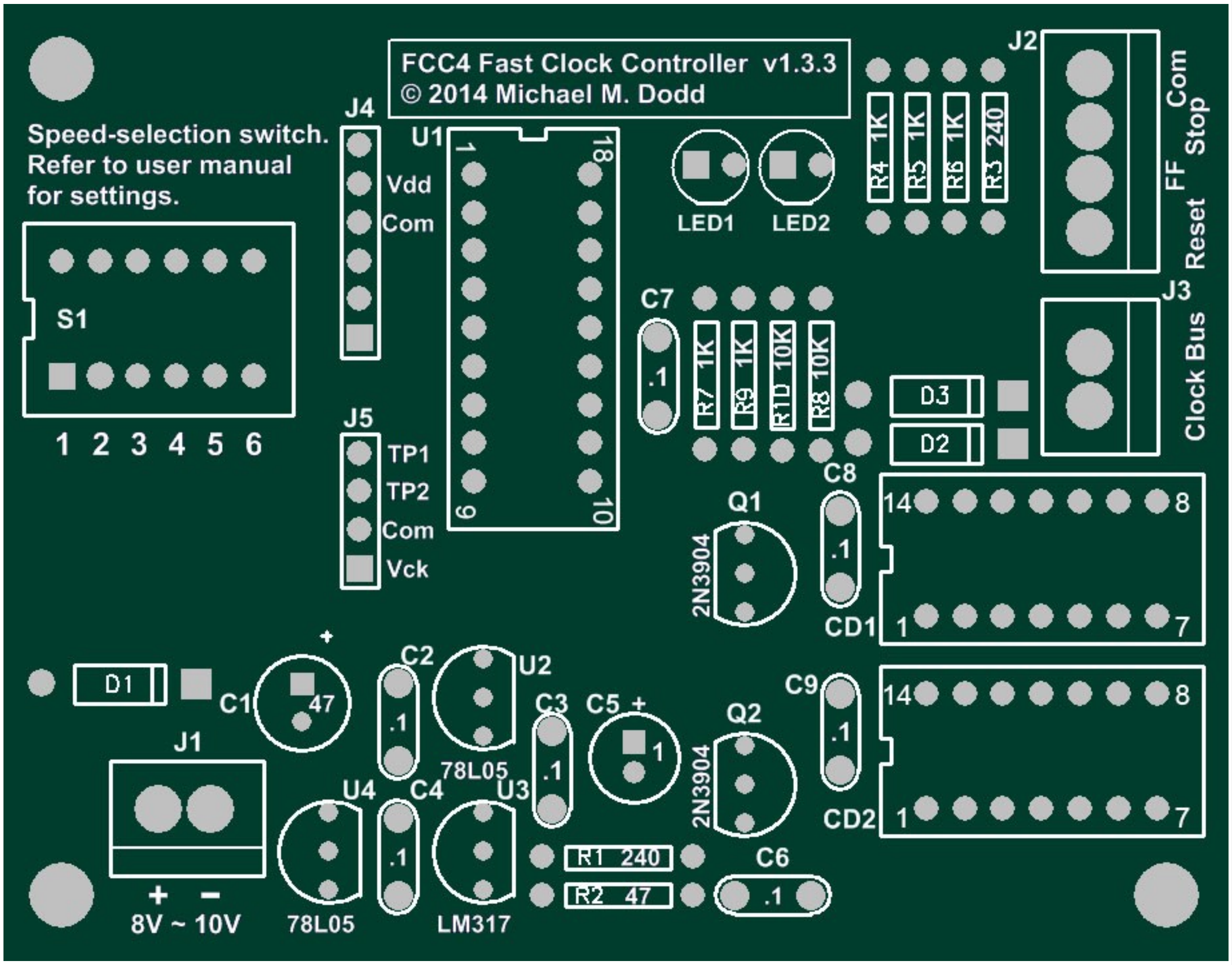


Fig. 18: FCC4 Component Layout.

Assembling the circuit board

The FCC4 is built on a professional-quality fiberglass printed circuit board (PCB) with copper traces on both sides, and a silk-screened component diagram on the front side.

Refer to **Fig. 18: FCC4 Component Layout.** for locations of the components when assembling the PCB. The speed-selector switch is near the upper-left, with J1 (power) near the lower-left. J2 (external control switches connector) and J3 (clock connector) are located near the upper-right corner.

The following steps are organized for easiest assembly, with the smaller parts installed first. After soldering a component in place, cut off the leads on the back of the PCB, just above the solder. Do not trim the leads on sockets, terminal blocks, and the speed-selector switch.

Bend the leads of all resistors and diodes at 0.4" spacing to fit the holes in the PCB. This goes faster if you buy or make a simple jig (**Fig. 17**) to get the same 0.4” spacing for all 11 resistors and three diodes.

Let's begin.

Diodes

- ☐ Install the three diodes oriented to match the outlines on the PCB, with the lead from the banded end in the hole in the square pad. Bend the leads at 0.4" spacing, insert, **solder/cool**, and trim the leads.
  - ○ D1
  - ○ D2
  - ○ D3

Resistors

- ☐ Install the two 240-ohm resistors (red-yellow-brown) in the locations marked on the PCB.
  - ○ R1
  - ○ R3
- ☐ Install resistor R2, 47 ohms (yellow-violet-black) in the location marked on the PCB.
- ☐ Install the five 1K resistors (brown-black-**red**) in the locations marked on the PCB. Take care to read the color code correctly, and not confuse these with the brown-black-**orange** resistors. Bend the leads at 0.4" spacing, insert, solder, and trim the leads.
  - ○ R4
  - ○ R5
  - ○ R6
  - ○ R7
  - ○ R9
- ☐ Install the two 10K resistors (brown-black-**orange**) in the locations marked on the PCB. Take care to read the color code correctly. Bend the leads at 0.4" spacing, insert, solder, and trim the leads.
  - ○ R8
  - ○ R10

Sockets

Installing the sockets before taller components are installed allows you to turn over the PCB on your workbench and press it against the bottom of the sockets while soldering the socket pins. Orient each socket so that its notch matches the outline on the PCB. Bend corner pins slightly to hold the sockets in place while you turn over the PCB.

Check carefully that there is a socket pin in each hole! It is easy for a pin to bend under the socket. If you discover this *after* soldering the socket, you will need to unsolder all the pins to remove the socket and straighten the pin. Unsoldering a socket is difficult, and risks damaging the PCB. Check carefully, then solder all pins on the back of the PCB. There is no need to trim socket pins after soldering.

- ☐ Install the three DIP sockets in the locations marked on the PCB. Insert, solder, but do not trim the leads. ***Do not insert the integrated circuits into the sockets at this time.***

- ○ U1 (18 pins, 9 on each row)
- ○ CD1 (14 pins, 7 on each row)
- ○ CD2 (14 pins, 7 on each row)

Capacitors

☐ Install the seven 0.1 µF capacitors (reddish-brown body, labeled 104) in the locations marked on the PCB. Insert, solder, and trim the leads.

- ○ C2
- ○ C3
- ○ C4
- ○ C6
- ○ C7
- ○ C8
- ○ C9

☐ Install electrolytic capacitor C1 (round, black, labeled 47 µF) in the location marked on the PCB. Insert the longer lead in the hole in the square pad, marked with a + sign. Insert, solder, and trim the leads.

☐ Install electrolytic capacitor C5 (tiny, round, black, labeled 1 µF) in the location marked on the PCB. Insert the longer lead in the hole in the square pad, marked with a + sign. Insert, solder, and trim the leads.

Voltage regulators and transistors

These five devices have a semi-circular body with three leads on the bottom. Install them oriented so the flat side matches the outline printed on the PCB. Be sure the orientation is correct before soldering.

Spread the leads slightly to match the hole spacing, and gently press the device into the holes until you feel slight resistance. Stop at this point, leaving the device standing about ¼" above the PCB. Do not attempt to press the device against the PCB! Doing so will break the leads where they enter the body. The holes are spaced wide to allow the device to stand above the PCB.

Some of these parts you receive might have their leads bent at the factory, as shown in Fig. 19. If so, simply drop the device into the three holes until it rests on the bends, then solder.

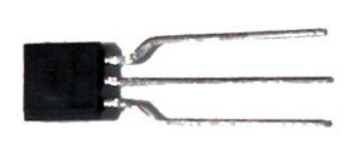


Fig. 19: Factory-bent leads.

Important! The identifying markings on U2, U3, U4, Q1, and Q2 are very small. Use a magnifier if necessary to be absolutely sure you are installing the correct part.

Shining light at an oblique angle on the flat surface of a component makes the markings more visible. Compare the straight-on view of a 78L05 voltage regulator on the left with the oblique lighting on the right.

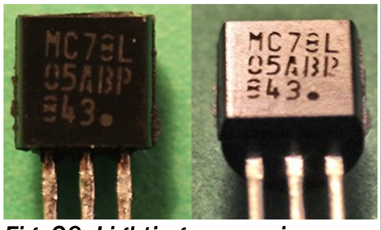


Fig. 20: Lighting comparison.

☐ Install the two voltage regulators ,U2 and U4, marked 78L05 in the locations marked on the PCB. Insert, **solder/cool** each lead, and trim the leads.

- ○ U2
- ○ U4

- [ ] Install voltage regulator U3 marked LM317, in the location marked on the PCB. Insert, **solder/cool** each lead, and trim the leads.
- [ ] Install the two transistors, Q1 and Q2, marked 2N3904, in the locations marked on the PCB. Insert, **solder/cool** each lead, and trim the leads.
  - Q1
  - Q2

LEDs

An LED has a yellow or green transparent body with two leads on the bottom. One lead is longer than the other, and the body might have a flat surface on the bottom flange (see the yellow sidebar below).

Flats on LEDs

Sadly, not all LEDs have a flat, or sometimes the flat does not match the outline on the FCC4 circuit board. ***To avoid confusion, disregard the flat on the PCB outline and on the LED, if present, and always place the longer lead into the hole with the square pad.***

LEDs can be installed flush with the PCB, or left standing about ¼" to ½" above it.

- [ ] Install the two LEDs in the locations marked on the PCB. Insert, **solder/cool** each lead, and trim the leads. Remember to place the longer lead into the hole with the square pad.
  - LED1
  - LED2

Terminal blocks, pin header, and speed switch

Press these components flat against the PCB and solder on the back side. This can be tricky, but once you solder one pin, the component will stay in place. Nevertheless, continue to press it until you have two pins soldered. Otherwise, the component might tilt, which looks sloppy and increases the chance of damage during use, since the its body is not supported by the PCB.

Remember, you will be tightening screws against wires in the terminal blocks, and moving switches on S1 to set the clock speed. These components need to be resting flat on the PCB for support.

- [ ] Install the three terminal blocks in the locations marked on the PCB with their side holes facing outward, away from the PCB. If, due to parts availability, your terminal blocks have the wire holes on top and the screws on the side, install these with the screws facing outward away from the PCB. Insert, press flat against the PCB, solder, but do not trim the leads.
  - J1 (2 terminals)
  - J2 (4 terminals)
  - J3 (2 terminals)

- [ ] Install the four-pin header in the J5 location marked on the PCB. Place the short pins into the holes, and solder them. The long leads protrude from the top of the header. There is no header for J5. See the yellow sidebar **below** to learn why.
- [ ] Install S1, the six-position speed-selector switch in the location marked on the PCB. Check that the switch is oriented as shown here before soldering; unsoldering this switch later could damage it or the PCB.
    - If the switch has protective plastic covering the switches, use a hobby knife or other sharp blade to snag a corner, then peel it off.

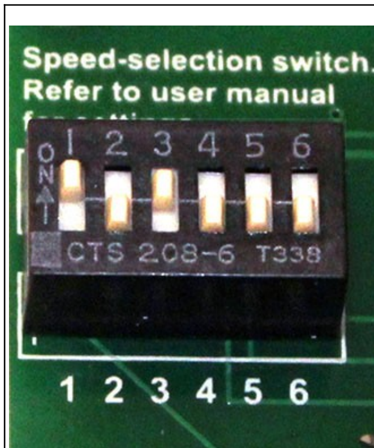


Fig. 21: Speed switch orientation.

Why is the pin header for J4 missing?

A pin header for J4 is not included with the FCC4, so the six holes within the J4 outline remain empty.

These holes are intended for possible future enhancements, and are not used at this time.

Do not fill the J4 holes with solder. I might need these holes empty if you send me your FCC4 for troubleshooting. These holes must remain empty when you complete the assembly.

Please resist any temptation to "mess around" with the J4 pads! They are connected directly to the microprocessor without protective resistors, so it is possible to **destroy this important chip** by improper use of these points. ***If these points could have been at all useful to you, I would have included the connector and protective resistors.***

Best bet: Ignore J4 entirely, except when instructed during the system checkout.

Assembly complete

Congratulations! Your FCC4 controller circuit board is completely assembled. Hold the PCB up to a light and verify that the only empty holes are the 10 holes at the J4 and J5 outlines, plus the large mounting holes in three corners. Inspect the PCB for poor or missed solder joints, or untrimmed leads. Correct any problems.

Check also for solder “bridges” between adjacent pins. To remove a solder bridge, place the end of desoldering braid (All Electronics #SWK http://www.allelectronics.com/make-a-store/item/swk/de-soldering-wick/1.html or Radio Shack #64-2090, http://www.radioshack.com/product/index.jsp?productId=2062744) on the offending solder and heat with your iron to wick up the excess.

Installing the chips

The final step in assembling the FCC4 kit is to install the three chips in their sockets. It is vital that these chips be inserted correctly into the sockets. If the rows of pins are spread too wide for the socket contacts, gently press them against a flat surface to bend them closer together.

Fig. 22 shows three things that can go wrong with chip pins and sockets.

- Pin 3 is bent under the chip, and is not in its socket, Remove the chip, straighten the pin, and re-insert into the socket.
- Pin 4 is outside the socket, and is not in its socket, Remove the chip, bend the pin inward slightly, and re-insert into the socket.
- Pin 5 of the socket is bent under the socket, and is not soldered in its hole on the PCB.

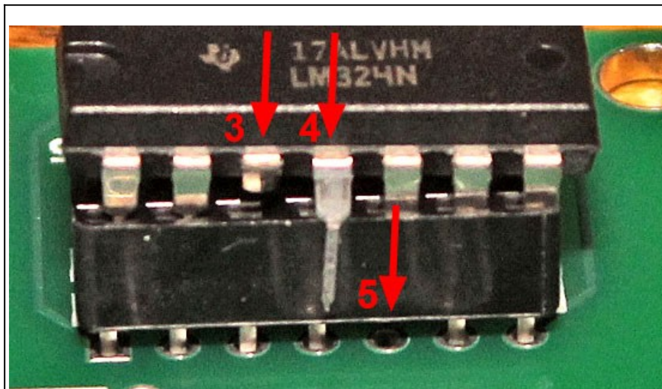


Fig. 22: Chip and socket pins that can go wrong.

Bent-under socket pins pose a serious problem because it might involve unsoldering all the socket pins, then removing the socket. Doing this can damage the PCB.

First remove the chip, and try to solder the socket pin on the top of the PCB, leaving it bent under the socket. This works if your soldering iron tip is small enough to touch the hole and the pin simultaneously.

If you can't solder the pin, use desoldering braid to remove the solder from all socket pin pads, remove the socket, straighten the pin, and re-install, soldering all pins. Be sure to remove the chip before unsoldering or soldering the socket pins.

Needless to say, it is far better to discover a bent-under socket pin during assembly, before soldering.

☐ First you need to choose a power supply, and check that the FCC4's power system is working properly. Read **Power supply – read this**, **above**, and return here when you reach the final step, **Power supply verified**. Turn off power to the FCC4.

☐ Insert U1 into its 18-pin socket. This chip is painted orange on the end with the notch that must match the notch in the socket. Orient the notch as shown on the component layout on page **27**. Check that it is oriented correctly, and that all pins are in the socket, not bent under the chip.

☐ Insert CD1 and CD1, the clock drivers, into their 14-pin sockets. These resemble U1, with two rows of pins. The center three pins in each row are absent. These chips are painted red on the end with the notch that must match the notch in the socket. Orient the notch as shown on the component layout on page **27**. Check that each is oriented correctly, and that all pins are in the socket, not bent under the chip.

☐ With the FCC4's power supply checked-out and the three chips in their sockets, perform the initial testing procedure starting on page **33**.

Initial testing – read this

Perform these steps to verify that the FCC4 operates correctly.

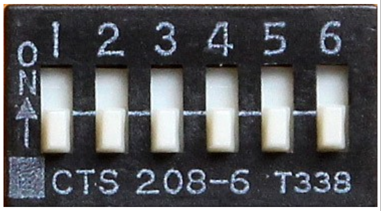


Fig. 23: Speed switch set for 1:1.

- ☐ Use a small screwdriver to slide all six switches on S1 to the Off position (Fig. 23). This selects a clock speed of 1:1.
- ☐ Verify that the three chips are installed in their sockets. If not, install them as instructed in **Installing the chips** on page **32**.
- ☐ Apply power. After a brief delay, LED1 and LED2 should alternately flash, each once per second. ***If the LEDs flash, the microprocessor is operating correctly.***
- ☐ Turn off the power. Connect the two wires from a modified clock movement to the two screw terminals on J3 (Fig. 24). It doesn't matter which wire connects to which screw.

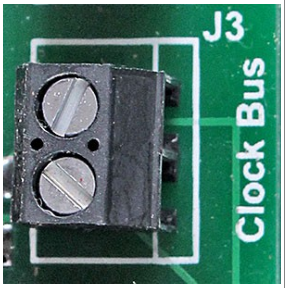


Fig. 24: Clock bus connector.

- ☐ Temporarily install clock hands on the movement, as instructed on page **12**.

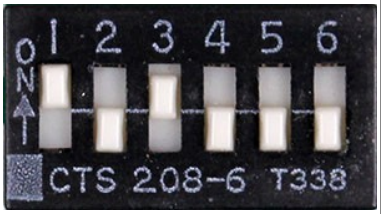


Fig. 25: Speed switch set for 6:1.

- ☐ Use a small screwdriver to slide the switches on S1 to select a 6:1 speed, as shown in this photo. (#1 and #3 **on**, #2 #4, #5, #6 **off**). Refer to **Table 5** on page **38** for switch settings to select various clock speeds.
- ☐ Apply power. After a brief delay, the clock movement should begin running. You should hear faint ticks from the movement, at a rate of six per second. The time-setting knob in the back should be visibly rotating.

How to count IC pins

Some of the troubleshooting steps below ask you to touch your voltmeter positive probe to specific pins on U1, CD1, or CD2. Notice that the component layout on page **27** shows these outlines with their corner pins numbered (only pin 1 is identified on the actual PCB).

To locate a specific pin, start at a corner and count along that row, stopping at the desired pin. You can start at a higher number and count backward. For example, to find pin 14 on U1, you could start at pin 18 and count 17-16-15-14. Pin 14 is the fourth pin from pin 18 along the row.

Some pins are absent on CD1 and CD2 but, even so, their pins are numbered as if all 14 pins were present. Count pins the same way for these devices, except count the *empty socket holes* for the absent pins.

- [ ] If the movement does not run, perform the following tests.
  - First connect your voltmeter's negative probe on the **Com** terminal on J5 (see page **8**).
  - When asked to make a voltage measurement, touch the positive probe to the specified point.
  - When asked to "check" the PCB, look for solder bridges between adjacent traces, incompletely soldered connections, improper component orientation, or component pins bent under and not inserted into the socket.
  - Verify that LED1 is flashing and that LED1 and LED2are alternately flashing. This indicates the microprocessor is working correctly.
    - If the LEDs are not flashing, touch the voltmeter's positive probe to the **Vdd** pad on the J4 outline to verify once again that +5V is present.
    - If so, touch the probe to U1 pin 14; +5V should be present there. If not, check that pin 14 is not bent under the chip, instead of inserted into the socket hole. Also check that pin 14 and all socket pins are soldered on the back of the PCB.
    - It is impossible for +5V to be present on J4-Vdd but not on U1 pin 14 unless pin 14 on the socket is not soldered, that chip pin is bent under, or a PCB trace is broken. Inspect the PCB carefully for unsoldered connections.
  - If the LEDs are flashing but the clock movement is not running, set your voltmeter to measure about 2V, then touch the positive probe to either pin on J3. You should see 0V pulsing briefly positive each time one of the LEDs flashes (this is easier to see on an analog meter with a needle, than on a digital meter). Move the probe to the other pin on J3, and the pulses should occur with the other LED's flashes. If you see pulses on both pins, the clock output driver is working correctly, and the movement should be running. If not, double-check its connection to J3, or try a different movement, or disassemble the movement to locate the problem inside it.
  - If you don't see the brief pulses on the J3 pins, perform the following checks to identify the defective component.
    - First check that diodes D2 and D3 are installed correctly, with the banded end oriented as shown on the component layout, and the lead from the banded end soldered to the square pad.
    - **No pulses on J3, pin 1:** Touch the positive probe to pin 6 of CD1. You should see +5V dropping briefly toward 0V at the same rate that LED1 is flashing. If not, Q1 likely is defective. Contact me for a replacement or replace it with a 2N3904 transistor. If you

see the pulses, but no pulses on J3-1, CD1 likely is defective. Contact me for a replacement.

- **No pulses on J3, pin 2:** Touch the positive probe to pin 6 of CD2. You should see +5V dropping briefly toward 0V at the same rate that LED2 is flashing. If not, Q2 likely is defective. Contact me for a replacement or replace it with a 2N3904 transistor. If you see the pulses, but no pulses on J3-2, CD2 likely is defective. Contact me for a replacement.

Next: Finishing up, page 40 **(Click the page number)**

Operational testing – read this

Congratulations! The FCC4 is running your clock at a 6:1 ratio. A few more tests and we'll be ready to put it into service.

- ☐ Connect the two wires from a modified clock movement to the two screw terminals on J3. It doesn't matter which wire connects to which screw.

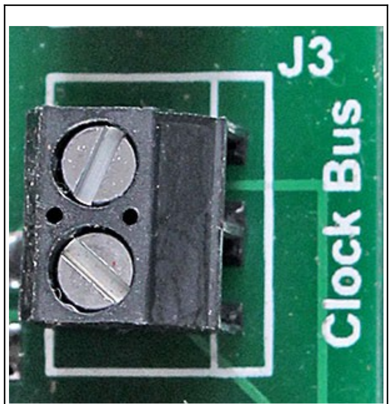


Fig. 26: Clock connector.

- ☐ Install clock hands on the movement, as instructed on page **12**.

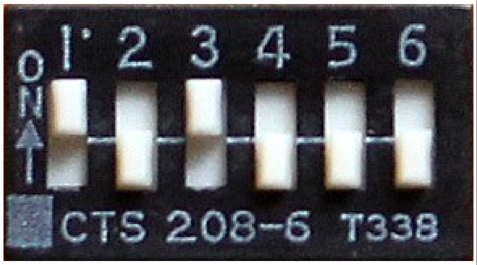


Fig. 27: Speed switch set for 6:1.

- ☐ Apply power and use a small screwdriver to slide the switches on S1 to select a 6:1 speed ratio, as shown in this photo (#1 and #3 **on**, #2 #4, #5, #6 **off**). Refer to **Table 5** on page **38** for switch settings to select clock speeds. The clock movement should change speed each time you change the switch selection.
- ☐ The following steps test some of the optional switch inputs on J2. If any test does not work, check the PCB in the area of J2 and resistors R9–R13.
- ☐ Connect two 4" wires to the **Com** terminal on J2. We will refer to one of these as the "test wire" in the following steps to simulate the control switches. The other wire will be used only in one step.
- ☐ With power on and the clock running, select a 6:1 speed on S1, as shown here in Fig. 27 (#1 and #3 **on**, #2, #4, #5, #6 **off**).
- ☐ Touch the test wire to the **Stop** terminal on J2; the clock should stop. Remove the wire and the clock should start again.
- ☐ Touch the test wire to the **FF** (fast-forward) terminal on J2; the clock should run much faster than normal (17:1). Remove the wire and the clock should continue running at the 6:1 speed.
- ☐ Insert the test wire into the **Stop** terminal on J2, and tighten the screw; the clock should stop. Touch the second wire attached to to J2's **Com** terminal to the **Reset** terminal. The clock should begin running at 17:1 speed, and continue even after you remove the wire from the **Reset** terminal. This simulates a momentary pushbutton.

  If you let the clock run, it should stop at clock's original starting time when power was applied at the beginning of these tests. This can take more than half-an-hour (see **Table 7**), but there is no need to wait until the clock stops – running at high speed confirms the Reset function is working.

Control switches – read this

You may connect external switches to the FCC4, for more control. *All switches are optional, but recommended.* Even with no switches connected, the clock runs at the selected fast-time speed as long as power is applied.

Here is a description of what each switch does; decide which ones you want to include on your system.

- ☐ **Power switch.** Connect between the positive wire from the power source and the **+** terminal on J1 to switch power to the fast clock controller on or off. ***Note:*** *This switches only the DC power to the FCC4.* You may choose to wire the 9V power adapter into your layout's 120V AC house power connection, so it powers-up when you switch on the layout power. ***Use caution when working around 120V AC house current!*** And ***never*** connect 120V AC to the FCC4.

The following control switches connect to J2, one wire to the function's designated terminal, and the other wire to the **Com** terminal. You can daisy-chain a single wire from the **Com** terminal to one terminal on each switch; you don't have to run a separate wire to each switch from the **Com** terminal. You must, however, run a separate wire from the designated terminal to each switch's second terminal. Refer to the block diagram on page **51** for switch wiring details.

Some switches come with three terminals: common, normally-open, and normally-closed. The center terminal usually is common.

Connect all J2 functions to the switch's normally-open terminal, not the normally-closed terminal.

Check with an ohm meter between the common terminals and the other two to find the normally-open terminal. This should show zero ohms resistance when the switch is in the position to activate the function (e.g., Stop for the Run/Stop switch, and Fast Forward for that switch). The Reset button show zero ohms when pressed.

- ☐ **Run/Stop switch.** When open, the clock runs; when closed, the clock stops. Connect between the **Stop** and **Com** terminals on J2.
- ☐ **Fast-forward switch.** When open, the clock runs at the selected fast-time speed; when closed, the clock runs at a 17:1 speed. Connect between the **FF** and **Com** terminals on J2. Install this if you anticipate the need to advance the clocks during an operating session (for example, to skip over a “dead” period if everyone is working faster than normal).
- ☐ **Clock Reset pushbutton.** Normally open. When momentarily pressed when the clock is stopped with the Run/Stop switch, the clock runs at 17:1 speed, then stops at the starting time (when power was turned on). This is useful for resetting all clocks simultaneously to the original time, in preparation for the next operating session. Connect between the **Reset** and **Com** terminals on J2. This should be a pushbutton because it must be open (inactive) for the clock to run. A toggle switch could be inadvertently closed (active), preventing normal operation.

Next: Finishing up, page 40 **(Click the page number)**

Clock speed switch settings – read this

S1 on the PCB has six switches, five of which set the fast-time speed for all clocks connected to the FCC4. ***The sixth switch is for future enhancements, and is not currently used.***

Standard clock speeds

This table shows the switch settings to select the "standard" clock speeds. See **Table 6** for fractional speeds.

TO make the table easier to read, a blank means the switch is <u>off</u>.

Turn <u>off</u> switch #5 to use these standard speeds.

Leave switch #6 turned <u>off</u> always.

Speed	Switch #1	Switch #2	Switch #3	Switch #4	Switch #5	Switch #6
1:1						
2:1	ON					
3:1		ON				
4:1	ON	ON				
5:1			ON			
6:1	ON		ON			
7:1		ON	ON			
8:1	ON	ON	ON			
9:1				ON		
10:1	ON			ON		
11:1		ON		ON		
12:1	ON	ON		ON		
13:1			ON	ON		
14:1	ON		ON	ON		
15:1		ON	ON	ON		
16:1	ON	ON	ON	ON		

Table 5: S1 standard speed switch settings (switch #5 off).

Fractional clock speed switch settings

Do you want a special clock speed that lies between two of the normal switch-selectable speeds? The FCC4's fractional speed selections give you fractional speeds between 2½:1 and 7¾:1

This table shows the speeds with switch #5 turned on. **7¾:1 is the fastest** fractional speed available**.** See **Table 5** for fractional speeds.

TO make the table easier to read, a blank means the switch is off.

Turn on switch #5 to use these fractional speeds.

Leave switch #6 turned off always.

Speed	Switch #1	Switch #2	Switch #3	Switch #4	Switch #5	Switch #6
2½:1					ON	
3¼:1	ON				ON	
3½:1		ON			ON	
3¾:1	ON	ON			ON	
4¼:1			ON		ON	
4½:1	ON		ON		ON	
4 ¾:1		ON	ON		ON	
5¼:1	ON	ON	ON		ON	
5½:1				ON	ON	
5 ¾:1	ON			ON	ON	
6¼:1		ON		ON	ON	
6½:1	ON	ON		ON	ON	
6 ¾:1			ON	ON	ON	
7¼:1	ON		ON	ON	ON	
7½:1		ON	ON	ON	ON	
7 ¾:1	ON	ON	ON	ON	ON	

Table 6: S1 fractional speed switch settings (switch #5 on).

Finishing up – read this

Installing and housing the controller

A case for the FCC4 PC board is optional. Many modelers choose to add the switches into an existing control panel, and mount the PCB somewhere inside that panel, or even screw it beneath the layout benchwork. If you prefer a separate case, see **Fig. 55** for a suggested panel that fits a common plastic "project box."

The PCB has three mounting holes for no. 6 screws. You'll need three short stand-offs to hold the PCB away from the mounting surface. 1/8" lengths of 3/16"-diameter styrene tubing (Evergreen no. 226C) work fine.

☐ Connect a wire from the **Com** terminal on J2 to the common terminal on all control switches. Be sure to mount and wire the switches so the switch is open in the normal (clocks running at selected speed) position (i.e., not activating the labeled function), and closed to activate the function. Specifically:

The Run/Stop switch should be open for **Run** and closed for **Stop**.

The Fast Forward switch should be open for normal fast-time running, and closed for **Fast Forward**.

The Reset pushbutton should be open for normal fast-time running, and momentarily closed to initiate **Reset** after the clocks are stopped with the Run/Stop switch.

Testing the Run/Stop switch

- ☐ Flip the Run/Stop switch to the Stop (closed) position. Turn on the Power switch. The clocks should not be running.
- ☐ Flip the Run/Stop switch to the Run (open) position. The clocks should begin running at the speed set by S1 on the PCB.

☐ Flip the Run/Stop switch to the **Stop** (closed) position. The clocks should stop running.

Testing the Fast Forward switch

- ☐ Turn on the Power switch. Flip the Run/Stop switch to the Run (open) position. The clocks should begin running at the speed set by S1 on the PCB.
- ☐ Flip the Fast Forward switch to the Fast Forward (closed) position. The clocks should begin running at a 17:1 speed.
- ☐ Flip the Fast Forward switch to the Normal (open) position. The clocks should resume running at the speed set by S1 on the PCB.
- ☐ Flip the Run/Stop switch to the **Stop** (closed) position. The clocks should stop running.

Testing the Reset switch

Recall that the purpose of the Reset function is to run the clock rapidly forward to the starting time.

- ☐ Flip the Run/Stop switch to the **Stop** (closed) position. Turn on the Power switch. Note the starting time on the fast clock and start it running with the Run/Stop switch.
- ☐ After 5-10 minutes of fast-time running, stop the clock with the Run/Stop switch.
- ☐ Press and release the Reset button. The clock should run much faster than normal (17:1), and should stop exactly at the starting time. Even though 17:1 seems pretty fast, this can more

than half-an-hour with only a brief fast-time period. The table on page **53** shows approximately how long it will take to run to the starting time, depending on the duration of your operating sessions.

- [ ] Turn off power to the controller.

Modifying clock movements

Modifying your clock movements is simple (10-15 minutes apiece), but requires care and attention.

Fig. 28 shows a modified Quartex Q80 movement. The only evidence of the modification is the two wires coming through a slot on top. The threaded bushing is available in various lengths, so be sure to order a movement with a bushing long enough to reach through your your clock dial (see **Measure the clock dial thickness**). This movement has a bushing for a 1/8" dial. It's long enough to extend through the dial, and still have exposed threads for a mounting nut.

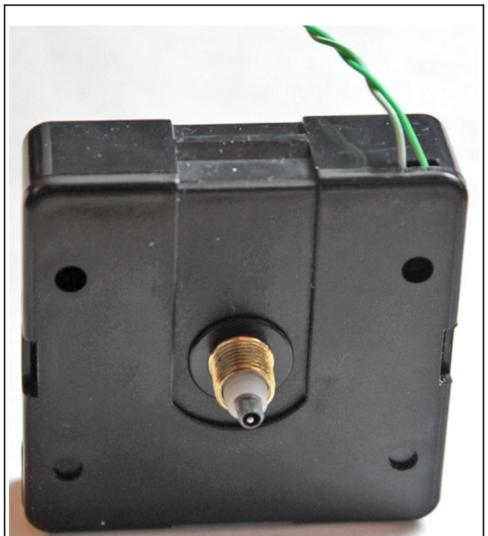


Fig. 28: Modified clock movement.

What you'll need

You will need the basic electronics tools and soldering iron listed in **What you'll need** on page **24**, plus these additional items:

- #1 (or equivalent) Phillips screwdriver (included in All Electronics #PSS-63 http://www.allelectronics.com/make-a-store/item/pss-63/6-piece-mini-phillips-screwdriver-set/1.html). Note: #1 Phillips screwdrivers are readily available at home improvement stores.
- Desoldering braid (also called "wick") (All Electronics #SWK http://www.allelectronics.com/make-a-store/item/swk/de-soldering-wick/1.html) or Radio Shack #64-2090 http://www.radioshack.com/product/index.jsp?productId=2062744).
- Solder sucker (All Electronics #50B-410 http://www.allelectronics.com/make-a-store/item/50b-410/solder-sucker/1.html). This is optional; desoldering braid often is sufficient by itself.
- 3/16" flat file. (included in All Electronics #FSET-2 http://www.allelectronics.com/make-a-store/item/fset-2/10-piece-needle-file-set/1.html).
- Approximately 6"-10" of insulated #24 or #26 solid (preferred) or stranded wire One twisted pair from a Cat 5 Ethernet cable is ideal. ***This wire is included in each MOV-KIT movement kit purchased from me.***
- One 22-ohm ¼-watt resistor (Digi-Key #22QBK-ND (http://www.digikey.com/product-search/en?pv7=3&k=22QBK-ND&mnonly=0&newproducts=0&ColumnSort=0&page=1&quantity=0&ptm=0&fid=0&pageSize=250). ***This resistor is included in each MOV-KIT movement kit purchased from me.***

Use only rosin-core solder. If you insist on using liquid or paste flux, check and double-check that it is ***rosin*** flux, not ***acid*** flux. ***Never*** use acid flux to solder electronics.

Opening the case

Remove the cover from the case by releasing the two locking clips, one on each side.

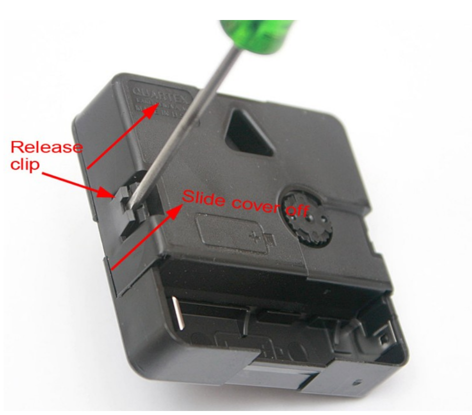


Fig. 29: Opening a movement.

☐ Insert a small screwdriver and gently pry a clip outward. When it opens, slide the cover away slightly, then release the other clip. The plastic case is slippery, so the screwdriver might slip out before the latch releases. Keep trying.

☐ With both clips released, pull the cover off.

Fig. 30 shows what you'll see with the cover removed. The mechanism is completely enclosed and contains the stepper motor (copper wire coil) and the gears. It rests freely inside the case; there are no screws to remove or wires to disconnect. Notice the metal clips in the battery compartment.

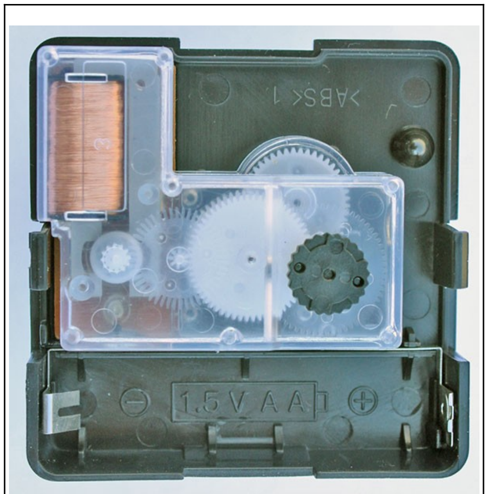


Fig. 30: Movement in the case.

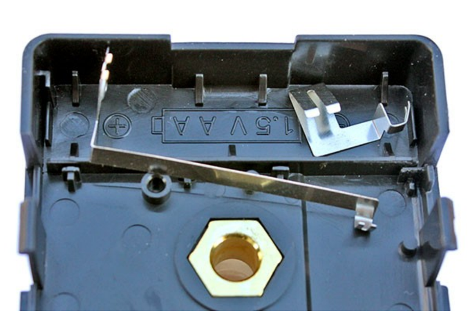


Fig. 31: Battery clips loose.

☐ Lift the movement out of the case and set it aside. Tap the case against a table to loosen both battery clips, or pull them loose with your fingers or pliers (Fig. 31). Discard the battery clips – they are not used in fast-time movements.

Terminology

The clock movement consists of an outer black "case" with a threaded brass bushing on the front, and a removable cover on the back. The movement's motor and gears are contained in a clear plastic "housing," with a circuit board (PCB) on top, that rests inside the case when the movement is assembled. These terms are used in the following instructions to avoid confusion.

Two methods to modify a movement

There are two ways to modify a Q80 movement. Both methods involve soldering a resistor and two wires to the motor, but differ in how these components connect to the motor terminals.

- ***Method 1 is preferred*** because it reduces the chance of breaking the fine motor wires. You use a hobby saw to cut the PCB and remove most of it, leaving only a narrow sliver still attached to the motor terminals. Then you solder the resistor and wire to the terminals on the remaining sliver. Thanks to Julian Garner for this idea.
- With Method 2, you unsolder and remove the entire PCB, then solder the resistor and wire to the bare motor terminals.

Modifying the movement – Method 1 (preferred)

☐ Cut two lengths of insulated #26 or #28 wire 6" - 10" long. Solid wire is better than stranded for this application, but stranded will work. This "pigtail" ultimately will connect your clock to a "bus" cable that you will run around your layout, so you might want to make it long enough to reach the bus cable location – several feet, if necessary. Wire color is not important. Cat 5 Ethernet cable with solid wires is ideal, and one length of cable yields pigtails for four clocks.

- ☐ Cut one wire about ½" shorter than the other. Strip 1/8" of insulation from one end of each wire (Fig. 32). Tin the bare wires with solder. "Tinning" means to coat the copper wire with a thin layer of molten solder. This is especially important with stranded wire, as it bonds the strands together.

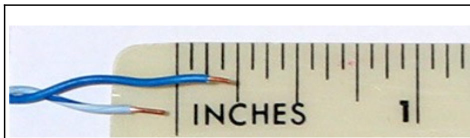


Fig. 32: Wires ready to tin.

- ☐ Clamp the movement in a vise, or otherwise secure it (you can tape it to your table).
- ☐ Use a small (#0 or #1) Phillips screwdriver to remove the screw holding the PCB to the housing. Discard the screw.

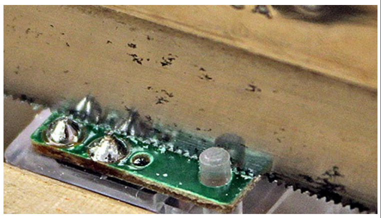


Fig. 33: Sawing the PCB.

- ☐ Use a hobby saw such as the X-Acto #34 blade (http://www.amazon.com/Xacto-X75300-Precision-Razor-Saw/dp/B00004Z2U4) to carefully cut through the PCB adjacent to the two motor terminals. See Fig. 33. Work slowly and carefully. Occasionally pause and lift the far end of the PCB to check if the saw has cut completely through. Fig. 34 shows the remaining PCB soldered to the motor terminals.

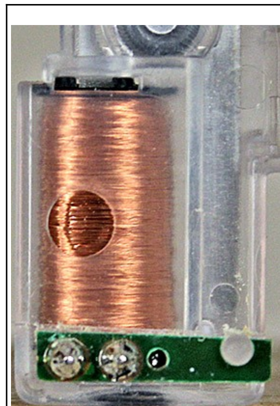


Fig. 34: Remaining PCB
.

- ☐ Cut both leads of the 22-ohm resistor to ¼". Bend one lead of at a 90° angle close to the body. Leave the other lead straight. Tin both leads to ensure solder flows smoothly when soldering to the resistor leads.
- ☐ Orient the movement as shown in with the motor terminals closest to you. Lay the resistor on the clear housing so the bent lead is near the hole on the housing, and bends toward the left. See Fig. 35.
- ☐ Use needle nose pliers to hold the resistor by the bent lead. Position the straight lead against the solder on the right side of the right-hand motor terminal. Touch a soldering iron to the terminal to melt the solder and allow the resistor lead to drop into it. The solder should flow onto the resistor lead. Allow the solder to cool. The resistor is now soldered in place.

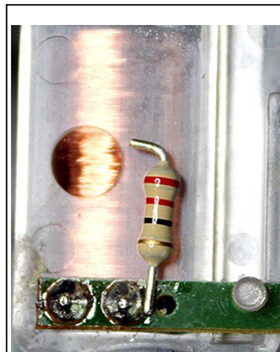


Fig. 35: Resistor ready to solder.

- ☐ Similarly, lay the tinned end of the short pigtail wire you prepared earlier against the solder on the right side of the left-hand motor terminal. Touch a soldering iron to the terminal to melt the solder and allow the wire to drop into it. The solder should flow onto the wire. Allow the solder to cool.
- ☐ Position the tinned end of the long pigtail wire against the bent resistor lead, and solder. It is not necessary to bend the wire around the resistor lead. The solder will hold it securely.
- ☐ Press a finger or thumb over the motor terminals, resistor, and the two wires. Carefully bend the wires downward 90° where they cross the edge of the housing, as in Fig. 43. This bend allows the movement to sit flat in the case, and the wires to pass through a slot you will cut in the case (next, below).

Fig. 36 shows the finished modification before bending the wires. Notice how the wire and resistor lead are soldered on the *right* side of the motor terminals (red arrows), and the long wire runs *between* the terminals. This positions the wires correctly to exit the movement case through a slot you will cut next. **Important!** Be sure the resistor lies flat against the housing, and it and the long wire are clear of the large hole in the housing.

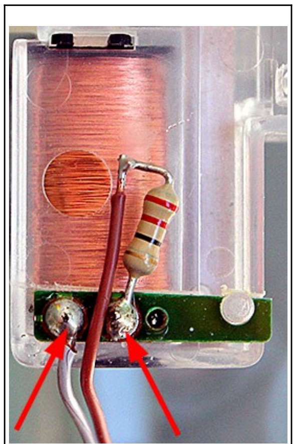


Fig. 36: Resistor and wires.

Modifying the movement – Method 2

Important! **Method 1** is the preferred way to modify a movement because it reduces the chance of breaking the fragile motor wires inside the housing. Work carefully if you choose Method 2. You will unsolder and remove the circuit board (PCB), then solder a resistor and a wire to the exposed motor coil terminals.

Important!

In the following steps, you will be using a hot soldering iron to unsolder and remove a PCB from two motor terminals, and then to solder a resistor and wire on those same terminals. Extremely fine wires connect these terminals to the motor coil inside the clear plastic housing. The terminals are into holes in the plastic housing. Excessive heat can soften or melt the plastic, allowing the terminals to move, which can break the fine wires. It is impossible to repair a broken coil wire, so the movement is destroyed if one breaks. Work quickly and move the terminals as little as possible.

- [ ] Cut two lengths of insulated #26 or #28 wire 6" - 10" long. Solid wire is better than stranded for this application, but stranded will work. This "pigtail" ultimately will connect your clock to a "bus" cable that you will run around your layout, so you might want to make it long enough to reach the bus cable location – several feet, if necessary. Wire color is not important. Cat 5 Ethernet cable with solid wires is ideal, and one length of cable yields pigtails for four clocks.
- [ ] Cut one wire about ½" shorter than the other. Strip 1/8" of insulation from one end of each wire and form the ends into "J" hooks. Tin the bare wires with solder. "Tinning" means to coat the copper wire with a thin layer of molten solder. This is especially important with stranded wire, as it bonds the strands together.

Fig. 37: Wires ready to tin.

- [ ] Clamp the movement in a vise, or otherwise secure it (you can tape it to your table).
- [ ] If you're using a solder sucker, place it on one of the two terminals at the end of the PCB, and heat the solder around the terminal with your soldering iron until it melts. Press the button to suck up the molten solder. Work quickly to avoid melting the plastic that holds the terminals beneath the PCB.
- [ ] Use a small (#0 or #1) Phillips screwdriver to remove the screw holding the PCB to the housing. Discard the screw.
- [ ] If you're using desoldering braid, place it on the solder around one terminal, then heat the braid with your soldering iron. The hot braid will melt the solder and wick it away from the terminal; see **Fig. 39**. Work quickly to avoid melting the plastic that holds the terminals beneath the PCB.

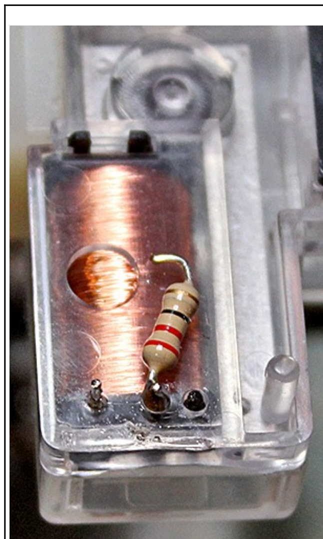


Fig. 38: Resistor soldered.

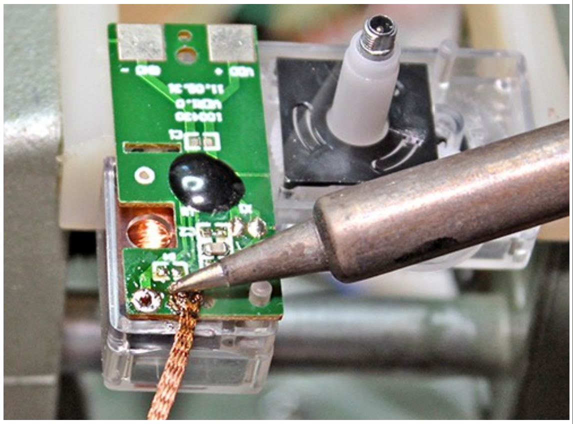


Fig. 39: Removing solder with desoldering braid.

- ☐ Repeat the unsoldering operation on the second terminal. When done, the terminals should move freely inside the PCB holes.
- ☐ Allow the unsoldered terminals to cool. Gently wiggle or pry the PCB upward away from the clear plastic housing. If it doesn't lift easily, probably some solder remains on one or both terminals. Remove the last of it with desoldering braid. It helps to push the pin toward the center of the hole with the braid and soldering iron while the solder is molten.
- ☐ Remove the PCB from the movement and discard it.
- ☐ Bend the leads of the 22-ohm resistor at 90° angles close to the body, one toward the left, and the other toward the right (Fig. 40).

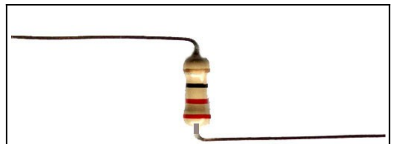


Fig. 40: Resistor leads bent 90°.

- ☐ Cut each lead ¼" beyond the bend. Orient the movement with the motor terminals closest to you, as shown in **Fig. 38**. Lay the resistor on the clear housing so the near lead bends toward the right. Use needle nose pliers to loop this lead around the right-hand motor terminal. Solder the resistor to the terminal. The other resistor lead should point toward the hole in the housing.

Fig. 41: Resistor with"super glue."

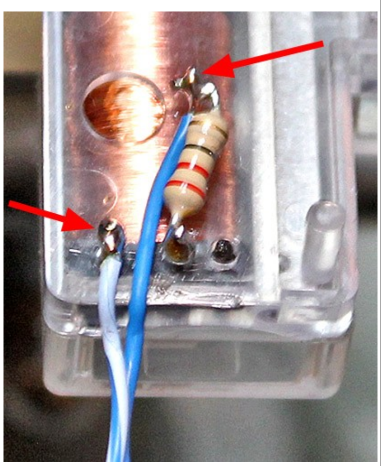


Fig. 42: Pigtail wires soldered.

◆ It is vital that the resistor lies flat against the housing before soldering. It must be below the top of the motor terminals.

- ☐ ***Important! Glue the resistor.*** Heating the motor terminals can loosen them in the plastic housing. The resistor acts like a lever to rotate the terminal. If the terminal rotates too far, the fine motor wire connected to it inside the housing will break, rendering the movement useless.

  Don't take chances! I strongly recommend securing the resistor to the housing before you perform the next step, using adhesive such as rubber cement, Goop (**Fig. 43**) http://eclecticproducts.com/ag_adhesives.htm, or cyanoacrylate ("super glue"), seen here in Fig. 41. Keep the adhesive off the resistor leads, or soldering will be impossible.

- ☐ Use needle nose pliers to wrap the hooked end of the longer "pigtail" wire you cut earlier around the remaining bent lead on the 22-ohm resistor. If you didn't glue the resistor as recommended above, be very careful not to rotate the resistor and the motor terminal more than a few degrees. The resistor acts as a "handle" that easily rotates the terminal. Run the wire between the two motor terminals at the edge of the movement housing to the resistor lead near the hole in the housing (blue wire, upper arrow in **Fig. 42**). Solder the wire to the resistor lead.
- ☐ Use needle nose pliers to wrap the hooked end of the shorter pigtail wire around the left-hand motor terminal (white/blue wire, lower arrow in Fig. 42), and solder it.

- [ ] Press a finger or thumb over the motor terminals, resistor, and the two wires. Carefully bend the wires downward 90° where they cross the edge of the housing, as in Fig. 43. This bend allows the movement to sit flat in the case, and the wires to pass through a slot you will cut in the case (**below**).

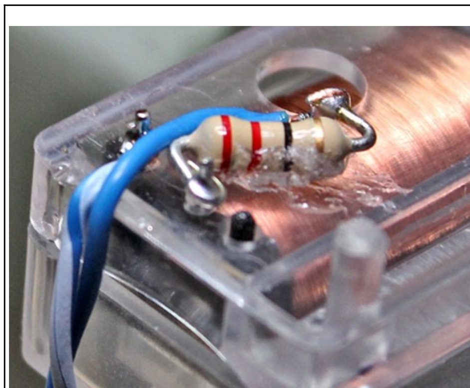


Fig. 43: Wires bent 90°at housing edge.

Cutting a slot in the case for the wires

The wires you added to the movement motor must must exit the black plastic case in the upper-left corner, as viewed from the rear (upper-right, as viewed from the front). As you can see in **Fig. 30**, there isn't much clearance between the movement and the case, so you must cut a slot in the both halves of the case for the wires to pass through.

The easiest and neatest way to do this is to use a narrow flat file, as shown in Fig. 44. Or you can use a sharp #11 blade in a hobby knife.

- [ ] Make the slot about 3/16" wide and about 1/16" deep. On the case front (Fig. 44), cut only the flange (ridge) that runs around the case. Stop cutting when you reach the case surface itself. One side of the slot should be adjacent to the corner curve in the flange; this is the correct location for the motor wires you installed above.

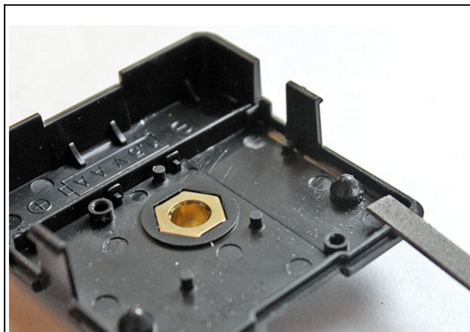


Fig. 44: Filing a slot in the case front .

- [ ] Cut a matching slot in the top side of the case cover (near the corner farthest from the large hole for the time-setting knob). Fig. 45 shows the notch in the case and the matching notch in the cover, which is flipped over to the right. Refer to **Fig. 28** on page **41** for a front view of the movement with the wires exiting through the slot.
- [ ]

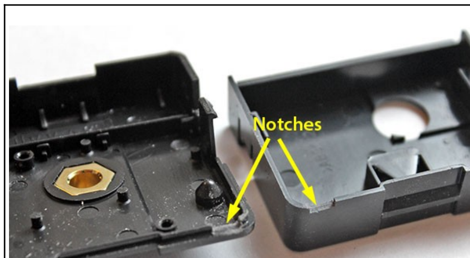


Fig. 45: Notches in case front (L) and cover (R).

Reassembling the movement

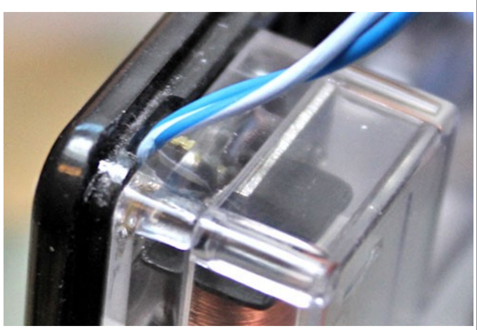


Fig. 46: Wires in slot in case front.

- [ ] Place the modified movement into the case, with the shaft passing through the brass bushing. Ensure that the wires rest in the slot you cut into the case flange (Fig. 46). Also ensure that the wires don't hold the housing too high. There is a conical protrusion molded into the case (visible at the end of the file in Fig. 44). This protrusion should fit into a hole in the movement housing above the motor coil, seen in **Fig. 42**.
- [ ] If the movement is not seated flat in the case, and firmly onto the conical protrusion, remove it and bend the wires close against the end of the movement housing, as shown in **Fig. 43**. This should allow the movement to seat flat.

- [ ] Hold the movement against the case front, making sure the wires pass freely through the slot. Gently bend the wires so they are parallel to the case front (e.g., bend them 45° toward the left in **Fig. 46**). Snap the case cover onto the case front. Be sure the slots in the case front and cover case align, and that the wires pass easily through the slot; see **Fig. 28** on page **41.**

Oh no! The gears fell out!

What do you do if the gears fall out while you're working on the movement? Sometimes the square black plastic retainer is not attached securely at the factory, so it comes loose and allows the gears to escape. Don't worry – they are easy to put back. Here's how to do it.

Note: Ignore the PCB shown in these photos. The photos were made before I determined that the PCB must be removed. A modified movement will have the resistor and two wires instead of the PCB, as shown in **Fig. 42**.

- [ ] Lay the movement, the three loose gears, and the square black gear retainer on your table, as shown in Fig. 47. Notice that the retainer has tabs on three corners, but not on the fourth corner. This is important in the final reassembly step.

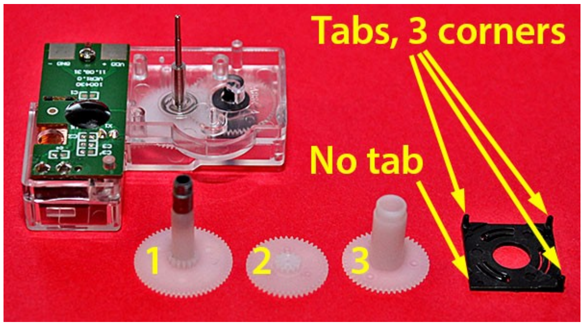


Fig. 47: Gears ready to assemble.

- [ ] **Gear #1.** Place gear #1 with the threaded metal top shaft over the tall thin spindle in the movement housing (Fig. 48).

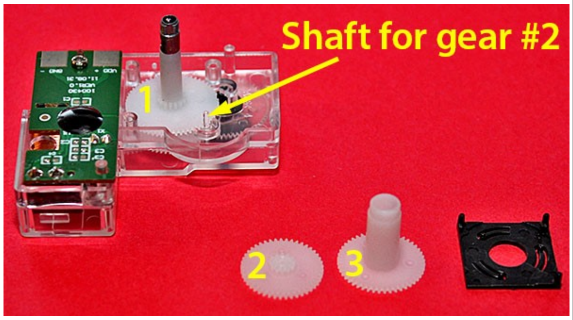


Fig. 48: Gear #1 in place.

- [ ] **Gear #2.** Place gear #2 onto the tiny clear plastic shaft protruding from the housing, shown in Fig. 48. The large-diameter gear should be on the bottom, and it should mesh with the small gear on top of gear #1. See Fig. 49.

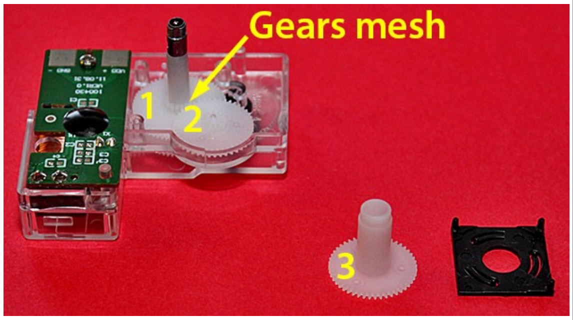


Fig. 49: Gear #2 in place.

☐ **Gear #3.** Place gear #3 over the shaft on gear #1. It should mesh with the small gear on the top of gear #2. See Fig. 50. Take special care to ensure that gears mesh where they are supposed to. It's easy to overlook this detail, and the movement won't work if gears don't mesh.

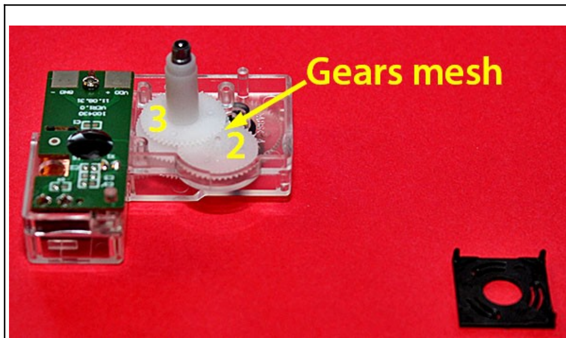


Fig. 50: Gear #3 in place.

☐ **Gear retainer.** Hold the square black gear retainer with the three tabs facing downward. Slide the retainer over the shaft on gear #3. Align it so the corner without tab is over gear #2. The tabs on the other three corners should fit into three mating holes in the clear plastic housing. Press these three corners downward so the tabs insert securely into the holes and hold the retainer in place. See Fig. 51.

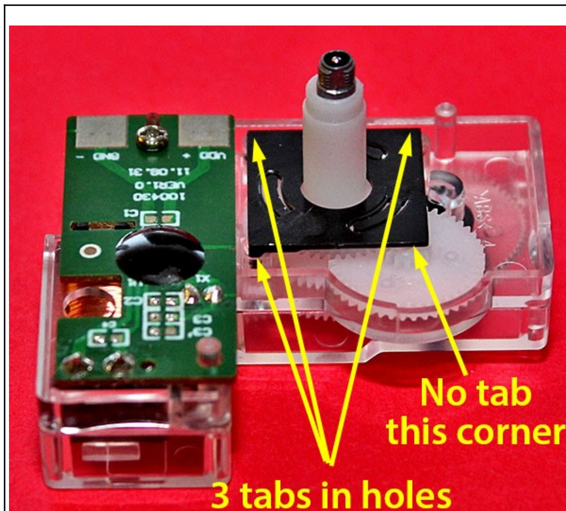


Fig. 51: Gear retainer in place.

The movement is now reassembled, and should work properly. You should be able to rotate the black setting knob on the rear of the movement, and feel only slight resistance. If not, remove the retainer and gears, and reassemble them carefully.

To remove the gears, use a small screwdriver to pry off the retainer, then lift off the three gears and repeat the assembly steps above.

Testing the modified movement

You will need a functional FCC4 fast clock controller to test modified clock movements.

- ☐ Connect the two wires from a modified clock movement to the two screw terminals on J2. It doesn't matter which wire connects to which screw. See Fig. 52.

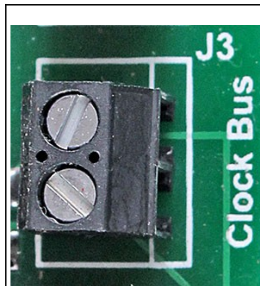


Fig. 52: Clock connector.

- ☐ Temporarily install clock hands on the movement, as instructed on page **12**.
- ☐ For the best test, the movement should be oriented vertically, as it will be when installed in a clock. Perhaps you can tape it to the edge of a table, or hang it from a nail driven into a board. Or just install it in a clock, and hang the clock on a wall.
- ☐ Use a small screwdriver to slide the switches on S1 to select a 6:1 speed ratio, as shown in Fig. 53 (#1 and #3 **on**, #2, #4, #5, #6 **off**). Refer to **Table 5** and **Table 6** for other switch settings.

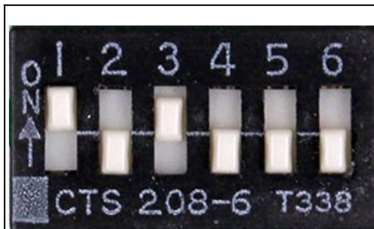


Fig. 53: Speed switch set for 6:1.

- ☐ Apply power to the FCC4. After a brief delay (a fraction of a second), LED1 and LED2 should begin alternately flashing at six flashes per second. The movement should run, and you should hear faint ticks from it at a rate of six per second. The time-setting knob in the back should be visibly rotating, and the minute hand should be visibly advancing.
- ☐ Observe the minute hand for at least two or three full rotations. It should move steadily without binding, jumping ahead, or bouncing back-and-forth in one position.

Note: The mass-produced Q80 movements have some "lash" (slop) in the gear train. It is normal for the minute hand to pause briefly just after the 12 position, as the gears transition from pushing the hand "uphill" on the left side of the clock dial to holding it back on its way "downhill" on the right side, toward the 6 position. The minute hand may pause briefly again just after the 6 position, as the gears transition to pushing it "uphill." What's important is that the minute hand does not jump ahead near the 3 position, and that it continues smoothly upward through the 9 position. These are the positions where gravity exerts the most force on the minute hand.

- ☐ Sometimes the gears in a new movement will bind, and the minute hand will stop completely. Give it a gentle push with a finger, and it should resume moving. Watch it for several more rotations. You might want to connect all your clocks to the clock bus and set the speed switch for 16:1, then run the clocks at that speed for an hour or two to "break them in." It is hard to believe that 15 or 30 "hours" of rotation will really smooth the gears significantly, but I have encountered movements that bind several times at first, but work perfectly after running for an hour at 16:1 speed.
- ☐ If a movement stubbornly refuses to work, take it apart and double-check your modification work. Look for a bad solder joint where the wires attach to the PCB, and look for binding gears inside the movement. Also consider completely disassembling it, and cleaning the gears. Follow the steps in **Disassembly** and **Cleaning the gears**, starting on page **57**.

Appendix A – Helper services

Need some help? I offer these services to ensure your FCC4 works properly.

Description	Price	Quan.
Helper Service		
Answers. Send me an email (mike@mdodd.com) if you have a question about the FCC4, power supplies, clock movements, hookup, operation, or anything related to fast clocks. I'll try to answer promptly.	Free	
Assembly Service. I encourage you to assemble the FCC4 controller yourself. If, after reading the assembly instructions starting on page **27**, you feel unsure about tacklingthis, send me the PCB with all parts and a $41.00 check (or PayPal mike@mdodd.com), and I will assemble and test it, and return it to you. This service is for PCB assembly *only* – wiring the control switches and other final assembly is up to you.	$35.00 + $6.00 shipping	
"Whatever it takes" repair service. The FCC4 kit is warranted for one year (see page **62**. But if you encounter a problem that is not covered by the warranty, mail it to me with a check for $31.00 (or PayPal mike@mdodd.com), and I will find and fix the problem. Why might you need this service? "Stuff" happens. Perhaps there are some bad solder joints on a newly-assembled kit, or a component was damaged while assembling the kit, or you believe a nearby lightning strike might have zapped something, or you mistakenly connected the FCC4 to the wrong power supply. First send me an email, and let's try to diagnose the problem (no charge). Only if it appears that the problem is not covered by the warranty should you use this service. The service includes replacing damaged components, finding and removing solder bridges, or whatever else is needed to make the controller work. The service includes repairing minor breaks in traces on the PC board, or even assembling a new controller from scratch on a new PC board, if necessary. But this service does ***not*** apply to a controller that has been seriously damaged or abused, such as a broken PCB, ripped-up copper traces, ***or damage caused by using acid flux or solder containg acid flux.*** If the FCC4 has been damaged beyond repair, you'll have to buy a new one.	$25.00 + 6.00 shipping	
On the Web		
Friends and clubs need fast clocks too! Order more controllers and movements on the Web at http://fastclock.mdodd.com		

For any helper service, first send me an email, and let's decide what should be done. Then mail your controller and a check (or PayPal) for the correct amount, including shipping, to me. Include your shipping address.

My address: Mike Dodd, 114 Creek Road, Louisa, VA 23093. Email: mike@mdodd.com.

APPENDIX B – FCC4 BLOCK DIAGRAM

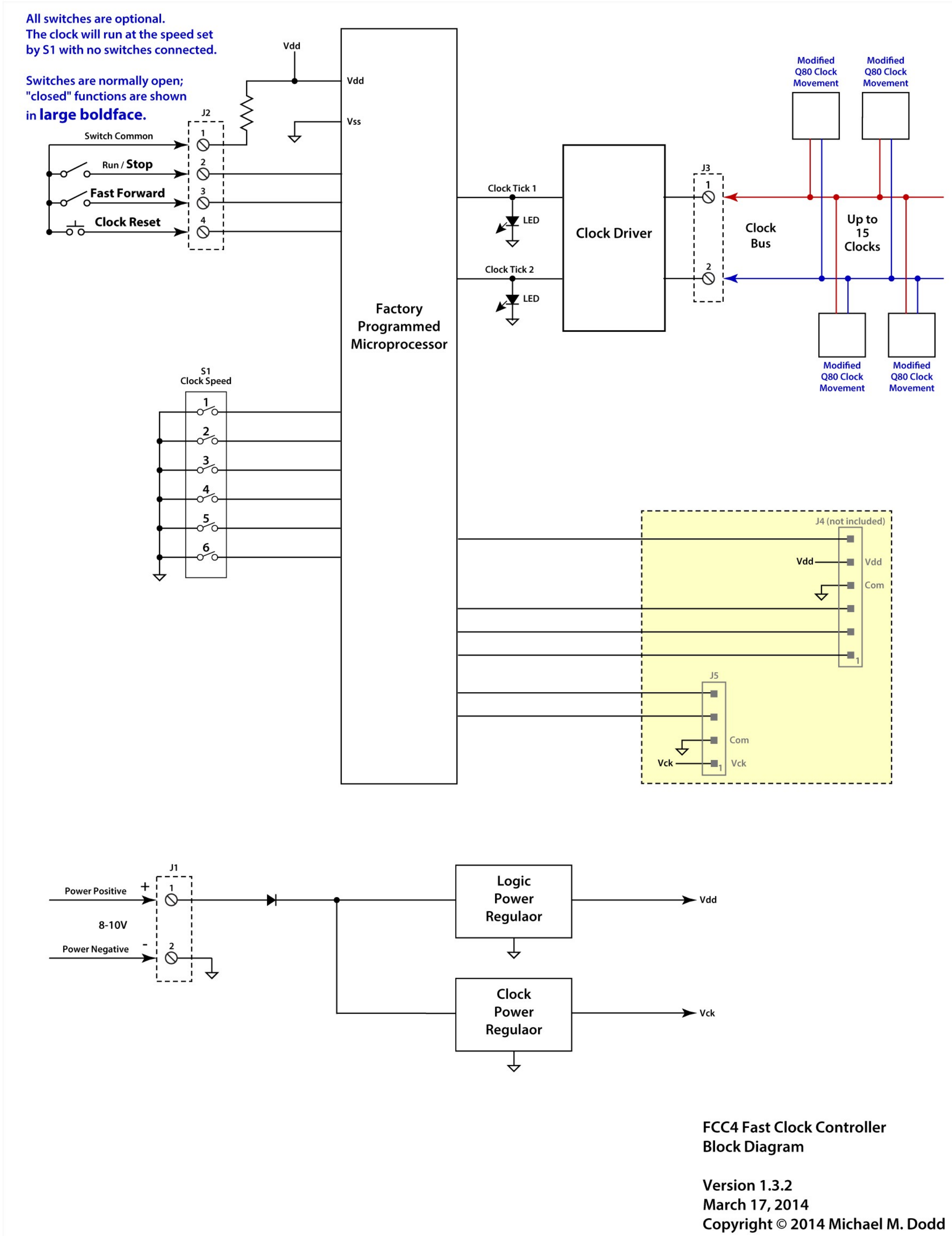


Fig. 54: FCC4 block diagram.

Appendix C – Sample front panel for case

If you purchased the styrene case along with your FCC4, it comes with a printed heavy paper panel (Fig. 55) that somewhat resembles a timetable.

If you want a case but didn't order one, look for a Pac Tec #61989-510-039 available from Mouser Electronics http://www.mouser.com/ProductDetail/PacTec/61989-510-039-HP-Bone-Kit/?qs=%2fha2pyFadujQVuV4d5Bb3N6zrQ8YLG7446X1ClmNaXJEyWO%252bftBtDFP6MYpf8R08. You can create your own panel in a word processor or vector drawing program.

Remember, a case is optional. Many modelers screw the controller to the layout benchwork, and install the switches in an existing fascia or control panel nearby.

This panel will print actual size if you turn off all scaling, such as "fit to page" or "fit to margins" in your PDF reader's Print dialog.

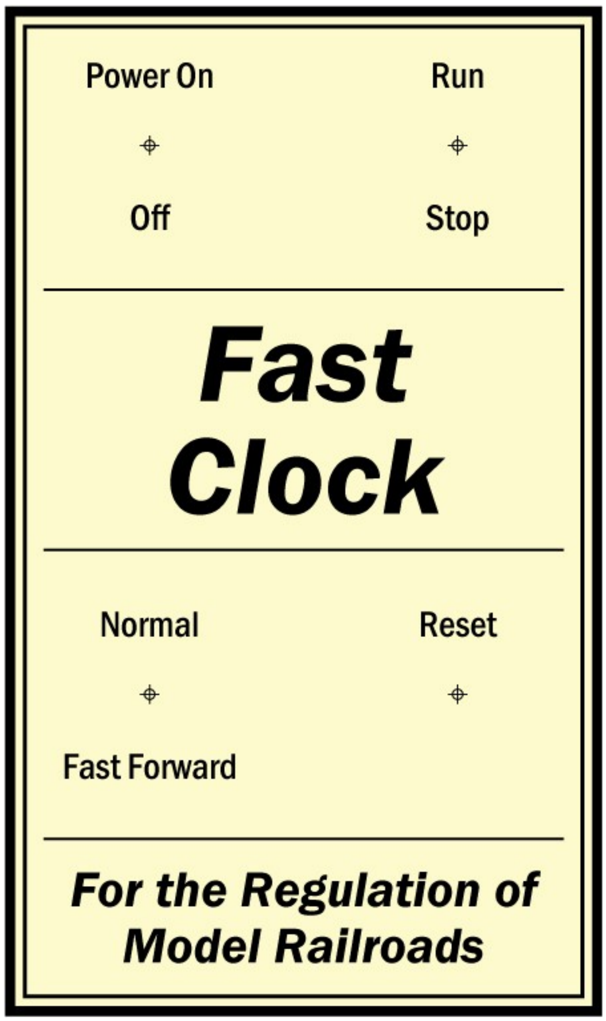


Fig. 55: Suggested panel for Pac Tec styrene case.

Appendix D – How the FCC4 works

Quartz clock movements

Inside a quartz clock movement there's a stepper motor and a circuit board holding an electronic chip and a quartz crystal. A stepper motor doesn't run continuously when you apply power. Instead, the shaft rotates a fraction of a turn and remains there until something changes. A stream of pulses makes the stepper motor rotate continuously in small steps.

The FCC4's role

Like a quartz clock movement, the FCC4 fast clock controller contains an electronic chip. In this case, the chip is a custom-programmed microprocessor that produces pulses at a switch-selectable speed, not just once per second. A "clock driver" converts these pulses to a level suitable to run the stepper motor at the faster rate.

There are 43,200 "ticks" in 12 hours. The FCC4 counts each tick, so it knows how many high-speed ticks to generate when you press the Reset button (see below).

Control switches

You may connect three external switches to control the FCC4's operation. With none connected, clocks begin running at the selected speed as soon as power is turned on. Connect any or all of these switches to have more control over your fast clocks:

- A **Run/Stop** switch controls whether the clocks run or stop.
- A **Fast Forward** switch commands the FCC4 to run your clocks at high speed.
- A **Reset** pushbutton commands the FCC4 to run the clocks at high speed around to their starting position, "resetting" them for the next operating session.

How resetting works

There are 43,200 seconds in 12 hours, so the FCC4 produces 43,200 "ticks" in 12 fast-time hours. The FCC4 counts the ticks sent to your clocks and, when you press the Reset button, it sends ticks at 17:1 speed until the full 43,200 have been sent. Then it stops, and your clocks are back at their starting position.

This table shows approximately how long it takes the clocks to reset. The session duration is stated in *fast-time hours*, or the amount of time elapsed on your clocks. The reset time is stated in actual minutes.

Op session duration (fast-time hours)	Ticks remaining	Time to reset @ 17:1
1	39,600	38¾ minutes
2	36,000	35½ minutes
4	28,800	28¼ minutes
6	21,600	21 minutes
8	14,400	14 minutes
10	7,200	7 minutes
11	3,600	3½ minutes

Table 7: Approximate clock reset times.

Appendix E – Evolution of the FCC4

History

I have offered fast clock controllers, culminating with the FCC3, since 1997, when my article appeared in the August 1997 *Model Railroader.* There have been minor improvements, but the FCC3 always gave excellent performance with the Quartex Q80 clock movement sold by Klockit.

End of the line?

Initially, all Q80 movements were manufactured in the USA. But around 2009, Quartex began importing Q80 movements from China, and I experimented to see if these would work with the FCC3. The test was a dismal failure – no amount of tweaking or programming changes would coerce them to run at high speed.

Fortunately, Klockit still had some USA-made Q80 movements, and sold these "premium" movements at a higher price, so the FCC3 enjoyed an extended life.

But all good things must end, and eventually Klockit's supply of premium movements ran out, and so did my stock. Quartex told Klockit all future Q80s would be imported – suitable fast-clock movements were no longer available.

Without a source of clock movements, the FCC3 was doomed.

Birth of the FCC4

In 2013 I decided to experiment again with the imported Q80 movements. Happily, it appears that the design changed since 2009, and making the movements operate at high speed turned out to be straightforward (after several months of experimenting and testing).

Major changes were needed. I completely redesigned the FCC3, turning it into the FCC4. I focused especially on the "clock driver" section, because this was key to make the imported Q80s work. The clock driver components cost significantly more than those on the FCC3, but the results are notable. The FCC4 can power up to 15 clocks using imported Q80s, compared to The FCC3's 10 clocks with USA-made Q80s.

In addition to the redesigned hardware, I rewrote the firmware (software code programmed into the microprocessor chip) and added several new features to the FCC4:

- 16 clock speeds vs. 15 for the FCC3.
- 16 additional "fractional" clock speeds from 2½:1 to 7¾:1.
- LEDs on the circuit board aid in verifying proper operation.
- Fewer control switches. The FCC3's seldom-used **1:1/Fast Time** and **1-Hour/12-Hour Reset** control switches are gone. These originally were intended for demonstration purposes, but few, if any, modelers used them. Their presence only confused the testing and installation instructions.
- Relaxed power supply requirements. The FCC4 needs a power supply delivering between 8VDC and 10VDC, compared to the FCC3's 11VDC, with little variance. The FCC3's stringent requirements were due to how the movements were modified, and the need to feed them a very narrow range of voltages. The FCC4 eliminates this restriction, and greatly expands the choice of suitable power supplies.

Appendix F – Making clock movements run reliably

Let's be honest: We are asking Q80 movements to run many times faster than they were designed to operate. I discovered the imported movements sometimes need a little help at first, but most run reliably after that.

Sometimes movements need a little "babying" to operate reliably as fast clocks. Here are some tips.

- If you're modifying your own movements, perform the modification and reassembly carefully, as described starting on page **41**. Reminders:
  - Use care when removing the movement's PCB; the motor coil terminals are fragile.
  - Solder quickly so the heat doesn't soften the plastic securing the motor terminals.
  - Secure the resistor to the movement housing to avoid twisting a motor terminal when soldering the pigtail wire to it.
  - Before replacing the movement in the case, be sure the gear retainer is installed securely, and test-run it with the FCC4 to check that the gears mesh properly and turn freely. See **Oh no! The gears fell out!** on page **47** for photos and more information about the gear retainer.
- ***Any*** resistance to the minute hand's free movement will cause problems. Be sure the minute hand doesn't hit the hour hand or scrape against the clock's clear front. Also check that the minute hand's central hub doesn't touch the hour hand's central hub. If it does, remove the minute hand and press the hour hand further onto its shaft, then reinstall the minute hand.
- "Break-in" your movements at high speed for 15 minutes or so. Install hands on your clocks, set the FCC4 speed switch to 16:1 (switches #1 - #4 turned on), set all clocks to the same time, and start them running. Periodically check that all clocks remain synchronized. If not, stop the clocks with the Run/Stop switch, and adjust the incorrect clocks to the right time. Then start the clocks again, and monitor them some more. Surprisingly, balky movements can begin running smoothly after a short break-in.
- After the high-speed break-in, switch the FCC4 to a slower speed, like 4:1 or 6:1, and start the clocks running again.
  - Sometimes the gears in a new movement can bind, and the minute hand stops completely. Give it a little push with a finger (or use the time-setting knob on the back), and it should resume moving. You might have to repeat this several times.
- Occasionally, no matter how much "babying" you do, a modified movement will not run reliably. Perhaps it runs, but doesn't remain synchronized with other fast clocks. Or maybe it runs for a while, then stops. First check the electrical connections:
  - Check your clock bus wiring and connections. A bad connection can cause intermittent running.
  - Open the movement and check the connections to the motor terminals and resistor. A bad solder joint can cause erratic operation.
- If all else fails, and you can't make a stubborn movement stay synchronized with other fast clocks, take it apart and wash the gears. This might sound drastic, but it actually is straightforward and easy if you follow the steps in **Disassembly** and **Cleaning the gears**, starting on page **57**.

Appendix G – Digging into the Q80 movement

During my work to make the FCC4 work with imported Q80 movements, I had occasion to disassemble some movements all the way down to the individual gears. Here you will find photos and instructions to take apart a movement and put it back together.

You might never need to disassemble a movement, but if you do, you'll discover it isn't difficult.

Quartex engineers must have been thinking of us modelers when they designed the Q80. Everything snaps together – nothing is glued, as it was on other movements. There are even three convenient thumbnail slots to help split the housing apart!

There are two sets of gears – the "primary" gears are enclosed inside the clear plastic housing, and the "secondary" gears with the shafts that hold the hands are on the open top side of the housing. The secondary gears are held in place by a square black retainer.

> **Why is the PCB present on this movement?**
>
> Some of these photos show the PCB still attached to the movement. These photos show a movement just removed from the square black case, before modification for fast time.
>
> If you are opening a modified movement, the PCB will be absent, replaced by a resistor and two wires, as shown in **Fig. 42** and described starting on page **41**.

Disassembly

Let's get started. For consistency with the modification instructions starting on page **41**, I refer to the clear plastic enclosure as the "housing," which fits inside the square black plastic "case."

- ☐ First open the square black case, and remove the movement.
- ☐ **Note:** It is not necessary to remove the secondary gears from the top of the housing. They can remain in place on the top half after the housing is split apart. If you choose to remove them, perform the following two steps.
    - ○ Pry gently with a small screwdriver at three corners of the black gear retainer to loosen its pins from the holes in the clear housing.
    - ○ Remove the retainer and the secondary gears, and set them aside.

Fig. 56: Removing the gear retainer.

☐ Inspect the sides of the clear housing and locate the three arched "thumbnail slots" molded into the housing – one at each end of the motor coil, and one on the end near the time-setting knob.

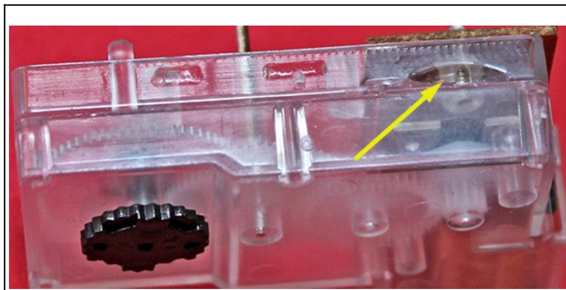


Fig. 57: Thumbnail slot in housing .

☐ The housing halves are held together with pins on one side that friction-fit into holes on the other side. Insert your small screwdriver between the housing halves at one of the thumbnail slots, and gently pry or twist to split the housing apart. Work your way around the housing until the halves are free. See Fig. 56 and Fig. 57.

Be careful not to insert the screwdriver too far into the housing. If it reaches the motor coil, you could pry the housing top away from the motor, breaking the fine wires attached to the terminals, and ruining the movement.

Fig. 58: Splitting the housing, step 1.

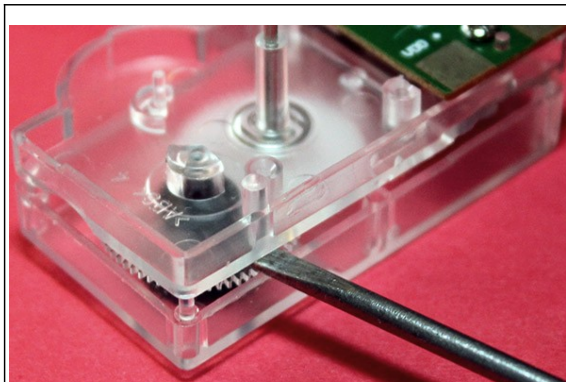


Fig. 59: Splitting the housing, step 2.

☐ Place the lower half of the housing (with the primary gears) on your table, and lift the upper half (with the motor) off. Lay it next to the lower half, with the motor terminals and wire/resistor you added facing down.

Fig. 60: Housing halves with primary gears.

- ☐ Remove primary gears #1 and #2 from the lower housing half. Keep them separate from the secondary gears, to avoid confusion. The primary gears shown here are numbered for reference when reassembling the movement.
- ☐ Gear #3 is held to the time-setting knob by gear #4. Gently pry gear #4 upward. It will come loose, and gear #3 will be free. The time-setting knob is held captive in the housing by a bulge on its shaft.

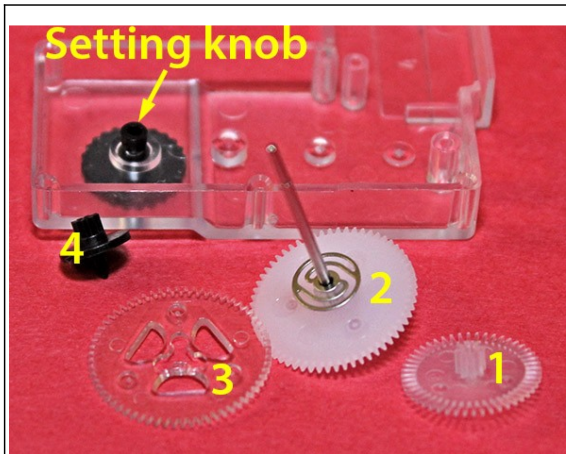


Fig. 61: Primary gears removed.

- ☐ Remove the small motor armature gear from between the metal bars on the opposite side of the housing. A magnet on the bottom of this gear holds it in place. You might be able to tap the motor against your palm to shake the gear loose, or you can use fingers or needle-nose pliers to pull it out. Use tools carefully to not damage the plastic gear.

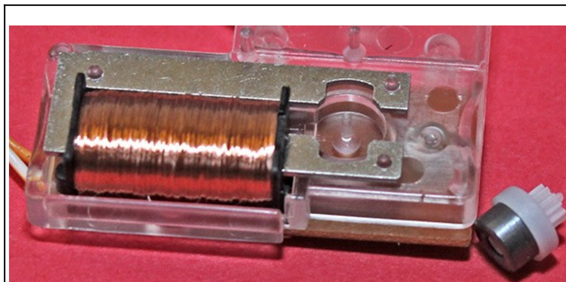


Fig. 62: Armature gear with magnet.

Cleaning the gears

The main reason to disassemble a movement is to clean the gears, in an attempt to restore an erratic movement to normal operation.

You can wash gears in soapy water, or brush or blow debris from them dry. I recommend washing.

- ☐ Inspect all gears for defects such as burrs on the teeth, "flash" (extra plastic) around molding marks, or anything that would prevent them from rotating easily and meshing freely with other gears.
- ☐ Wash all gears *except the armature gear* in a bowl of water with a drop or two of dishwashing liquid. It is best not to wet the armature gear because the magnet might rust.
- ☐ Allow the gears to air-dry thoroughly, then reassemble.

Reassembly

Reassemble the movement in the reverse order.

- ☐ Perform the following steps with round bullets to replace the primary gears.
  - First replace the motor armature gear.
  - Place the pointed shaft on gear #4 through the central hole in gear #3. Press the pointed shaft into the hole in the time-setting knob's shaft.

    Friction secures gear #4 to the setting knob, and #4 holds gear #3 in place, but allows it to rotate. Gear #4 pokes through the housing top, and will mesh with secondary gear #1 when reassembly is complete.

- Notice the holes for gears #1 and #2, to be installed in the next steps.

Fig. 63: Gears #3 and #4 snapped together.

- Place the pointed shaft of gear #1 in its hole in the housing top. The the long teeth on gear #1 with will mesh with the motor armature gear when the housing is closed in the final step. (The teeth are long and somewhat flexible so they don't have to be precisely aligned with the armature gear when the housing halves are snapped together.)

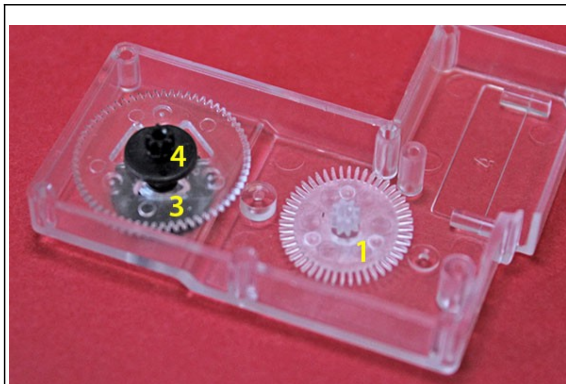


Fig. 65: Gear #1 installed.

- Slide gear #2 under gear #3 and over gear #1. Place its short shaft into its hole in the housing top. The small gear on #2 meshes with gear #3. The metal retainer disk on gear #2's shaft is positioned above gear #3. Gear #2 meshes with the small gear on #1.

- [ ] Fig. 65 shows the four primary gears correctly installed. Notice how gear #3 is positioned above gear #2 and below the metal retainer. Also notice how gear #3 meshes with the small gear on #2, and how gear #2 meshes with the small gear on #1. The pointed shaft on the armature gear will fit into the hole to the right of gear #1, and the armature gear will mesh with the long teeth on gear #1.

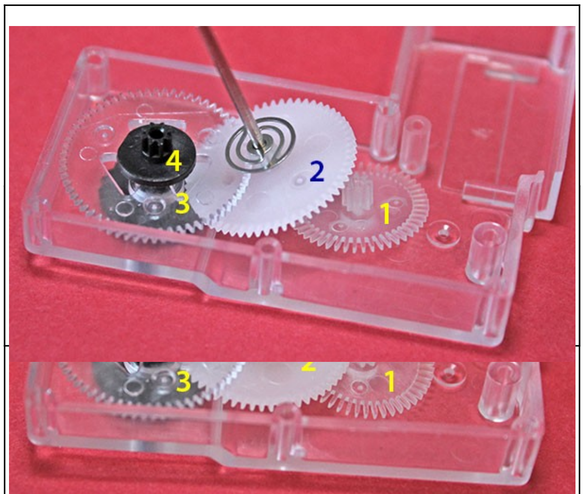


Fig. 67: Primary gears installed.

- [ ] Hold the top half of the housing with the motor coil and armature gear over the bottom half. Insert the metal shaft on gear #2 through its hole in the housing top. Slide the top down the shaft and position it so the pins on one half mate with the holes on the other half. Squeeze the halves together firmly until their edges touch. You should hear four or five clicks as you squeeze the housing together around its perimeter. Squeeze around the housing two or three times to ensure that is tight together all the way around

- [ ] Fig. 66 shows the primary gears in place, looking through the bottom of the closed housing. The armature gear meshes with gear #1. Transparent gear #3 is hard to see, and the tiny gear #4 that meshes with #2 is completely hidden under the time-setting knob.

- [ ] Connect the movement to an operating FCC4, and check that the primary gears and the time-setting knob are rotating. If not, disconnect and split the housing, then try again to position the primary gears correctly.

- [ ] When the primary gears rotate, disconnect the movement from the FCC4.

- [ ] If you chose to remove the secondary gears from the top housing half, replace them and the gear retainer, following the instructions and photos starting on page **47**.

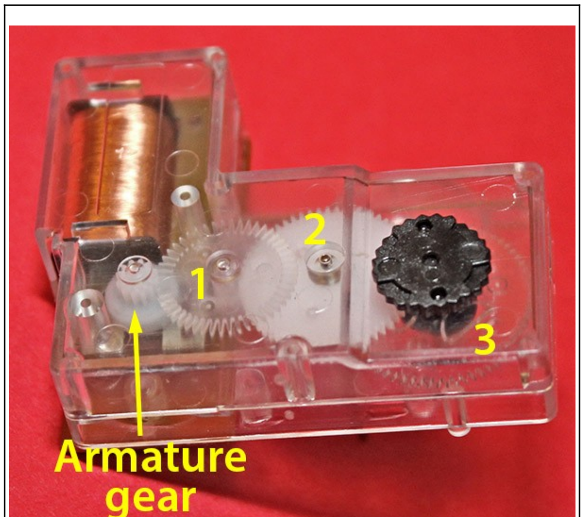


Fig. 68: Housing bottom view, primary gears assembled.

- [ ] Place the movement into its square black case, as described on page **46**. Be sure the wires are correctly positioned in the slot in the case.

- [ ] Install the movement in your clock, attach the hands, connect the clock to the FCC4 clock bus, and test for smooth and accurate running.

Limited Warranty – read this

Assembled and tested FCC4

Each assembled and tested FCC4 is warranted against defects in components and workmanship for a period of one year from date of purchase. If your FCC4 fails, send an email to mike@mdodd.com describing the problem. If the problem appears to be caused by a removable component (installed in a socket), I will ship you a replacement component. If the problem appears to be caused by a soldered component, I will ask you to send the FCC4 to me for diagnosis and repair, after which I will return it to you.

FCC4 kit

If you receive an FCC4 kit that has incorrect or missing parts, send an email to mike@mdodd.com, and I will promptly mail the parts to you.

All components in the FCC4 kit are warranted to function properly for a period of one year from date of purchase. The microprocessor is tested prior to shipment.

It is your responsibility to carefully assemble the kit according to the instructions starting on page **24** in this User Manual. If your FCC4 kit does not operate correctly following assembly, send an email to mike@mdodd.com describing the problem, and I will work with you to get it working.

If you decide after receiving the kit that you do not wish to assemble it, I will assemble it for you, as described under **Assembly Service** on page **50**. Once assembled, the FCC4 is warranted as an assembled and tested unit, as shown above.

Do not use acid flux or solder containing acid flux when assembling the FCC4 kit. Using acid flux voids this warranty. Use only rosin-core solder, as stated on page 25.

Modified clock movements

I test every clock movement I modify for proper operation before I ship it to you. If a modified movement fails to operate with your functional FCC4 fast clock controller during a period of one year from date of purchase, I will replace it. Send an email to mike@mdodd.com with details of the failure. I might ask you to return the defective movement, so I can try to determine why it failed.

As described elsewhere in this User Manual, occasionally a movement might not keep accurate time while running with the FCC4. This is due to issues with the internal mechanism, ***not*** due to the modification made to the movement or the FCC4 controller.

Nevertheless, for a period of one year from date of purchase, I will replace a movement that does not remain synchronized with other modified movements connected to a functional FCC4

I ask that you first disassemble the movement and clean the gears (page **57**), since this has been shown to restore erratic movements to normal operation.

If you can't get the movement to run normally after cleaning, I will replace it.

You don't need to return the movement to me, but I ask you to pay the postage for a replacement. Send an email to mike@mdodd.com with details of the inaccurate movement (how long it's been in service, how much time it gains or loses over a specified number of fast-time hours, etc.), and what you have tried to make it run normally.

Clock movement kits

Each clock movement kit contains one new Q80 movement from Klockit, one resistor, and approximately 10" of twisted-pair wire. If you receive a kit that has incorrect or missing parts, send an email to mike@mdodd.com, and I will promptly mail the parts to you.

The movement is ***not*** warranted. I purchase the movements from Klockit, visually inspect them, insert an AA battery and listen for ticks, add the resistor and wire, and ship the kit to you. I do not ship movements that are obviously damaged or do not run with an AA battery.