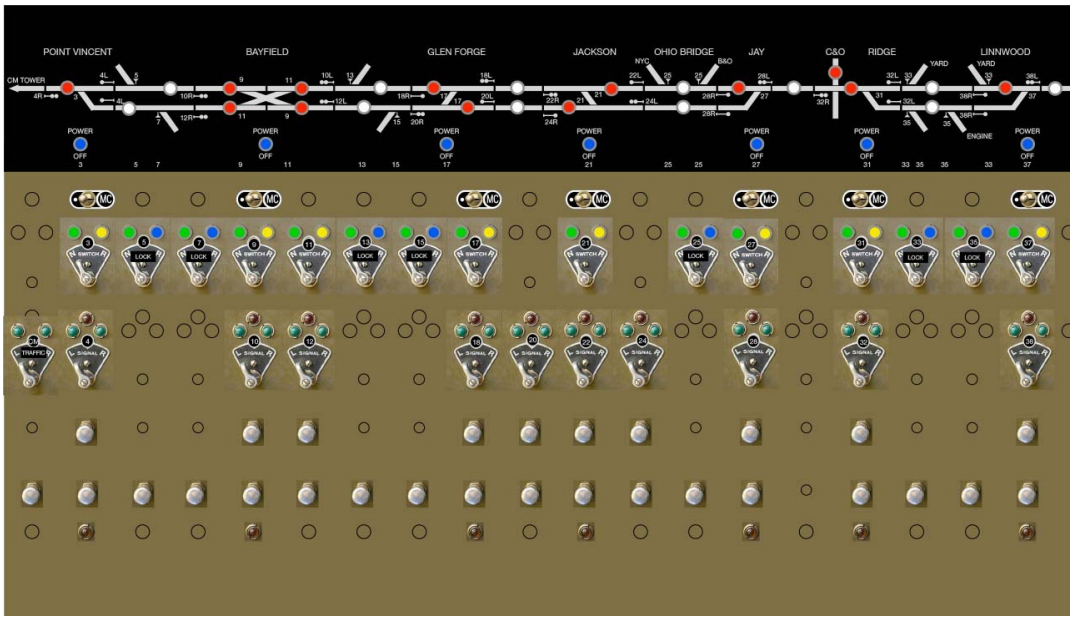
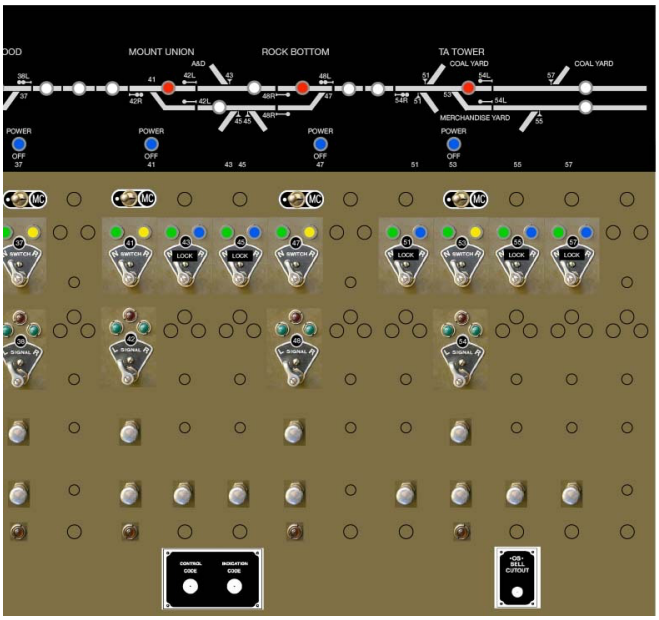
CTC Machine Build

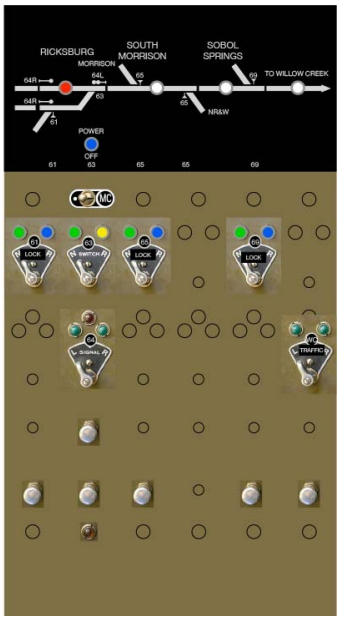
Bob #1 February 14, 2016, 10:35pm

It is time to start work on the CTC machine and catch-up installing the signaling in the field. This is a huge project and already numerous folks have contributed in various ways. These include Vince, Craig, Jack, Bill, David and myself. Doug Geiger and Rod Black (of CATS fame) have been kind and very helpful consultants.

Here is a two-part mock-up assembled using Intaglio (a Mac CAD program) and Photoshop. It is still a work-in-progress but we think we have what hardware goes in a column pretty well nailed-down.







First some disclaimers:

- There will be a track schematic along the top of the model board giving siding lengths
- Model board artwork will be redone for greater prototype accuracy
- Switch and signal lever plates are shown “old US&S style” but we will install the later style
- Blue lights for unlocked switches may instead be red

Replica hardware has been ordered from Mike Burgett at **CTCParts.com** for the lever knobs and all the plates.

Replica hardware for the code and call-on buttons, and the indicator bezels are being fabricated on my Sherline lathe and mill (more on this later.)

We plan to use steel main panels and model boards that have been cut on a CNC water jet. Once the plates from Mike arrive, we can prepare final CAD drawings for the panels.

Bob #2 February 14, 2016, 10:35pm

Unless you are familiar with a US&S panel, a little explanation may be in order.

Starting at the top we have the model board. Red lamps indicate that an interlocking (or control point) is occupied. Likewise, white lamps indicate occupancy of intermediate blocks.

Blue lamps show that an operator has inserted a key in an automatic locked turnout and taken it off-power. Operators cannot use a key without dispatcher permission. The idea of locating Power Off lamps along the bottom of the panel was found in a US&S builder's photo of a machine being built for the Clinchfield.

MC stands for Maintainer Call. When thrown to the right and coded, a white light illuminates on the layout fascia. These are located at every interlocking. When the dispatcher wants to talk to a crew, he will in advance set the home signals to stop and light the lamp. A crew, when stopped for a signal, should look for the illuminated light and pick up the nearest crew phone. On the prototype these lights were found on the side of relay cabins, but fascia lights will be easier to notice.

The top row of levers control switches and unlock siding switches.

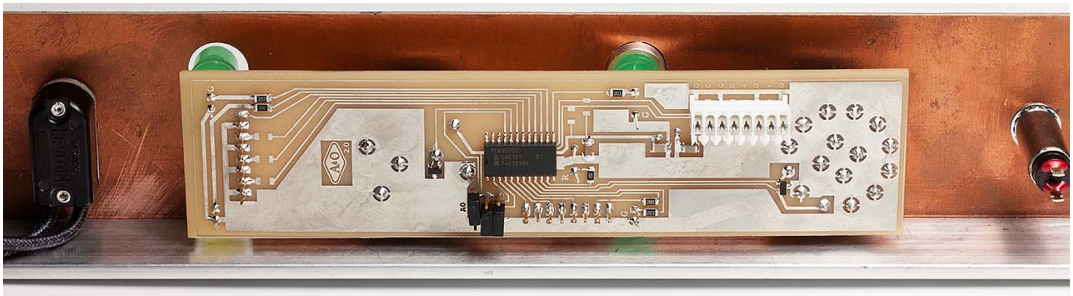
The lower row of levers control signals and hand-off trains to the next dispatcher at the ends of the machine.

The upper row of pushbuttons produce Call-On control codes. These are pressed and held in prior to pressing the corresponding code button in the lower row. Call-on overrides certain, but not all, interlocks for moves such as a locomotive returning to his train.

The bottom amber lights illuminate when Maintainer Call field lamps are on.

Bob #3 February 14, 2016, 10:35pm

CTC machines are full of long wires; some machines may contain over 1000 that run from one point to another. I'm not very good at neat wiring, so a circuit board was in order to help eliminate most of the wires and make the remaining ones easily manageable.



Here we see the first prototype board mounted on the back of an LED mounting fixture. First on the left we see a maintainer call switch. The fixture has a hole for these so that a small wiring harness can be made to attach it to the leftmost connector pins on the PC board. Those pins can also drive up to 3 LEDs on the model board.

The leftmost green LED indicates switch position. A yellow LED is soldered below it.

To the right of the A&O logo are the pins for the 60 degree 2 position switch lever. It is a standard Mouser part.

The black integrated circuit is a 16-bit I2C GPIO chip. It reads all the switches and drives the LEDs. By deploying one on each column we can funnel control of up to 128 switches and LEDs down to a daisy-chained cable containing just 8 wires (gold pins along the bottom of the board.) The I2C buses and CTC machine management (approach bell, etc.) will be managed by an inexpensive Arduino processor board. Most likely the Arduino will make the CTC machine appear as a collection of CMRI hardware boards to the main computer.

The rightmost green LED is one of three signal indicator lamps.

Next is another 8-pin connector that goes to a mini wiring harness serving the code, call on and MC lamps.

At the right end of the board is the 30 degree 3 position rotary switch for controlling signals.

At the far right is a call-on pushbutton switch.

Bob #4 February 14, 2016, 10:35pm

Some of the replica hardware is home made. Many modelers use 8mm LEDs and a silver painted nylon bezel but to my eye they don't look right. Also, I could only find the full set of colors needed for the panel in 10mm LEDs. 10mm bezels were far oversize and would end up interfering with the lever plates.

It was time to "think different." Doug Geiger loaned me a real US&S indicator lamp assembly, which gave up its prototype dimensions. 10mm LEDs were too large in diameter to look right, but a replica bezel could hide some of the excess if it was bored wide at the back but narrow on the front.

Here’s the prototype indicator attached to a panel.

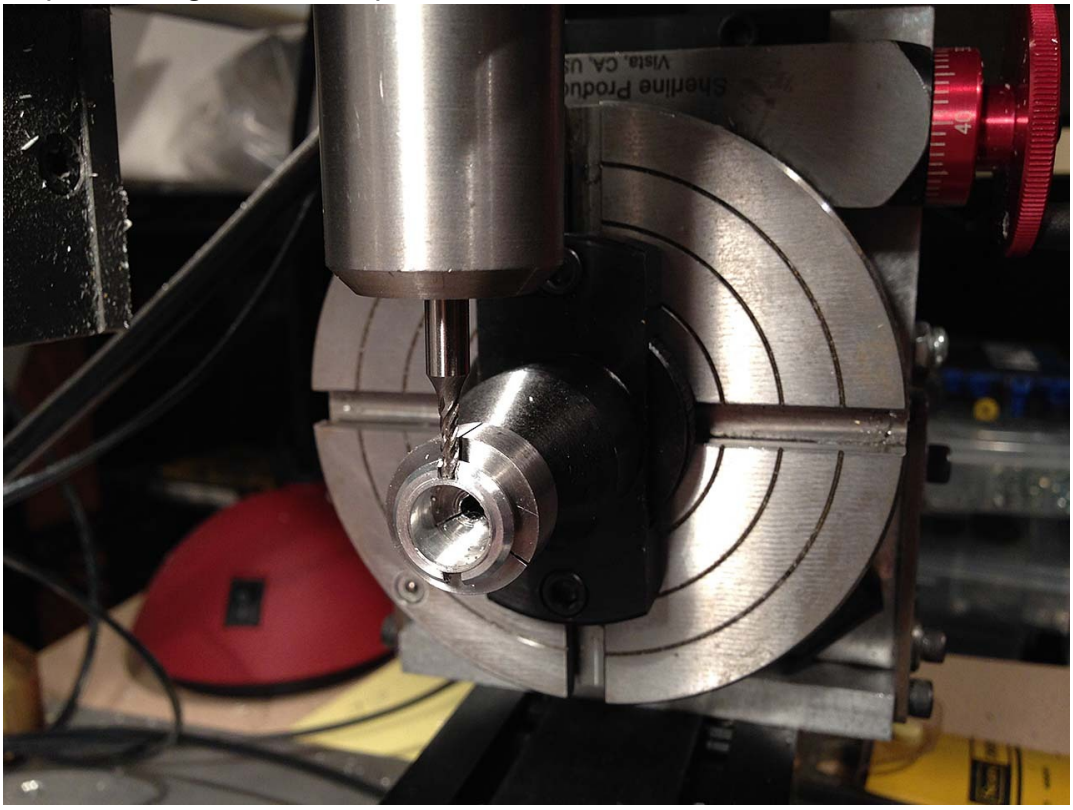
Now the replicas, which appear to need some weathering.

1 Like

Bob #5 February 14, 2016, 10:35pm

There is just one minor problem with homemade bezels. We need a lot of them, about 161 by current count.

Once the bezels are cut to length (0.3 inches), the only way to hold them for further machining is in a custom sized step collet. Sherline sells inexpensive blank pot chucks for this purpose. This is the final step of adding simulated spanner wrench slots.



1 Like

Craig #6 February 14, 2016, 10:35pm

Beautiful job on all of this stuff Bob. Those bezels look great!! And the board layout will really help out with a lot of the wiring.

I"ll be able to pitch in to help stuff some boards after I get back from a little R&R in Alaska. Should be back around the 21st.

rnb3 #7 February 14, 2016, 10:35pm

Super cool Bob! This will add some serious play value to the mothership! Those LEDs look very realistic when combined with your scratch built bezels.

RickL #8 February 14, 2016, 10:35pm

Bob,
Would you consider listing the part numbers of the switches that are being used for the CTC stack?

The PCBs looks like an excellent idea as well; I wonder if Mike B with CTCparts has ever considered going to that model in the backend of the machines he is making?

Bob #9 February 14, 2016, 10:35pm

Rick L -

There’s good news and bad news. The good news is that I’m happy to give you the Mouser part numbers.

2-position, 60 degree: SR2616F-0202-18F5B-D8-N
3-position, 30 degree: SR2612F-43-21RN

The bad news is that Mouser now shows both of these as special order. There are still about 200 of the 3-position switches in stock at the moment. Six months ago Mouser had 700 of the 2-position switches in stock but today none are available. It is also not clear whether quantities less than 1000

can be special ordered. 🙁

Note that the Mouser catalog shows the 2-position switch as 90 degree but it is really a correct 60 degree.

Switches might be available from other sources. Fortunately we already have just enough stock in-hand for the A&O machine build. I bought them over 7 years ago and made *very* lucky guesses for quantities!

This particular PCB solution isn't for everyone. It requires a custom Arduino-based controller board to translate between CMRI protocol and multiple I2C buses that connect to the columns. Arduino programming skills are required. The surface mount parts require better than average soldering equipment and skills. I suspect that most modelers would prefer to use standard CMRI hardware.

One *could* design a column PCB that connects directly to the CMRI bus. Such a board would require its own Arduino or PIC processor and RS485 interface adapter. However, a reliable source of PC-mount switches would still be needed.

I am aware that the NMRA has been working on CAN bus hardware but have no opinion as I haven't been following it very closely. CMRI-compatible work by the Arduini group shows promise.

RickL #10 February 14, 2016, 10:35pm

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Thanks for the part numbers; I'll see if I can scare up other sources besides Mouser. I had to do something similar to source card edge connectors from EDAC, so this isn't something totally outside my comfort zone.

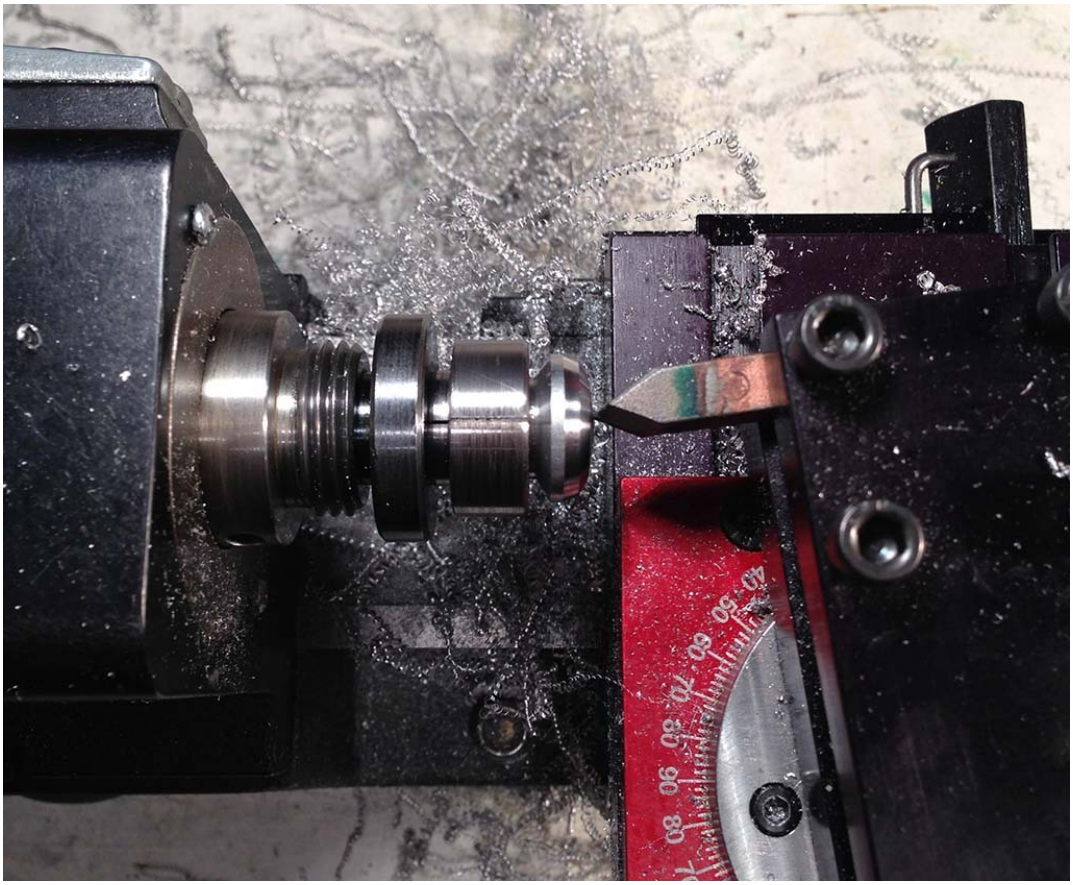
The arduino requirement isn't exactly a huge stumbling block in my view - both the cpnode (a CMRI

related project that two gents previewed at the latest NMRA national convention) and some of the OpenLCB/NMRANet/whatever they are going to call it next stuff (aka the CAN bus stuff) is Arduino compatible. Also there is a pretty good library for loconet for the Arduino platforms.

The custom PCB appeals to me since I could make a couple and use it in a small panel to allow my yardmasters to allow traffic into the yard or request the exit of train out of the yard and just use some input that I already have on boards that could get it to loconet and my main, JMRI based panel, could handle the logic from there. I can see your point if you want this sans an active PC.

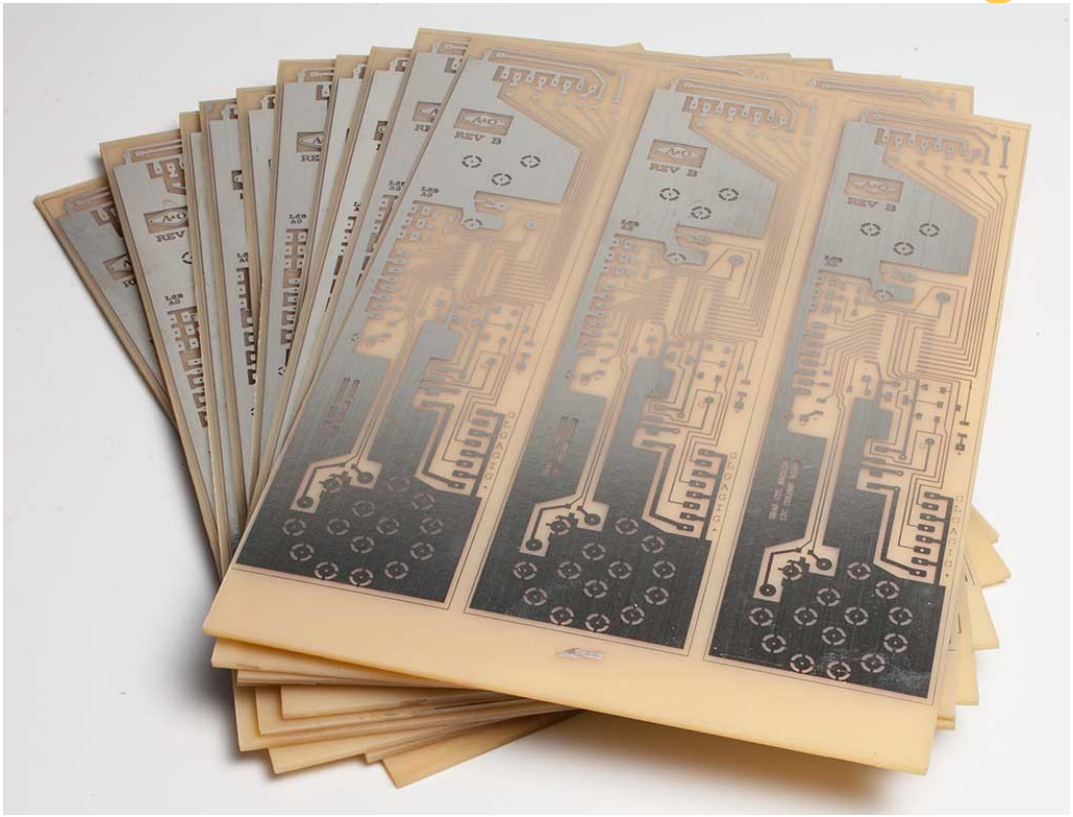
Bob #11 February 14, 2016, 10:35pm

The build continues in between other projects. I just finished turning replica pushbutton caps for the code and call on switches. Shaping the caps was a lot of fun as it could be done by eye instead of “by the numbers.” The final profile was formed on the lathe using a smooth cut file.



Finished pile of 46 caps. A 4-40 set screw firmly holds these caps in place. I aimed for a bit of a rough-turned appearance, similar to a prototype US&S code button in my collection.

Meanwhile an etch marathon produced a stack of column boards ready to be drilled and stuffed with parts. We will need 32 of them. Craig volunteered to solder them up. 😃



For those who like to count things, there are 32 of these column boards, each containing an I2C GPIO expander chip that provides 16 individually-configurable input or output connections, so a

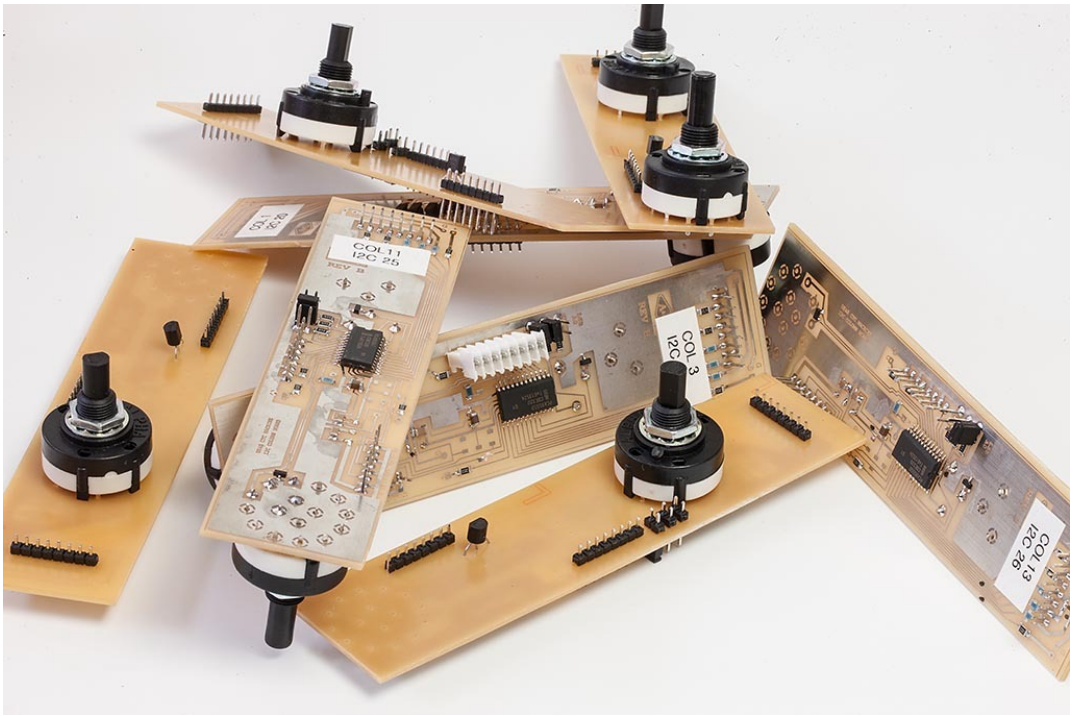
maximum of 32*16=512 switches and LEDs could be supported. Fortunately not *all* of them will be needed.

Bob #12 February 14, 2016, 10:35pm

The CTC machine build progresses. Craig volunteered to stuff the surface mount parts and that's all done. I've been adding the connectors, voltage regulator and switches.

We decided it would be wiser to load and solder the LEDs on these boards at the time we mount the boards on the panel. Not every bezel has the same inside depth and we don't yet have the actual panels on hand to know how thick the panel material will be. The latter will be known once RFQs have been sent out and an order awarded to the supplier. I already received an acceptable bid.

Here are 8 of the 32 column boards ready to be installed and tested. Each is labeled according to the column number and I2C programming address.



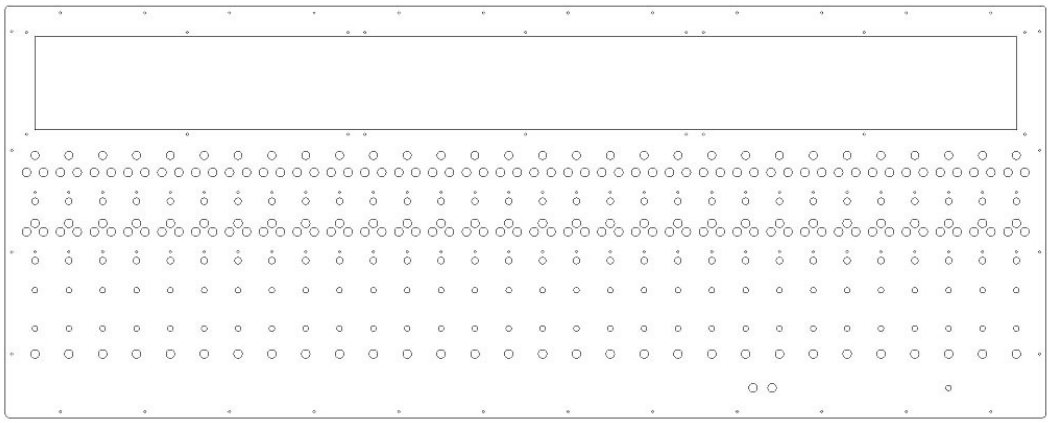
Meanwhile, Mike Burgett of CTC Parts graciously did a design review of the panel and came up with some important suggestions, all of which we eagerly accepted. It turns out that OFF POWER lamps signify that an interlocking has lost AC power and is running on battery backup, so they have been deleted. The other major item was the need for an automatic dwarf signal wherever a siding enters an interlocking, so 3 will be added to the layout. Mike also explained that after the dispatcher unlocks the turnout, and the local crew is inside the switch machine, both indicators on lock lever go out.

When the crew aligns the turnout to enter the interlocking from the siding, a dwarf (not Happy, Doc or Grumpy) automatically gives a permissive indication. So in three columns switch levers have been changed over to lock levers. A few minor changes involved the color of LEDs on lock levers and traffic levers.

Bob #13 February 14, 2016, 10:35pm

CTC panels will soon be cut on a CNC water jet from 16 gage (about 0.06" thick) sheet steel. The main panel is just over 61" wide, and a smaller wing panel a bit over 12" wide. CAD drawings were prepared using a free version of QCAD, which is primarily open source so most everything needed must be free. Only a few options are proprietary, such as Autocad .DWG import/export, and they work for a few minutes before timing out. QCAD runs on Mac, Linux and Windoz. The learning curved proved easy for this simple project.

I sent several RFQs containing 1:1 scale .DXF files and received an acceptable local bid that should be awarded in a few days. The large panel should fit in my vehicle and is estimated to weigh under 30 pounds.



It was standard US&S practice to drill a full pattern of holes then apply hole plugs over empty holes. Anodized aluminum model boards attach over the wide horizontal cutout along the top. I extended the panel 3/4 of an inch along all 4 edges as a mounting flange. Holes along the perimeter will clear 6-32 wood screws. David enjoys finish carpentry and plans to make a rolling wood cabinet of custom

dimensions, designed to easily roll out of the dispatcher's office for access to a mechanical room.

Model board artwork is final and an acceptable bid was received from a sign shop on the east coast.

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emdalco01 #14 February 14, 2016, 10:35pm

You guys constantly have me picking my jaw up off the floor with what you are doing. I hope I can see the A&O in the flesh one day.

It's going to be one of the true great O scale model railroads.

Regards Daryl Blake
Melbourne Australia

David #15 February 14, 2016, 10:35pm

Hi Daryl,

Yes, Bob has done some amazing part preparation for the CTC machine. I hope the rest of the A&O measures up.
Next time you're in our area be sure to stop by. I'll do the same!

David

Bob #16 February 14, 2016, 10:35pm

Rick Lull -

It was great to meet you in person during the RockyOp A&O open house. Hope you can make it to RockyOp North in two years and hopefully operate on the A&O!

Bob #17 February 14, 2016, 10:35pm

Things are getting **really serious** on the CTC build because we can see the light at the end of the tunnel, and it isn't blowing a horn at us! Unfortunately, I first need to stuff and wire a large pile of control panel boxes that David built, and also finish the design and construction of a custom 10 telephone line PBX machine.

I'm already salivating with with sweet and savory anticipation of serene sirloin steak aromas of celebration rising above the seemingly-endless build-out of the CTC machine! Try to out-do *that* alliteration, my friends! 😆

Sorry. I'll try to recompose myself. Just a bit.

Anyway, today was an A&O **milestone** (David's word, not mine.) The two of us picked up the two large hot-rolled steel lower panels for the CTC machine at Rocky Mountain Waterjet in Greeley. I really like using the services of a local and small supplier! (A+ for their service.)

This large panel has an active width of 60 inches, the same as prototype US&S panels. Mostly out of view, on the far right, is a short 12" wide "wing" panel (prototype machines were usually 30" wide here.)

Fortunately a first prototype CTC Column PC board fit just fine and that was a *great* relief! David has his hands on a signal lever shaft on that PC board, trial fitted on the back of the panel. The custom-turned bezels fit just fine. They will be held in place from the rear with 1/2 inch diameter snap rings.

After we picked up the panels I countersunk the perimeter mounting holes to accept #6 flat head wood screws. By design there is an extra 3/4 inch mounting flange that runs around the perimeters of both panels, except for the left side of a short 12" wide wing panel that abuts the main steel panel.

The wide cutout at the top is where the model board and associated occupancy lamps will go. I already have an acceptable bid but am holding off because once those arrive, I*** will ***drop everything else and work only on *the machine*.

Notice that the steel panel rests on a desktop with a drawer… David has been busy applying his carpentry skills to the construction of a “portable” i.e. rolling cabinet. This oversize desk is mounted on 4 large casters, so that it can be easily rolled out of the Dispatcher’s office for periodic access to a mechanical room. Here is a rear view of the desk, minus desktop and upper cabinet frame. The shelf halfway down and along the rear of the modesty panel will serve as mounting locations for the Arduino processor and other associated electronics. Visible along the top and rear is a large desk drawer on smooth gliding ball bearing tracks. This drawer will hold train sheets, pencils and erasers…

Trainsheets? Consider for a moment the steel panel photo. There is a giant horizontal cutout where the model board panels will be surface mounted. These will be photo-reproduced in aluminum. Magnets won’t stick to them, just as magnets would not stick to a prototype US&S model board. I learned while dispatching A&O 1.0 that magnets weren’t really needed, and often got far behind of the action, but keeping the trainsheet current was golden! I know, a lot of model railroads use magnets as a crutch to deal with the accelerated pace of the model compared to prototype. But to slow things down a bit, and help the dispatcher, we plan to have a phone system that lets the DS finish current work and receive stopped-on-red complaints only when he/she is *ready!*

Bob #18 February 14, 2016, 10:35pm

A little more progress… Sorry about the poor-quality cell phone photo. Here we see the unit placed in the dispatcher's office.

The steel panels served as helpful full-size templates while David built the upper cabinet with occasional mis-directed “help” from myself. The upper is quite shallow in depth compared to a prototype, but requires a tiny fraction of internal volume since integrated circuits substitute for relays and shorter parts replace the amazing but deep US&S prototype switches and lamp holders. A PC board in each column eliminates or shortens all of the point-to-point wires branching to rotary switches, associated LEDs, and model board lights and MC call toggle/lamp. The loose lumber laying along the lateral lip of the desktop will become a trim strip. (sorry, ran out of L words!) 😆

Anyway, I can’t wait for the day when Craig and I start to install the PC boards and lights. 😃

For sound effects, one of these Sparkfun “Surface Transducers” or exciters will be attached to the back of the panel, turning the steel plate into a loudspeaker for “various” and “occasionally unanticipated” sound effects. The nominal effect would be clacking of relays mounted in swing-out bays behind the panel of a prototype cabinet. A transducer is fundamentally a speaker with a very strong voice coil mount or spider, but no cone, mounted to a flexible surface that becomes the cone. The white disk is double-sided adhesive to attach the aluminum flange to the vibrating surface.

1 Like

Mike_Walsh #19 February 14, 2016, 10:35pm

Do you anticipate placing similar sound effect generators at each location that the CTC Machine controls?

I helped my friend wire up a CTC machine from CP Stony Point on the Erie. We have the entire unit (except one field unit) wired up and operational. We actually got the machine to operate HO scale turnouts and pick up occupancy. Hearing the relays clicking away is a pretty awesome effect. I think it would add that touch of realism as well.

Perhaps you could program your circuits to generate the sound(s) when they pick up occupancy, receive/send code for throwing turnouts, changing signals, etc…

Lots of opportunities here!

I'll try to post the video later today…

Mike Walsh

Bob #20 February 14, 2016, 10:35pm

Mike -

I don't plan to install any relay sounds in field locations. The clicking of indication codes might be useful to the dispatcher, if he/she doesn't turn off that sound altogether. Road crews would not be able to hear a thing coming out of the field relay cabins. Things happen pretty fast on a model railroad so the constant noise might prove irritating after a while. There will be a volume control so the dispatcher can set a personal preference.

That said, Doug Geiger has a working field unit installed in an alcove under his stairway. The office unit sound that ships with JMRI is a recording I made in Doug's dispatcher office. I have not recorded his field unit. Although a control code goes to the field, and indication code received from it, there are too many errors in the units for Doug to drive anything in the layout. But the sound pattern changes as different columns are coded, so it is a sweet sound to a "geek" dispatcher.

Also I do not plan to insert a long delay between a single control code going out and the return of its corresponding indication code, even though on the prototype it could be 30 seconds or longer. However, I hope to let the dispatcher quickly code several columns so that the control codes go out first, before any indication codes come back. This does, however pose a bit of a puzzler for a nominal model-railroad "friendly" implementation.

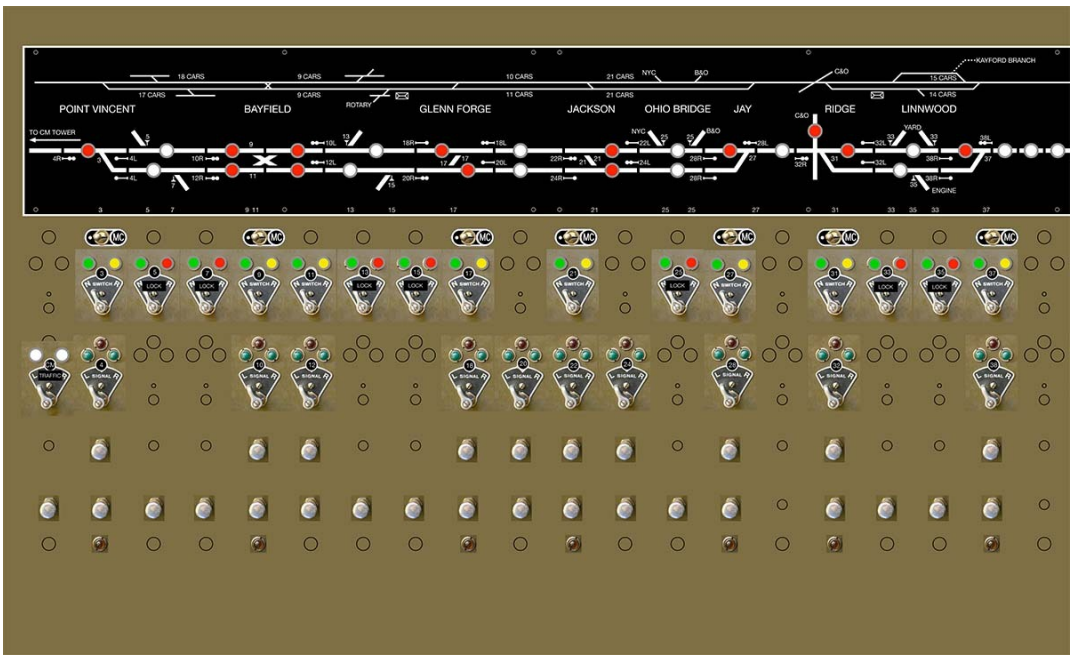
On the prototype, the vital logic is implemented in the field. The DS can code a disallowed request and the field will just reject that, not changing state. The control code goes out just the same, and the indication code shows no change. All too many model railroad emulations sound a buzzer when the DS tries to code something that can't be allowed, and that reflects that the vital logic is in the office machine, not the field. That's not what happens on the prototype.

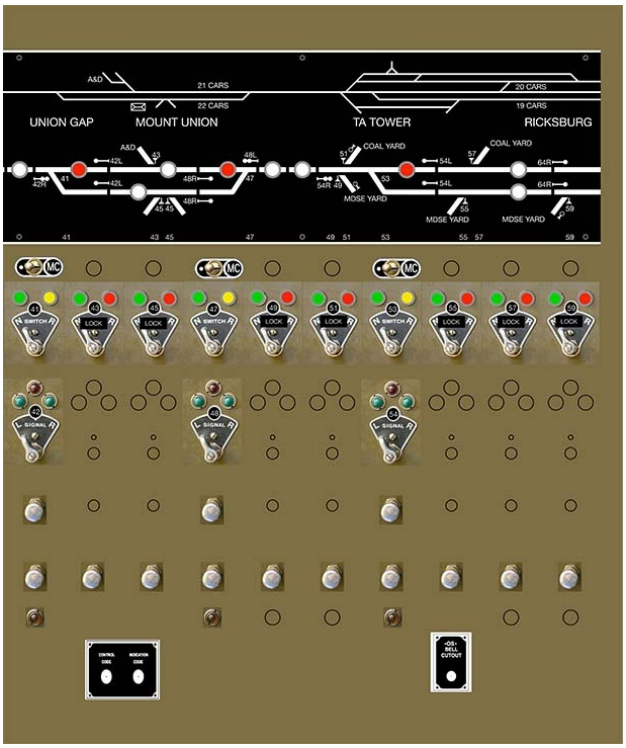
If I do implement vital logic in the CTC machine to keep local model railroaders happy, it might just play a few sounds that vary from a simple buzzer. One might be "I'm sorry Dave, but I'm afraid I can't do that." Another might be a sound of Pacman being eaten in the classic video game. Not prototypical you say? Neither is a buzzer.

Bob #21 February 14, 2016, 10:35pm

Should anyone be curious, here is the CTC machine layout after Mike Burgett reviewed it. Not that much changed. Primarily, the blue POWER OFF lamps were removed, automatic dwarf signals added to locked turnouts entering an OS section, unlocked lamps changed from blue to red, and white lamps on the correspondence levers. Column 61 was moved to 59 to simplify cabinet construction.

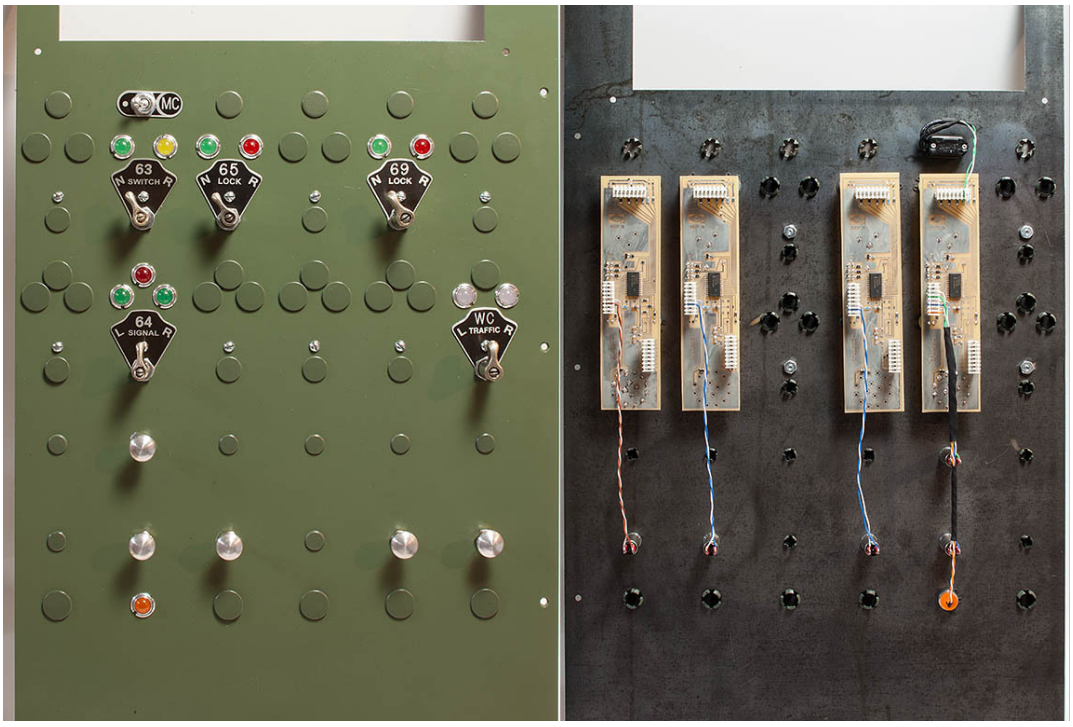
A schematic track plan showing siding lengths and stations was added to the top of the model board. That's about it.





Bob #22 February 14, 2016, 10:35pm

Today I did a test build-out of the CTC machine short right side panel. There were a few annoyances but nothing insurmountable.



The cutout at the top is where the aluminum model board will attach. In the rear view, the top white connectors power occupancy lamps on the model board. There will be a bit of untidiness as individual model board LEDs may be a couple inches to one side or the other of the column board that provides power.

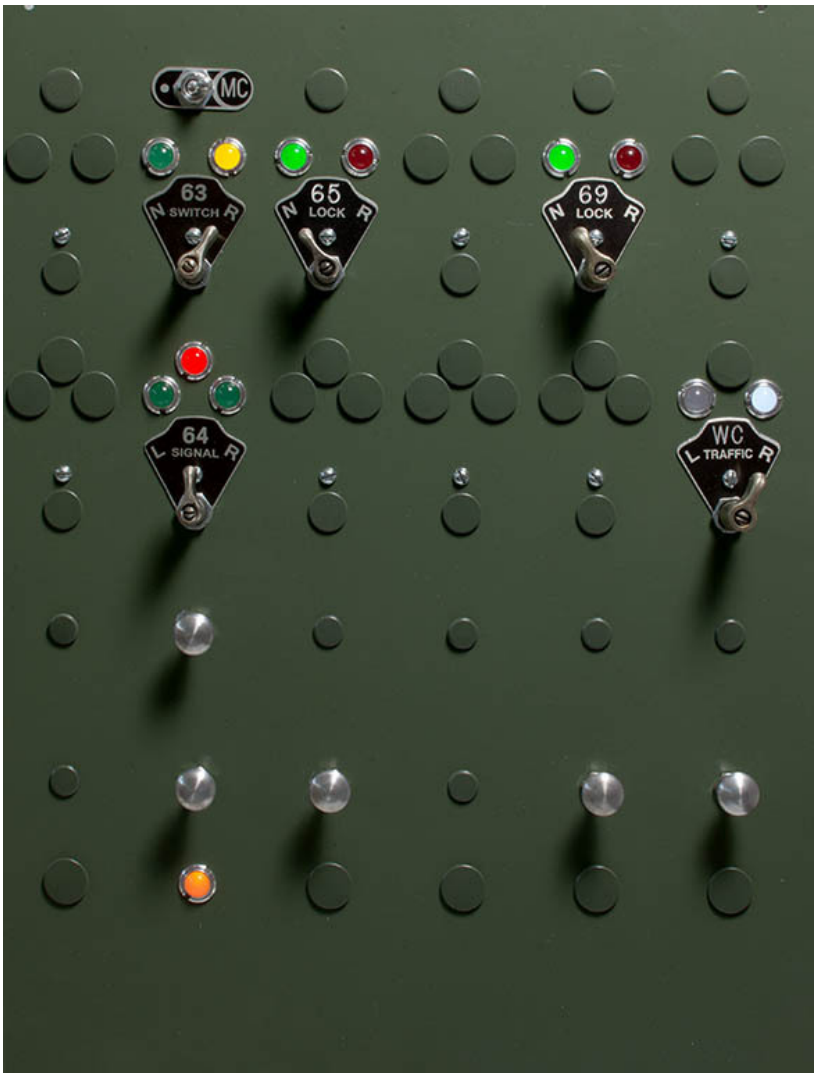
Wire management seems to be working out quite well. If we had used a conventional CMRI motherboard with DIN and DOUT boards, there would be over 500 point-point wires running all over the place behind this short panel and the 5 foot long main panel. With CMRI hardware, it is also necessary to solder LED resistors directly to the LEDs, as there is no home for them on the DOUT boards. Likewise, to “pulse stretch” a code button press, it is common to epoxy a large electrolytic capacitor to the panel next to the switch, and hang a resistor in the air between the switch and the pushbutton. Most of those wires would need to make a “home run” connection to the CMRI DIN or DOUT boards.

Thirty-two PC boards, one for each live column, eliminate about 300 of those wires. The remaining wires are short and connect directly above or below the boards. Along the bottom of each board is a currently unwired connector. For each set of 8 PC boards, a single CAT5 network cable will daisy-chain horizontally to carry power and an I2C communications bus. Essentially each of these cards acts as a wire “funnel” to the CAT5 cable. That cable then terminates at an Arduino-powered PC board that replaces the CMRI motherboard, DIN and DOUT cards. For 32 boards, I need 4 CAT5 cables.

The PC boards also carry all the LED resistors. By programming the Arduino to be notified by interrupt whenever a switch changes, there is no need for code button press stretching capacitors.

Because each board has 16 individually-programmable input or output pins, there is a maximum “capacity” of 512 switch inputs and/or LED outputs. That’s more than enough.

All-in-all, except for a few mistakes I made, I’m rather pleased with how this is shaping up. It looks particularly good when powered-up by a Sparkfun Arduino Redboard used as a test harness. In person the LEDs are many times brighter than in the photo. During an 8 second exposure they were illuminated for only about 1/2 second.



Bob #23 February 14, 2016, 10:35pm

Mike -

About halfway through C++ coding of the CTC machine into a single, $20 “Teensy 3.1” ARM Cortex M4 embedded microcontroller, adding an explicit software model of the code line from the office to the field works very well. The DS can code any number of columns. The software prioritizes them according to distance along the code line, then receives automatic station recall indication codes and any delayed indication codes when power turnouts complete their moves. The MP3 player stays perfectly in synch although I only have one recording each for control codes and indication codes. There are, however, multiple “error” sounds, none of which are remotely prototypical.

Since I need to add an Arduino to control signals at the New River diamond where it crosses the A&O, I may as well add an MP3 player to that processor for office relay sounds and bell for the traffic

levers at Willow Creek and opposite the aisle at CM Tower. These sounds should help the single operator of both of these stations to respond in a timely fashion without the DS always needing to call on the phone.

At a recent “Op 'till you drop!” road trip to Kansas City and Springfield MO, we learned that Joe Kasper refers to his new CTC machine as the “Great Wurlitzer.” That’s causing a number of strange ideas to spin around in my head, some involving a sound clip of Bach’s Toccata and Fugue in D Minor. 😆

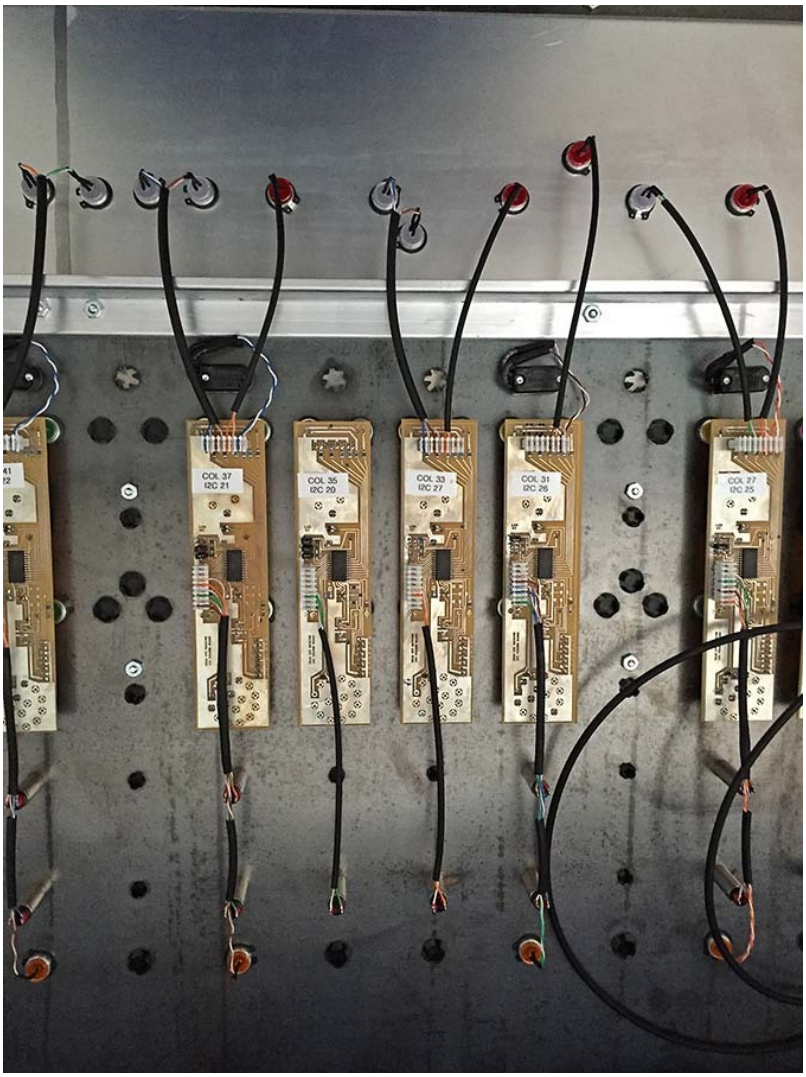
Bob #24 February 14, 2016, 10:35pm

We waited as long as we could before ordering MetalPhoto process model boards, as a hedge against changes to the track plan. And changes *did* happen, not long before awarding the contract to Metal Photo Service of Wall, PA! David moved the A&D interchange to the south side of Mount Union and repurposed the former A&D staging to the N&W.

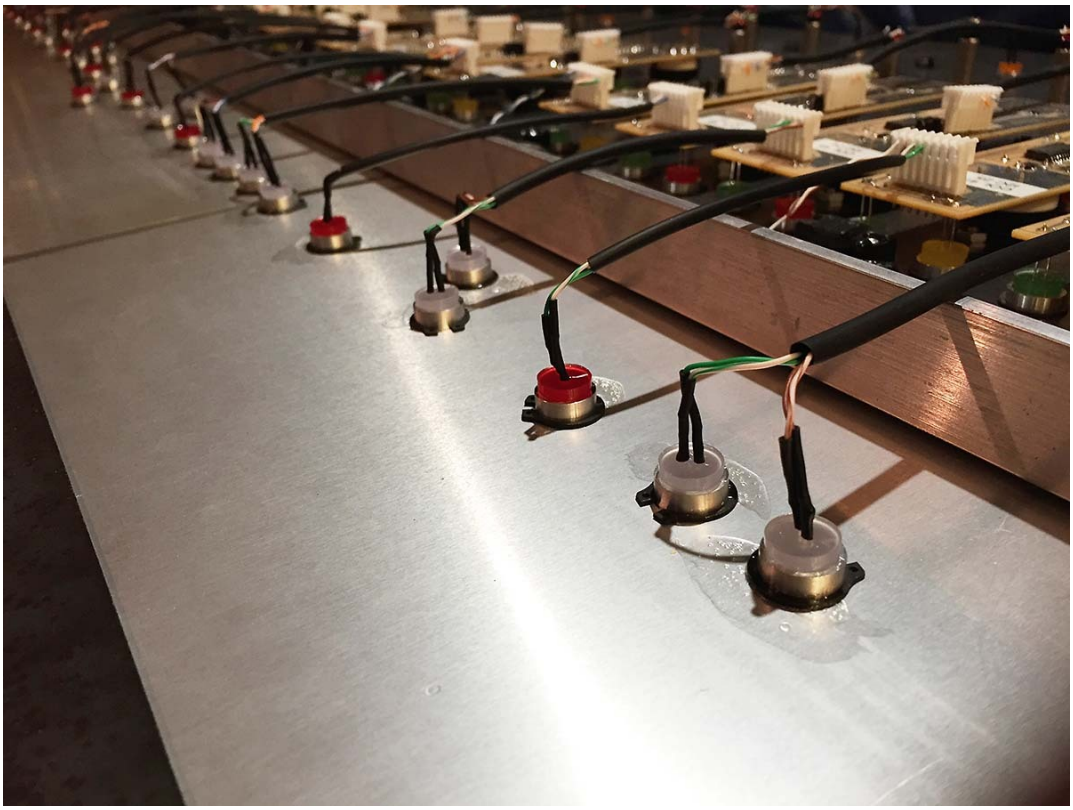
The four 0.032" thick aluminum model boards arrived the week after after Christmas. These came un-drilled to save money.

Hole fabrication was a multi-step process consisting of center-punching, #52 pilot hole, a generous 6-32 clearance hole (for mounting screws), then an Irwin step drill to enlarge occupancy lamp holes to 1/2." A padded clamp prevented the panel from bending if a drill should catch and it certainly improved safety by eliminating the chance of a panel spinning violently and slashing the drill press operator. In the following photo, what appears to be a burr is actually a bit of a protective plastic lamination to be later peeled off.

After bolting the model boards to the steel panel it was time for wiring. This came out fairly neat since improved wire management was one of the design objectives for the per-column PC boards. The next photo was taken during model board wiring. Two sizes of heat shrink tubing were employed to dress and bundle wires from the LEDs. A few loops from the larger diameter tubing reel appear in the lower left.

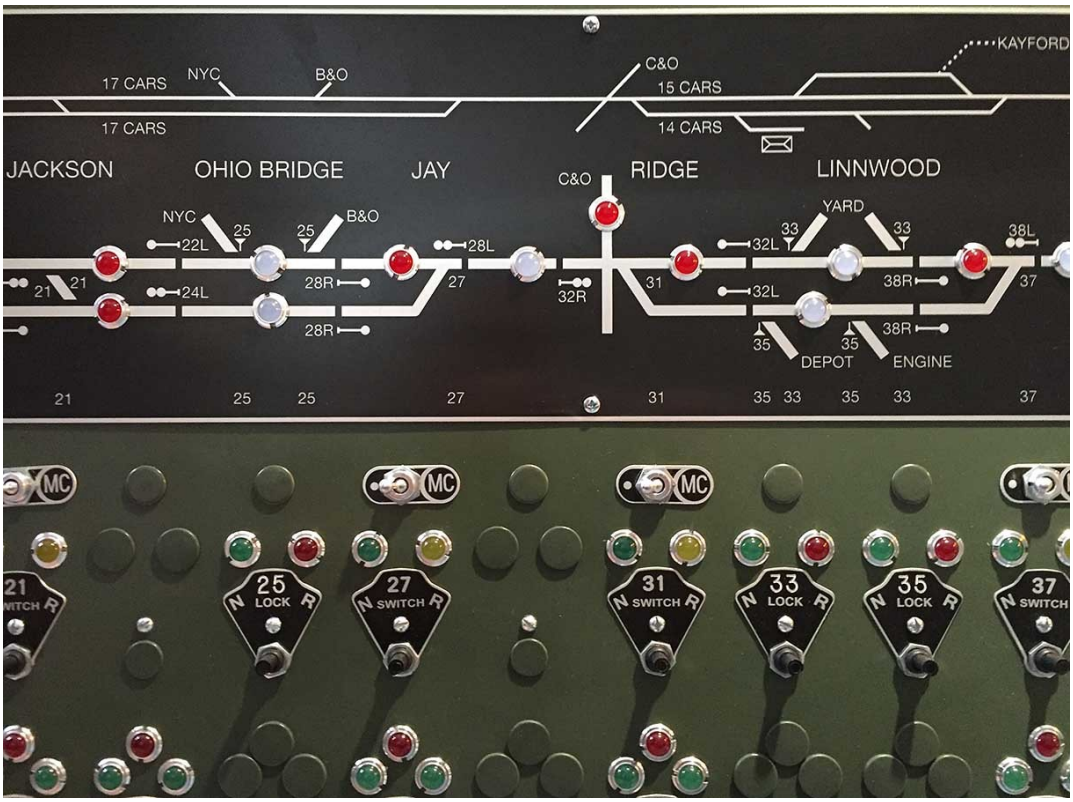


Wiring went pretty quickly thanks to Craig’s prior work to attach and insulate lengths of CAT5 wire pairs to each LED. Thanks again, Craig! Here we see the LEDs installed in the bezels, each held in its bezel by a drop of CA glue. Ordinary Elmer’s rubber cement smeared on and around each bezel prevents mechanical rattles.



Bob #25 February 14, 2016, 10:35pm

So… what does the front side look like? Here it is before adding the CTC Parts switch lever knobs. It looks like there are a couple maintainer call plates that need to be straightened. We are getting close!



1 Like

Craig #26 February 14, 2016, 10:35pm

I'm glad that I could help out Bob.

I must admit though…it was for selfish reasons…I'm so looking forward to being a dispatcher on the A&O! 🙂 This CTC is just plain amazing.

I can't wait to see the code development portion Bob.

Ready and waiting to help on some troubleshooting!

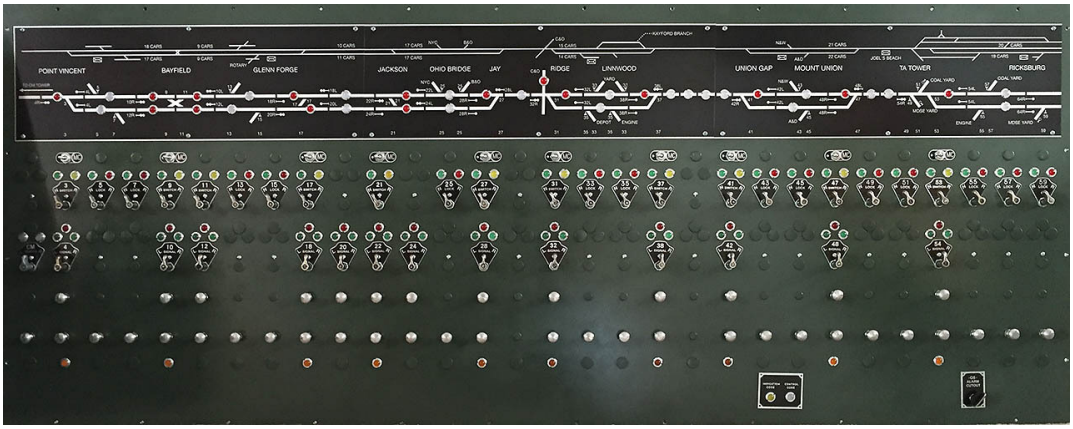
(Ok…back to car cards on my pike).

Bob #27 February 14, 2016, 10:35pm

The main CTC panel is ready for to be hooked up to the Teensy 3.1 based controller for software development and testing. During installation a couple plates be leveled. The short side panel is also

complete.

Installation should be deferred until I attend to a backlog of fascia-mounted control panels.



1 Like

David #28 February 14, 2016, 10:35pm

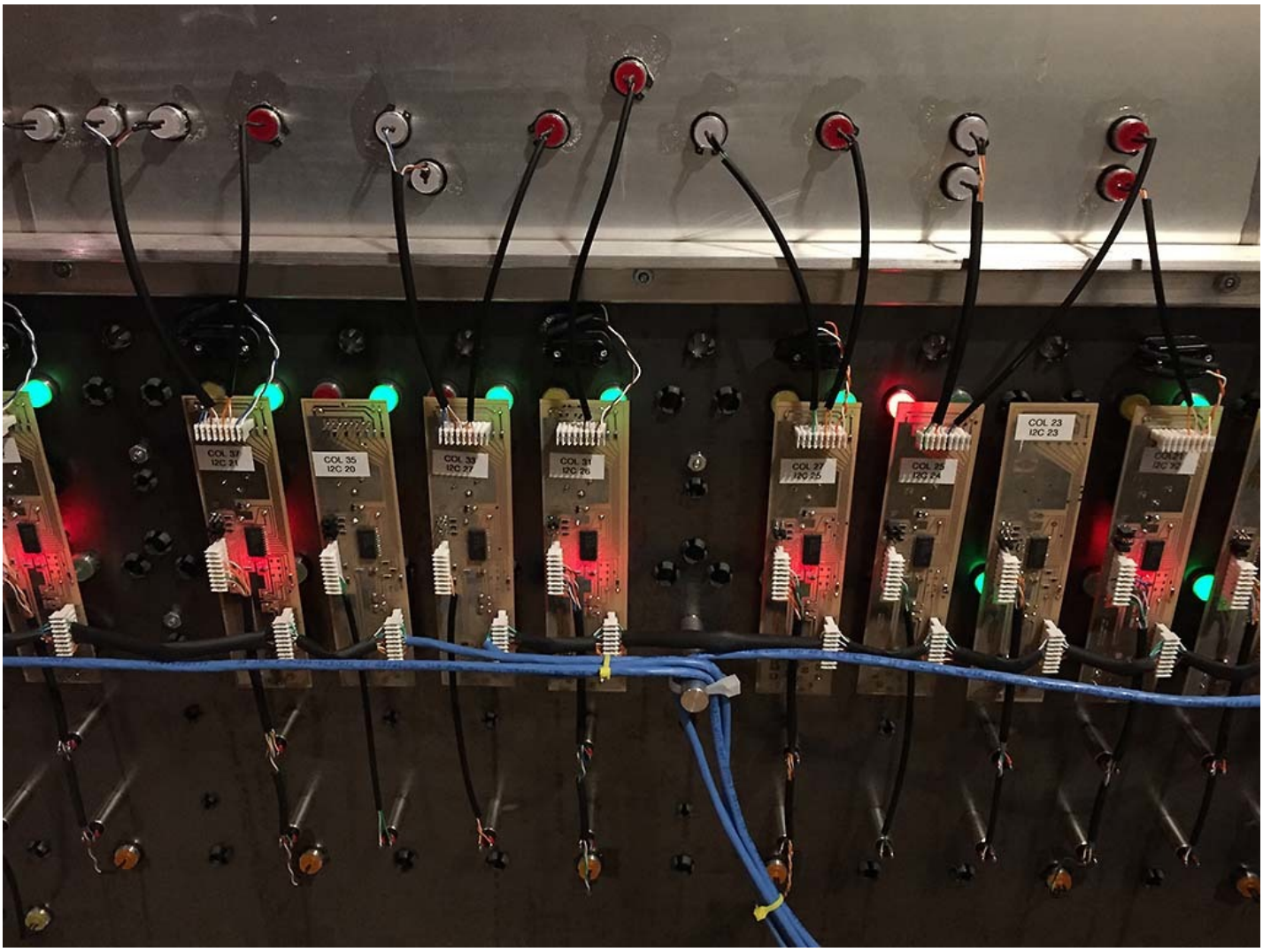
Simply amazing, Bob, in all its aspects. Beautiful job. I can't believe it (2.0) is finally to this point. When do we operate!! 😛

David

Bob #29 February 16, 2016, 9:51pm

Wire management in the back of the main panel came out neater than hoped. The blue CAT5 cables carry four I2C buses and power. They are the only connections between the panel and a control board mounted in the base of the cabinet. A massive "spaghetti bowl" has been avoided.

The red and white LEDs in the aluminum panel at the top are track occupancy indicators in the model board.



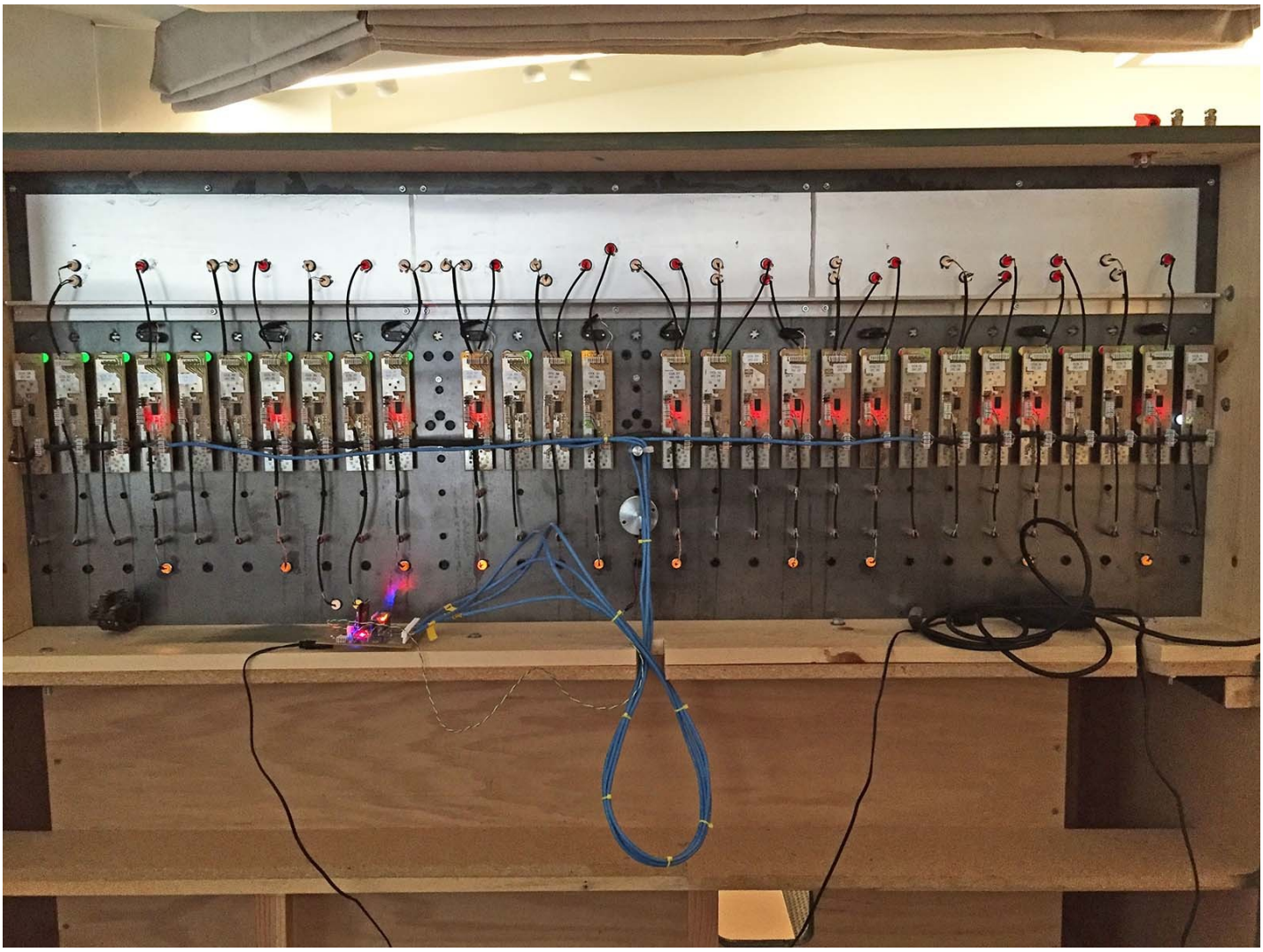
A gratuitous photo.

1 Like

Bob #30 May 1, 2016, 3:28pm

On April 30th we mounted the panels into David's wood CTC cabinet. Now he can install a Formica desktop and finish trim pieces.

Here’s the back side.



Not meant as a brag, but this might be the cleanest wiring behind any model CTC machine.

The round silver puck is an audio “exciter” that causes the steel panel to work as the speaker cone. The 4x4 inch control computer board sitting on the top shelf contains an MP3 player and audio amplifier, along with an integrated RS485 driver that connects to the layout’s CMRI bus. The processor is a Teensy 3.1 board from PRJC. It uses a 96 MHz ARM Cortex M4 32 bit processor programmed in C++.

I’ll shorten the four blue CAT5 cables when I decide where that control board will be located. A real US&S single stroke bell will be mounted below the top shelf.

Everything is powered by a single 12 volt wall wart.

1 Like

rnb3 #31 May 2, 2016, 4:38am

Amazing Bob! When you said you didn't want to deal with all of the wiring needed for CTC; you weren't kidding! I believe you have set the bar for model CTC panels.

Bob #32 May 14, 2016, 11:47pm

On May 14, 2016 the cabinet, finish work completed by David, was powered-up. Vince and I started confirming that SMINI inputs and outputs could be controlled by the machine's computer, through a test program prepared for this purpose. Things generally went well with 2 SMINIs out of 5 partially tested, though there were some failures to be fixed.

Vince and I used the PBX system to communicate between the Dispatcher's office and Vince's location in the field.

Craig #33 May 15, 2016, 1:19am

Bob…I just gotta say every time that I see this CTC panel I'm just in awe! Fantastic work.

Sorry I didn't get over to help out today. But good news is the weeds have been dealt with, and the a few of the honey do's are done 🙂

Bob #34 May 21, 2016, 12:57am

So, Craig… I still want you to have fun getting this beast up and running. You already have a lot of "skin in the game." But we haven't seen you in a while! Can you set aside a few Saturdays this spring and summer?

Vince and I had a lot of laughs (incompletely) testing the Bayfield and Glenn Forge SMINIs. At one point, Vince quoted the 3 Stooges: "We ain't getting no place fast!" It turned out that I failed to connect the end of the CAT5 RS485 cable from the CTC machine to the input side of the Bayfield SMINI. There was a long cable spilling electrons directly on the floor… We swept them up as best we could then I punched down an IDC connector on the end of the 485 cable and plugged it in. Everything was "more better" in Missouri speak.

Anyway, of course you will get to dispatch! David doesn't want to have a seniority system to let crew members preferentially choose operating positions, and I'm in total agreement. I look forward to sitting beside CTC trainees who soon become qualified dispatchers. And frankly, I'll need to do that a lot when we start running, as I'm sure there will be a few bugs in the CTC software and I want to catch them as the dispatcher runs into them.

Craig #35 May 24, 2016, 12:15pm

Hey Bob!!! You bet I want to get over to try that panel and the railroad out. Sadly, I've been spending every waking minute outside getting the yard/garden ready to go for the season. Spent the whole (I mean WHOLE) time last weekend working in the garden, but everything is in…so now it's sit back and wait for the payback 🙂

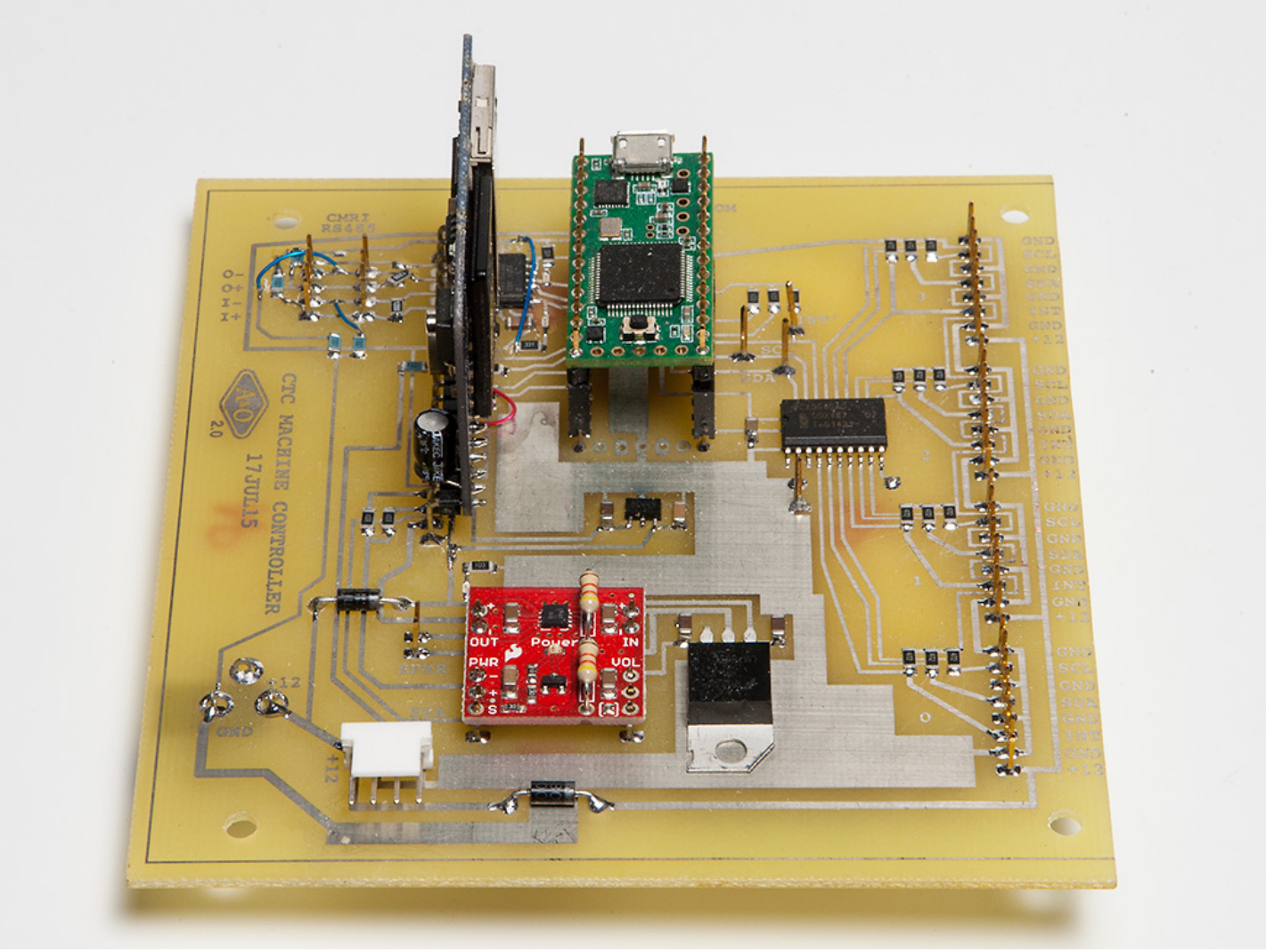
I should be open most of the weekends in June (at least as far as I know unless the Master Planner has other plans. heheheheh). Drop me a note when you'll be working.

On a side note I've been getting the new track laid in Chama for the caboose track and I've also been working on the cross-over in Salida from the A/D to the Yard 1 track. Hoping to get that done in a few weeks, and then tackle relayout of a few other areas. But…after seeing all of the great photos of the scenery work, I'm itching to get back on that as well.

Craig

Bob #36 June 3, 2016, 1:14pm

Here's a quick look at the 4x4 inch single-sided controller board. Most of it is empty space.



The green board is a $20 Teensy 3.1 processor. It has a 96 MHz Arm Cortex M4 and enough horsepower to drive the signal system. The blue vertical board is a cheap MP3 player. To the left are two sets of RS485 interfaces, one to drive the layout and the second for debugging with an

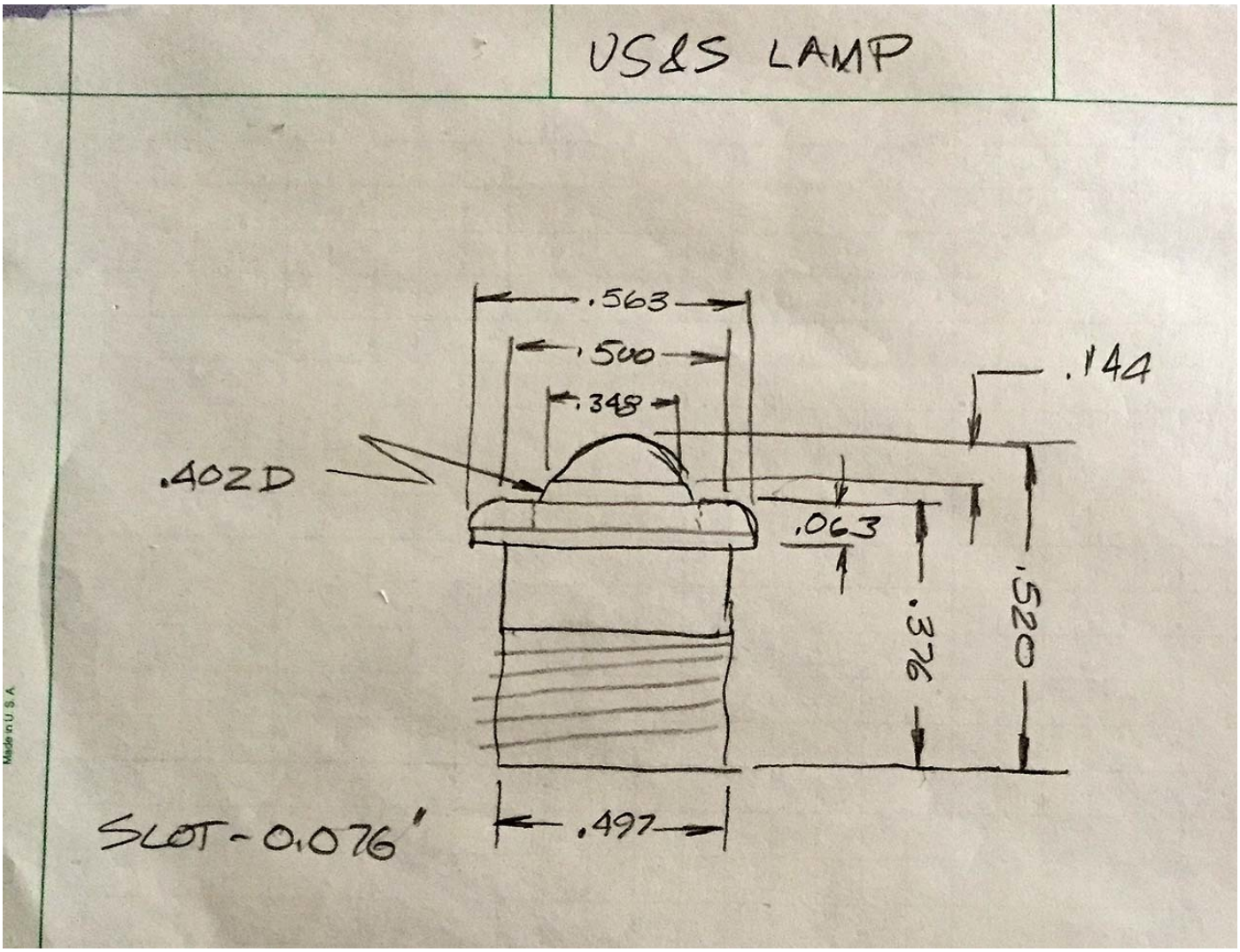
oscilloscope, if needed.

Along the right side of the board are four I2C buses. A PCA9545A 4-way MUX drives these buses and does 3.3V to 5V level translation. It also supports interrupts, so there is no need to constantly poll all the columns looking for code button presses as would be required if we used CMRI hardware inside the machine.

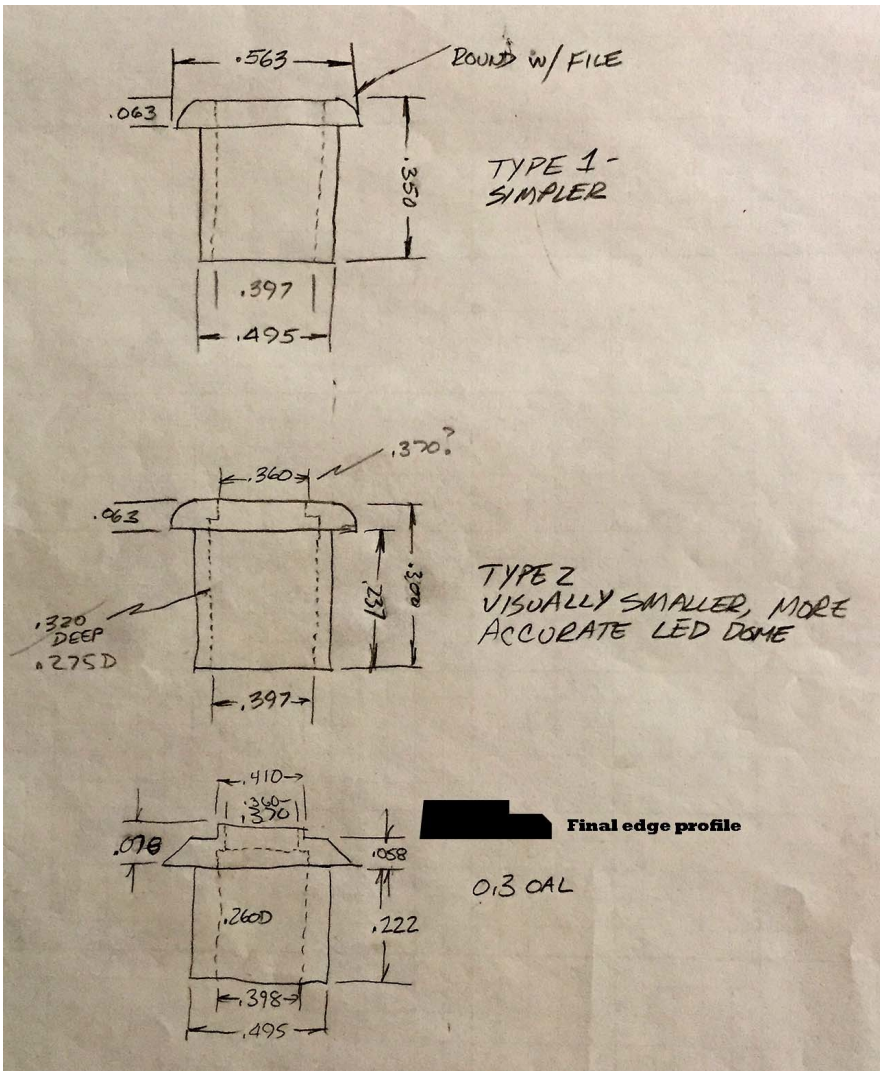
When the software is finished I estimate that it will take about 5 milliseconds to poll the 5 CMRI SMINI boards under the layout at 28,800 baud. Testing has shown that faster baud rates produce SMINI read errors, even with a 5 inch long RS485 bus. Signal integrity on the bus is fine; it is the SMINI itself that fails at higher baud rates.

Bob #37 June 3, 2016, 2:56pm

On the Arduini Yahoo group, Chuck Catania asked about the LED bezels. I found a couple old drawings dating to the time I machined ones for the A&O. The first one has measurements I made from a US&S prototype loaned by Doug Geiger.



Next is an “intermediate” sketch of some possibilities. I ended up using the last one, slightly modified to use what I’ve annotated as “Final edge profile.” I was not able to find my “final” sketch which detailed the dimensions of that last profile. This was a lot easier to do than the radius of the prototype.



Bob #38 June 19, 2016, 12:52am

Today was a milestone.

Vince plugged-in most of the signals to see if we could control them through the CTC system, confirming the integrity of wiring from CMRI SMINI nodes to the signal LEDs. I don't know why I didn't take any photos, but almost every signal woke up just fine.

We found a couple of bad connections on IDC connectors and intermittent shorts inside signal heads and a cracked power trace on a SMINI "wing board." There was also a bad CMOS chip on one of the SMINI boards, which was found instantly when Vince suggested swapping socketed output chips.

All-in-all, it was a very rewarding day to see the signal heads light up one by one. "I love it when a plan comes together…" This one was started in early 2008 when I ordered 60 degree switches for the

CTC machine, and a few months later Vince placed a huge CMRI order and started stuffing detector and SMINI circuit boards.

“What a long, strange trip it’s been!” - Jerry Garcia

Bob #39 August 28, 2016, 2:11pm

Here’s a short video of the machine. We first clear signal 42R on the main, but then change our minds and want to send the train into the passing siding. Vital field logic prevents throwing a switch when any signal in an interlocking displays an indication greater than stop, or a signal is running time, or the interlocking is occupied.

https://photos.smugmug.com/Trains/Model/Electronics/i-7gfv2hL/0/960/IMG_3433-960.mp4

1 Like

Bob #40 January 1, 2017, 2:06pm

It is alive! Two weeks ago David announced that he wanted to hold a New Year’s Eve operating session for the guys who helped build the layout. That caused me to go into a “coding coma” for a week. Call on and field OS unlocking still need to be added, but everything else worked fine.

Here we see second trick dispatcher Craig pondering his next move. Vince dispatched the first half. Because these two guys did so much to get the signaling system running, I pulled a few strings with the Grand Poobah to get them first session dispatching jobs.

For those curious, the whole signaling system still runs on the one square inch $20 Teensy 3.1 processor board. The C++ code compiles to all of 41 Kbytes out of 256 K available. That will grow by a small amount when all functions are complete. At 72 MHz the software is able to detect and respond to a code button press in about 20 milliseconds worst-case.

Bob #41 January 12, 2017, 4:05am

Call-on woke up today. This feature allows a locomotive to return to the rest of its train parked on the opposite side of an interlocking or OS section. Normally a signal can not be cleared if the intermediate block past the interlocking is occupied. In this situation, it is occupied by the rest of the train. Call-on removes the safety feature and shows a restricting signal aspect to the locomotive crew.

Coding a call-on requires the dispatcher to press and hold a pushbutton in the row above while pressing the code button directly below.

ErikLindgren #42 January 12, 2017, 4:40am

Wow Bob you are just amazing. Incredible

ErikLindgren #43 January 12, 2017, 4:52am

Hal 9000 trapped in the dispatch panel! That is just brilliant Dave, brilliant.

Pony #44 May 2, 2017, 3:01am

Hi, I'm really impressed with the quality of the work on your CTC machine!

I am starting my own small CTC panel, and wanted to know if you custom make and sell those metal bezels for the schematic block indicator lamps?

Not sure if this is the right place for this message, so I might post it near the bezel entries, too. Hope you'll forgive my redundancy.

Thanks!
Pony Horton
pponyrhorton@gmail.com

Pony #45 May 2, 2017, 3:03am

Hi, I'm really impressed with the quality of the work on your CTC machine!

I am starting my own small CTC panel, and wanted to know if you custom make and sell those metal bezels for the schematic block indicator lamps?

I posted this same message near the bottom of the blog, just in case this was not the right place… Hope you'll forgive my redundancy.

Thanks!

Pony Horton
pponyrhorton@gmail.com

Bob #46 May 2, 2017, 3:26am

Pony -

I'm sorry, but I don't commercially make the bezels. Chuck Catania asked for dimensions to investigate what might be needed to have them made commercially. My sketches are a few posts up. I'll send him an email to see where that's at.

At one time there were some reasonable black nylon LED mounting clips for 8mm diameter LEDs that looked pretty good when painted silver. If I recall they were made by Kingbright and I bought some from Mouser. Unfortunately they don't come up in my catalog searches.

You might search eBay for 8mm LED clips. At the moment a search for "8mm LED clip" came up with a few viable hits.

Sorry.

Pony #47 May 2, 2017, 4:29am

Bob,

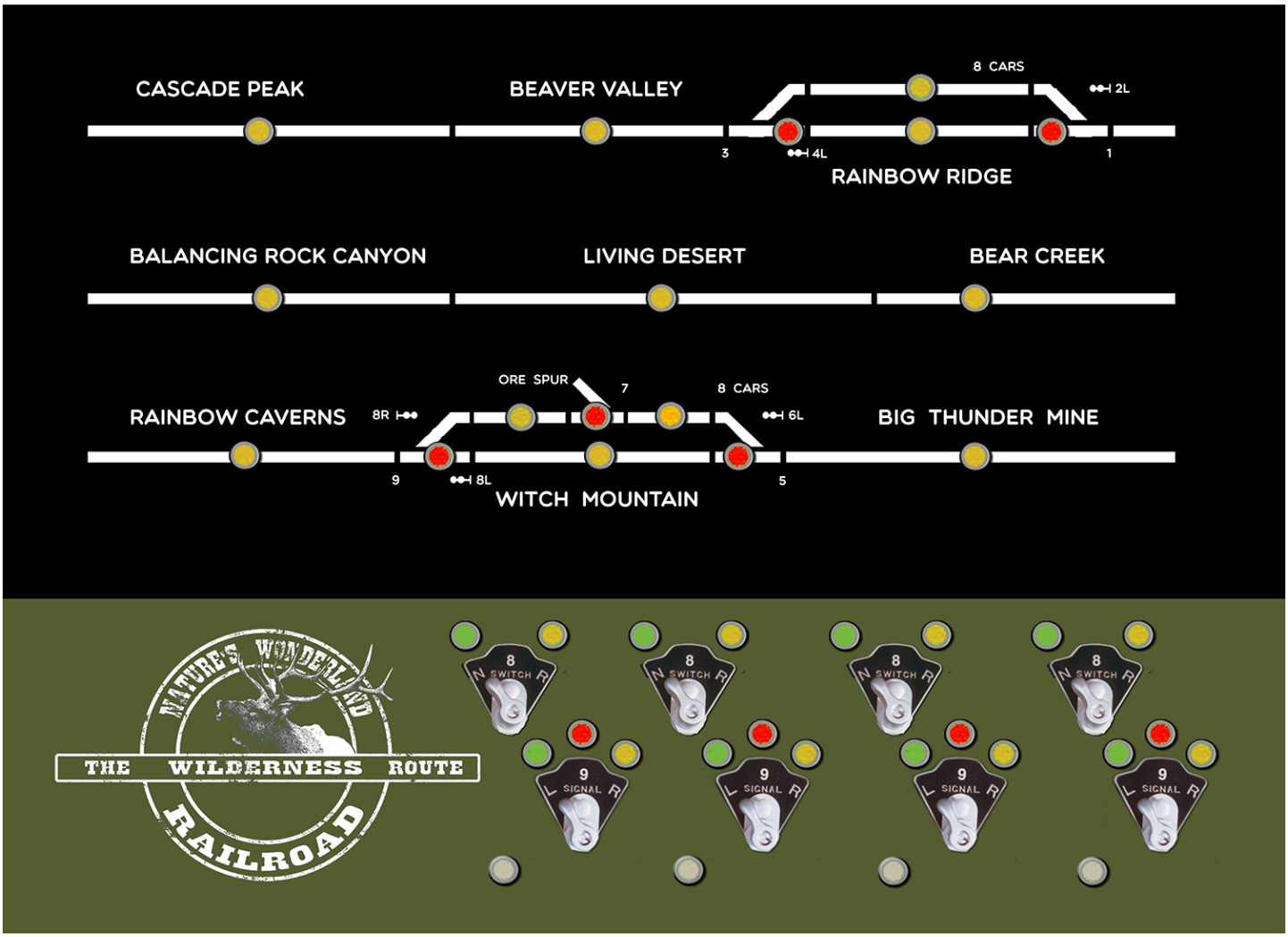
Thanks so much for the reply and info. Maybe Mr. Catania will know something.

In the meantime, I ordered some of those 8mm plastic ones. Cheap enough to experiment with.

Here's a picture of the basic plan for my little CTC panel.

Thanks again!

Pony



Bob #48 May 2, 2017, 2:35pm

Pony -
I checked with Chuck. Sorry, but at MRCS the bezel manufacturing is currently a “feasibility study”.

If you can get just a bit more height on your panel, locating the signal levers directly under the switch levers would look more prototypical. Also, numbers on a US&S panel normally increase from left to right.

All the best.

Pony #49 May 2, 2017, 3:49pm

Hi, Bob!

Thanks for the advice! In this case, it's based on Disneyland's old Mine Train Thru Nature's Wonderland, and like that attraction, this railroad only moves in ONE direction, so traffic conflicts are no issue.

As in the prototype, the trains start heading west (LEFT) from Rainbow Ridge. and all operation there was from right-to-left based on the guests' viewpoint. So that's why the panel layout seems backwards. It's actually easier to picture where the trains are this way.

As to the knob layout, that was more for practicality as my space is limited, but I'll play with it to see what I can do to make them in-line.

The whole panel will also depart from true prototype panels, in that it will be laid down like the control panels on the bridge of a ship, or like a museum's display fascia, close to horizontal but tilted up toward the rear like most control panels.

So the idea is to re-create the Ride Operator's panel at the Loading Area where guests board the ride, only theme the panel for steampunk, as that fits the 1890's-era "Big Thunder" theme.

I am attaching an image of the idea for the full-sized control panel. I've NEVER seen a panel quite like this one!

I'd love to chat via phone sometime, should you wish! 661-823-4778

Thanks again!

Pony

Bob #50 July 24, 2017, 6:01pm

Just a minor update here. Code to run the intermediate signals along yet-to-be-completed track

between Linnwood and Ricksburg appears to be functional, even if much of the rails are not yet connected and many signal heads have been removed for safe keeping during scenery work.

Not at all started is code to interact with a yet-to-be-built Arduino board to control signals at the New River & Western / A&O diamond in Willow Creek. Hardware to run that and the traffic lever has yet to be built.

Currently the software runs about 4,700 lines of C++ and requires about 1/4 of the Teensy 3.1 processor's resources.

Redsky #51 September 15, 2017, 11:25pm

Greetings Bob, I'm in the process of building my own CTC machine and about to get started on the main panel. Would it be possible to get a copy (psd or dxf) of your panel. It would save me a lot of time in redrawing it photoshop. Many thanks! I see the CTC Parts website has gone dark this week any idea what's up? I would hate to have to reproduce the switch and signal name plates.

Regards
Jay Roman

Bob #52 September 16, 2017, 12:24am

Jay -

Send me your email address via private message on the forum and I'll send you the .dxf. You will probably want to change some of the hole sizes to match the switches and LED bezels you procure. Also note that there is a 3/4" flange around the perimeter of the panel with screw holes for mounting in a wood cabinet.

The model boards containing the occupancy indicators and track plan were prepared using Intaglio on a Mac. I exported artwork for 4 panels to PDF and sent them to a company in PA that used the MetalPhoto process for fabrication in aluminum.

I too noticed that the **CTCParts.com** web site is down. The domain name registration did not expire but the site can not be pinged. Mike runs a signaling department for CN in Michigan and his vocational job keeps him very busy. You might ask folks on the railway signaling forum or CMRI forum on Yahoo.

Right now I'm unaware of any source for prototypical 2 position 60 degree rotary switches. I estimated and bought mine from Mouser back in 2008. Some folks used to buy 3 position 30 degree switches from Radio Shack and mechanically remove the middle detent.

Good luck!

Bob #53 September 16, 2017, 12:32am

Jay -

One more thing. The steel panels were cut by a CNC waterjet cutter and the fab shop wanted a .dxf file if at all possible. You mentioned Photoshop. If you don't already have something like Autocad (I don't) there are free versions of QCAD for both Mac and Windows. I used QCAD for the steel panel artwork.

Bob

Bob #54 September 6, 2018, 6:06pm

The CTC project that "keeps on giving" has me thinking again. At times that's dangerous.

Long ago while testing the CTC machine controller board on the work bench, with only a 6" RS485 bus to a CMRI SMINI board, I was seeing a *lot* of read errors. The error rate was 0 (or nearly so) at 28,800 baud but went up exponentially at faster baud rates. An oscilloscope showed the bus signals to be perfectly clean. Errors happened with all 5 of the SMINI boards. It seemed odd that everyone I asked ran their CMRI RS485 buses at a slow 9600.

On the layout I was seeing more read errors even at 28,800, prompting the addition of a "unanimous vote" noise filter in the CTC machine. A specified number of SMINI reads in a row had to agree before the CTC machine would accept that an input pin changed state. That helped.

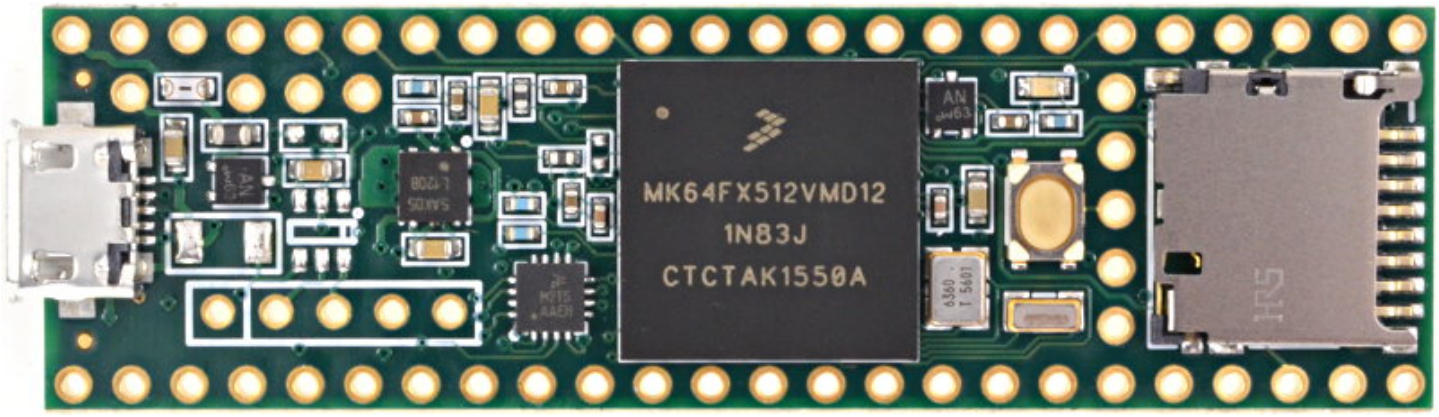
But twice I observed *write* errors, during which an OS signal and a maintainer call LED momentarily flashed when they shouldn't. One of those times Vince and I were talking when the problem occurred. Vince asked me "Did you see that?" I did. It is not clear whether the cause was noise on the 485 bus or something else.

After a while my brain could no longer accept communication errors. This called for action. The decades-old CMRI protocol has no error detection. No parity, checksum, or CRC. A modern protocol

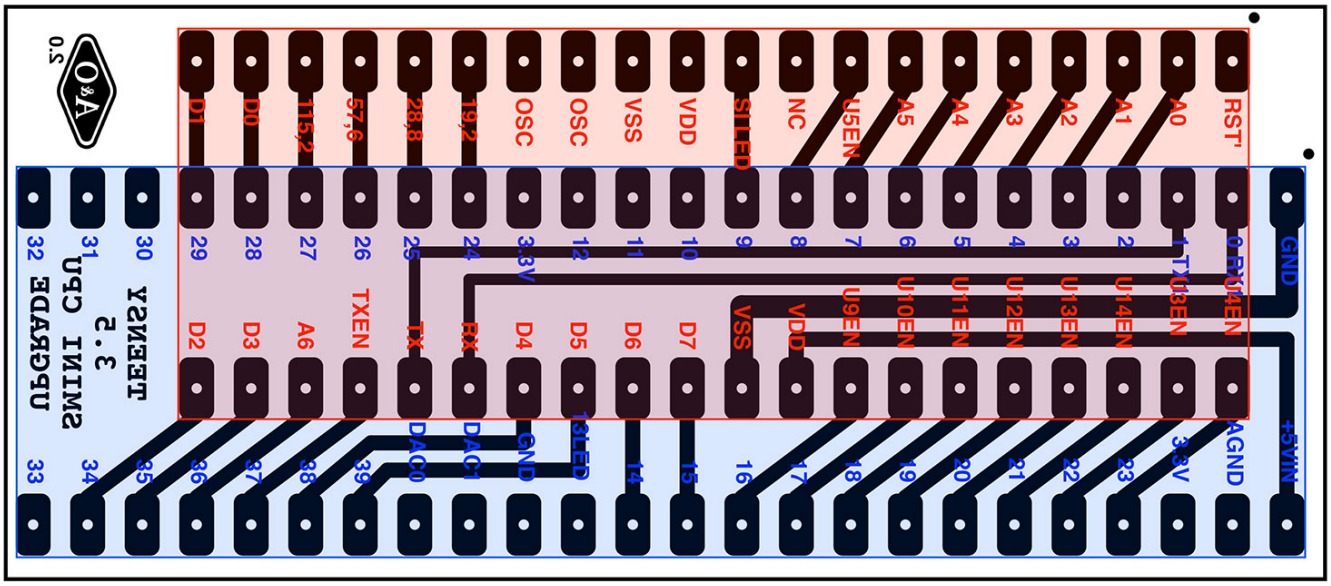
needs a CRC so that 485 bus packets can be inspected, errors detected rejected and logged. However the SMINI PIC processor's firmware is not open source.

Having no desire to reinvent the PIC's presumed assembly language, I intend to make a small daughter board that plugs into the SMINI processor socket. On that board will be a Teensy 3.5 processor from Paul at PJRC. Available through Sparkfun and Adafruit, these small and inexpensive processor boards have lots of 5 Volt tolerant I/O pins and a fast 32-bit ARM M4 processor. They are a "big brother" to the Teensy 3.1 that runs the CTC machine. In this application an even less-expensive 8-bit Arduino Pro Mini would suffice, but would require external I2C I/O expander chips that would add bulk and complexity to the PC board layout.

This is the 3.5 board, in a photo from the **PJRC.com** web site:



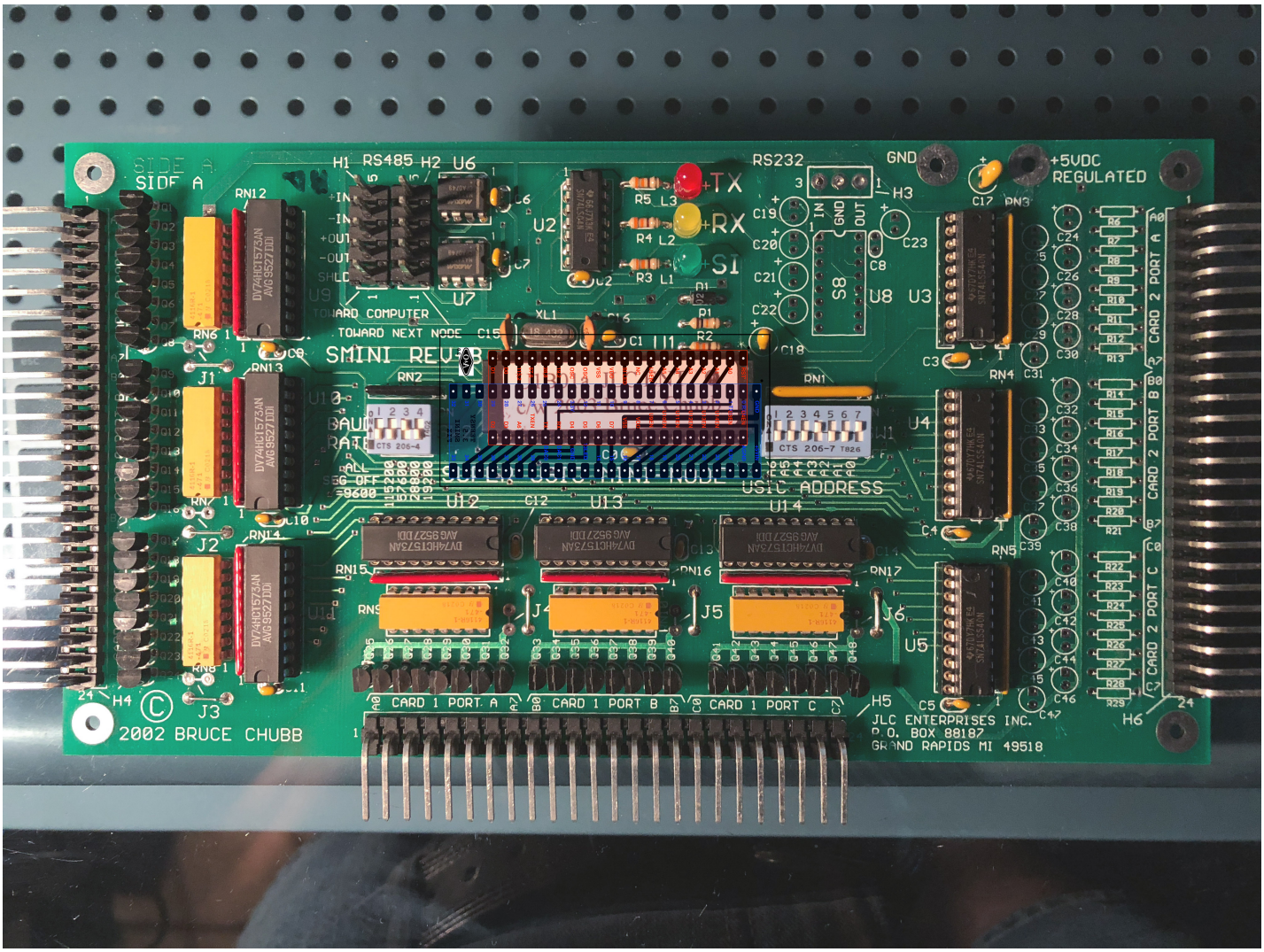
Here's preliminary artwork for the daughter board:



The red box shows the outline and pin designations of the SMINI's PIC processor. Headers with

round screw machine terminals will attach to these pads and plug into the PIC's 40-pin socket. The blue box shows the outline and pins of the Teensy 3.5 that will plug into the daughter board. Note that the processor is rotated 180 degrees from the photo above, so the micro USB plug will on the right end.

A sort-of X-ray rendering of the daughter board as it will plug into into an SMINI:



The Teensy's processor runs at 3.3 Volts with an on-board regulator, but the digital pins are all 5 Volt tolerant. The 5 Volt logic on the SMINI only requires a high level input voltage or Vih of 2 V, so it will work when being driven by the Teensy's processor.

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jaybarnaby #55 September 7, 2018, 3:53pm

I'll take your word for it… 😄

Bob #56 September 9, 2018, 12:18am

Through another communication medium I received an excellent question from Conrail Bill. He wondered why I'm not replacing the SMINIs with Arduino-based cpNodes from MRCS. Skipping most of my reply, the bottom-line is simple:

I'm not excited about crawling back under the layout to rip out then replace wiring we already have! That would not be fun, and it would disable the layout for a fairly long period of time.

Vince generously provided us with a spare SMINI board that I can use for development. It can sit on the CTC machine desktop and connect through a short cable to the machine's control board. With two MacBook computers (old and new) I will be able to simultaneously code and debug both ends of the system. (Mental picture of one hand on each keyboard and eyes crossed… 😛) That should eliminate most if not all of the need to be "in two places at once"—under the layout at an SMIN and at the CTC machine.

Don't get me wrong. The cpNode is an excellent product. But at this point in time it would be a *lot* more hard work!

RickL #57 September 15, 2018, 2:46pm

Hey Bob - long time no talk. Since I was out there in 2015, I've moved to a bigger basement and thick roof so I'm starting to think about putting together a physical panel again.

Working with the LCC working group some - I'd like to start putting some CTC useful pieces together inside the LCC/OpenLCB ecosystem so a couple of questions:

Do you know/have the dimensions of the PCBs you made to hold the switches and LEDs used for the columns? I've not been able to find any prototype drawings to figure out the physical size I should aim for, which is probably the most critical concern as everything else flows from there.

And as an FYI to whoever else may be interested - the 2 position switches show as stocked now (Sept 2018) on Mouser. The 3 positions don't, but I have not searched for alternatives, so far, so that's next on the list.

Rick

Bob #58 September 15, 2018, 3:35pm

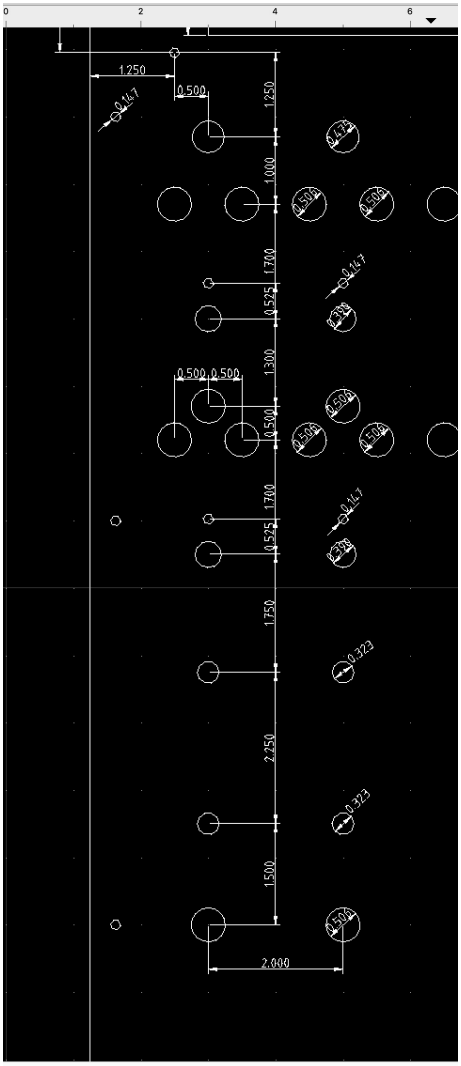
Rick -

Dimensions of the PC boards are dictated by prototype dimensions and what options you want to have on your machine. Column spacing is always 2 inches, so PC boards must be narrower than that. The layout of signal and switch levers is also standard, with the exception that some railroads opted for 3 lamps on the switch levers instead of the more typical two.

Also, since I was etching boards at home, dimensions were also influenced by standard pre-sensitized panel sizes.

Perhaps more helpful to you might be the steel panel artwork. If you want, I can send you a .DXF file for the A&O main panel. QCAD is free, runs on Mac and Windows, and is the software I used to prepare artwork for water jet cutting. Note that the top row of 0.475D holes are for a particular toggle switch used for maintainer call. Any or all of the hole diameters may need to be adjusted to best fit the parts you are able to source.

Here’s a screen snapshot of the panel column dimensions we used.



Good luck finding a mate to the 2-position 60 degree switch. A successful column board requires that both switches to have the same height from the panel mounting surface to the PC board.

Although boards are securely mounted when they have both signal and switch levers, columns with only a single switch would benefit from optional 6-32 standoffs attached to the PC board and the panel using the small holes that currently hold the aluminum number plates.

From what I've heard, Mike Burgett no longer stocks cast metal switch knobs because the manufacturer the Japanese supplier shut down.

Before you choose a solution, I strongly encourage reading both Bruce Chubb's signaling tome and his signaling articles in MRC. Prototype signaling requires complicated programming and it isn't just plug-and-play.

I briefly browsed the OpenLCC web site for documents. All I found were ones that related to CAN bus messaging protocol and firmware updates. Unless I missed something, how to actually implement interlocking code is left entirely as an exercise to the reader. Did I miss something?

RickL #59 September 15, 2018, 11:51pm

I will message you with my email address for the CAD drawing - that would really help, thanks!

I had a CTC setup on the last railroad - all programmed inside JMRI - so I understand the complexity involved. I think that I'm going to end up with 2 or possibly 3 small panels, maybe 10 columns total, that my yardmaster, staging master and tower man will be using, while the DS will still use a computer driven panel via JMRI. Mostly that is because I don't have the physical space I need for a complete machine for the railroad until the kids move out and my office goes upstairs. I have a not quite 8 year old, so that is well in the future. 😉

OpenLCB/LCC is a framework to accomplish something so you are right that it is on you to make the logic needed work, but that doesn't scare me since I've done it once already and planned to do it on this railroad anyway. Having some physical columns is just a bonus and stretch goal. I'll probably order the 2 position switches now to have them, and then just wait for Mouser to either stock the 3 positions OR try to figure out how I could get rid of the surplus if I bought a 1000.

Bob #60 September 16, 2018, 12:10am

Rick - The DXF files have been sent.

Bob #61 September 22, 2018, 6:09pm

Rick -

I see that Mouser stocks a C&K 3 position switch that might be useful. I haven't checked the distance from the panel to the bottom of the switch to see if it is the same as the 2 position Taiwan Alpha, but it is probably close.

arotary-1369275.pdf

593.39 KB

Cpelliott #62 October 10, 2018, 6:57am

Bob, Thanks for putting this info on the forum, the panel looks fantastic. I hope to build one soon. With regards to the 3 position switch, have a look at mouser part number 105-SR2611F-25-18NS. There is a tabbed washer that controls how many switch positions you can have. I will be setting mine to 3 position. The angle of the throw is correct.

Bob #63 October 10, 2018, 12:37pm

Chris -

That switch *would* be perfect for the 3-position. Unfortunately, Mouser shows it to be non-stocked with a minimum order quantity of 1000. 😞

Ten years ago something prompted me to stock up on both the 30deg-3 and 60deg-2, long before the A&O track plan was finalized. Fortunately my guess was pretty good, as there are now only a couple spares left over.

Bob #64 February 6, 2019, 11:00pm

Chris -

I don't know if it is too late, but Mouser now shows stock of both Taiwan Alpha rotary switches suitable for US&S CTC machines. I haven't ordered any, but from a catalog search it appears that they have both:

60 degree 2 position: SR2616F-0202-18F5B-D8-N

30 degree 3 position: SR2612F-0304-21R0B-D8-N

The latter is actually 4 position, but it comes with a washer with a pin on it that serves as a rotation limiter, so it should convert to 3 positions without any difficulty.

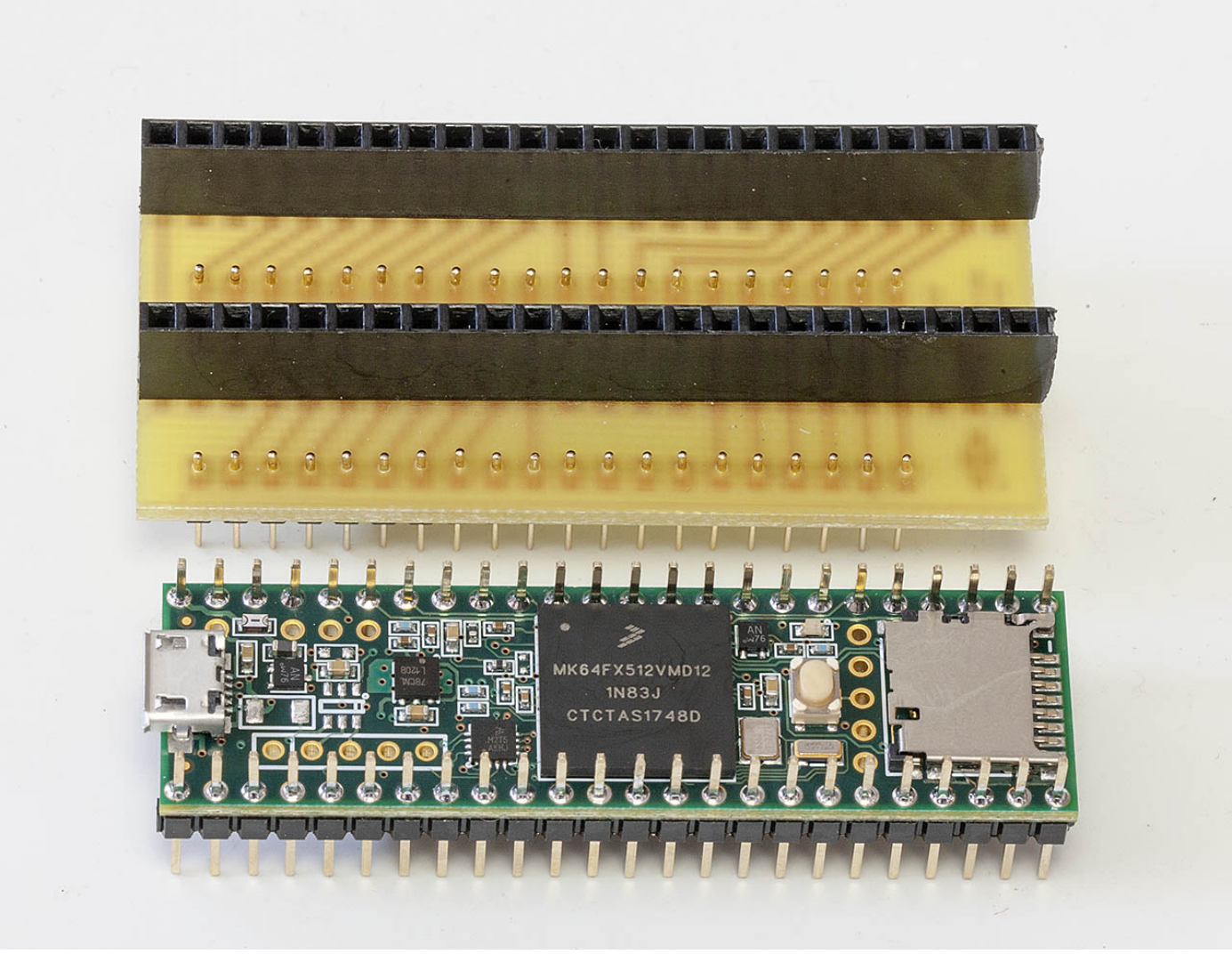
At the moment less than 25 quantity price is $4.24 each.

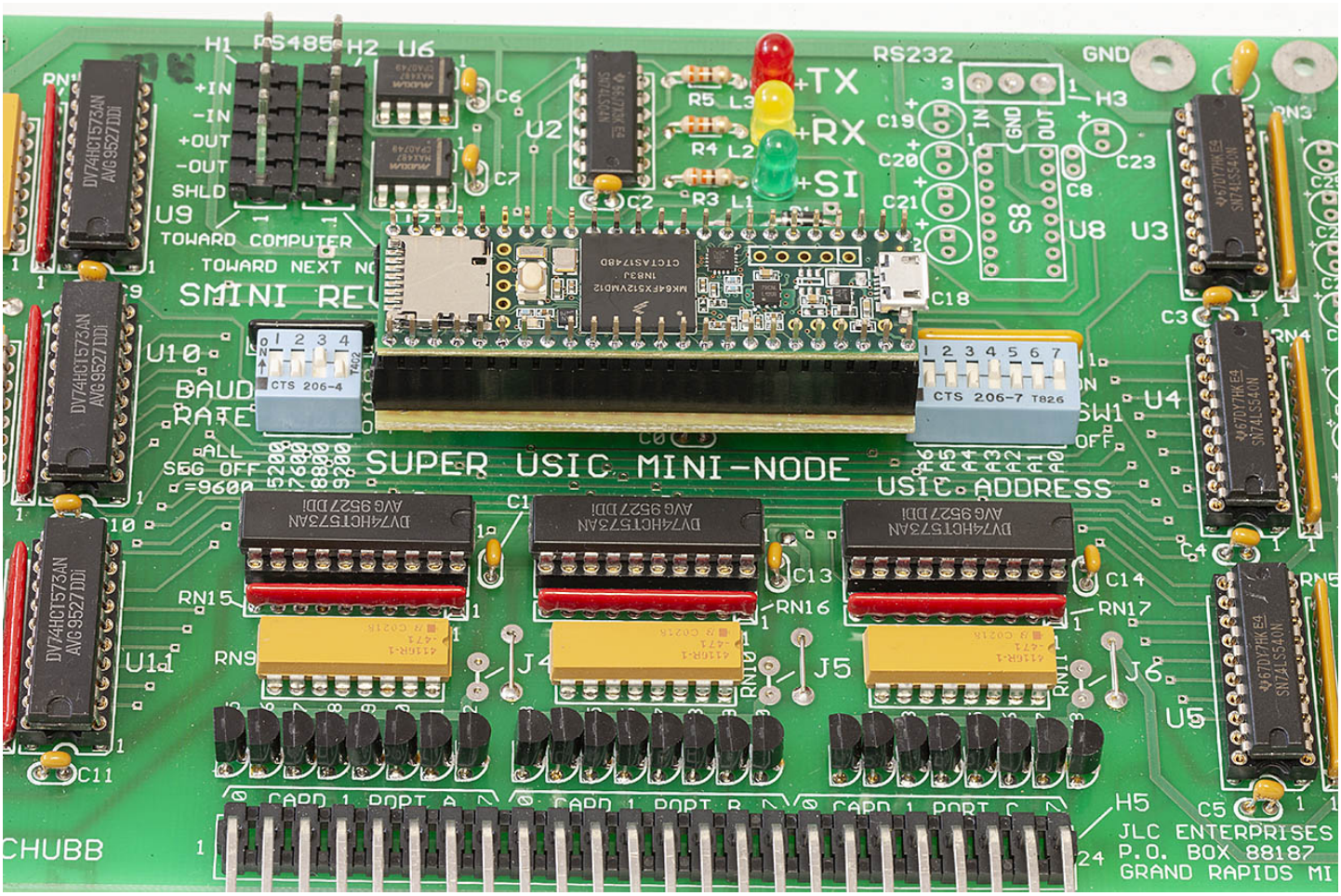
Cpelliott #65 February 22, 2019, 3:23pm

Bob, thanks of keeping an eye out for switches. Fortunately, like you, I stocked up on switches a few years ago in anticipation/ preparation of building a CTC machine. I'm not sure how many I bought but it was a lot.

Bob #66 March 4, 2019, 9:13pm

Yesterday I finally set up the PC etch tank, which afterwords went in the trash due to extreme cracking. Anyway a prototype replacement for the SMINI PIC processor has been assembled. The firmware is about half complete.





As a refresher, the goal is to enrich the SMINI communications protocol to add a CRC for error detection, inquire error statistics, and read-back output data that was written. Since the processor has EEPROM, it can be made to remember the last-known output state and return switches to their former position (i.e., pre-lunch time.) The normal SMINI powers up with random output states. That might be bad if a lunch call was issued and a train was left straddling an OS switch. (How do I know? That happened when I was a pre-opening volunteer at the Greeley Model Train Museum.)

There is also a micro SD slot for data logging. I'm thinking of swapping out the current Teensy 3.1 processor that runs the CTC machine for one of these, so that log files of train movements and dispatcher movements can be logged. That would assist in debugging and adding new features.

Edit: For electrical geeks, all the parts that Bruce selected for this board have a minimum high level input voltage (Vih) of 2V. The Teensy will output at least 3V given its 3.3V on-board power supply. All the Teensy digital inputs are 5V tolerant. So it should play well with 5V children. External level-shifting circuitry is not needed.

jaybarnaby #67 March 11, 2019, 9:07pm

Watching all this thread, and some others, make me think I should go to narrow gauge where none of this is needed… If you only have one trains you don;t need signals. Or orders.

DavidOlesen #68 July 6, 2019, 4:26pm

Hi all. I bought some 4-position rotary switches per your discussion. Have you documented HO to modify it for three positions? Thanks in advance for any help you could offer - I'm designing my CTC system and need a little help with this detail.

Best regards,

David Olesen

David.olesen at me dot com

Bob #69 July 6, 2019, 6:00pm

David -

That's *really* easy!

Underneath the panel mounting nut should be a washer with a pin that sticks into the switch. By moving it over by one hole (I don't remember which direction) it converts a 4 position switch to a 3 position switch. The hardest part is keeping the washer in place when mounting the switch on the panel.

All the best.

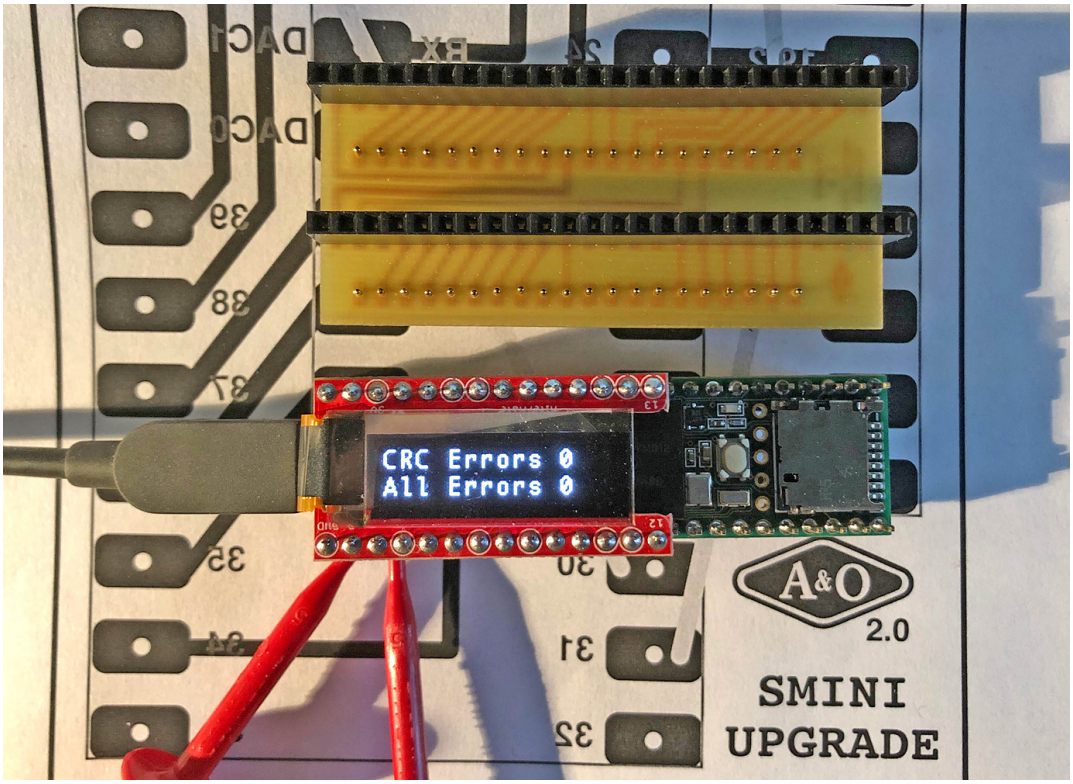
DavidOlesen #70 July 13, 2019, 10:59pm

Thank you! That WAS easy.

Bob #71 August 23, 2019, 2:54pm

I'm back to working on the SMINI processor upgrade, inspired by an acquisition of a Sparkfun OLED display designed to piggyback on a TEENSY processor board.

The SMINI firmware now supports legacy C/MRI commands with additional commands for bidirectional CRC error detection. I didn't implement the 2-lead semaphore signals with yellow adjust since the A&O uses 3 lead signals.



The red clip lead connects the serial port transmit pin to the receive pin for loopback testing.

Bob

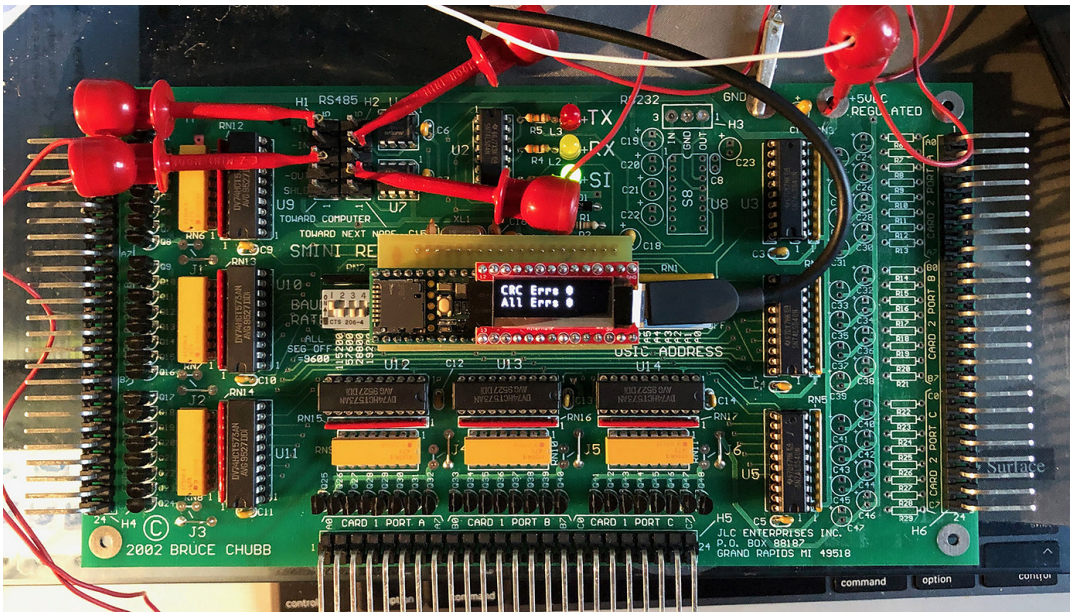
Bob #72 September 2, 2019, 8:57pm

Loopback testing passed on a spare SMINI card. In the photo it runs great at the maximum baud rate of 115,200. This same card (and several others) produced numerous read errors above 28,800 baud. The error rate was consistent among the multiple SMINIs tested.

When tested on the workbench with the original C/MRI PIC processor at 115, it produced read errors so fast I couldn't count them by eye. The WRITE error rate was not measured since reads failed so

frequently.

In the photo below the brain transplant sends itself new CRC-enabled commands to read the 24 input pins and write data to the 48 output pins. The new firmware also supports legacy C/MRI commands, although their use is not anticipated except during initial turn-on when there will be a mix of Teensy 3.5 brain transplants and original PIC processors.



Hopefully this week I can test one in the Linnwood SMINI. If all goes well, others are ready to deploy throughout the layout. Due to DCC noise coupling into the RS485 bus I don't expect the displayed error rate to stay at 0. But I do expect that any corrupted commands will be safely ignored and reported on the OLED display.

CRC errors indicate that one or more payload data bytes were corrupted. All errors includes the entire message packet including bytes used to build the message packet surrounding the payload.

Bob

Bob #73 September 6, 2019, 12:22am

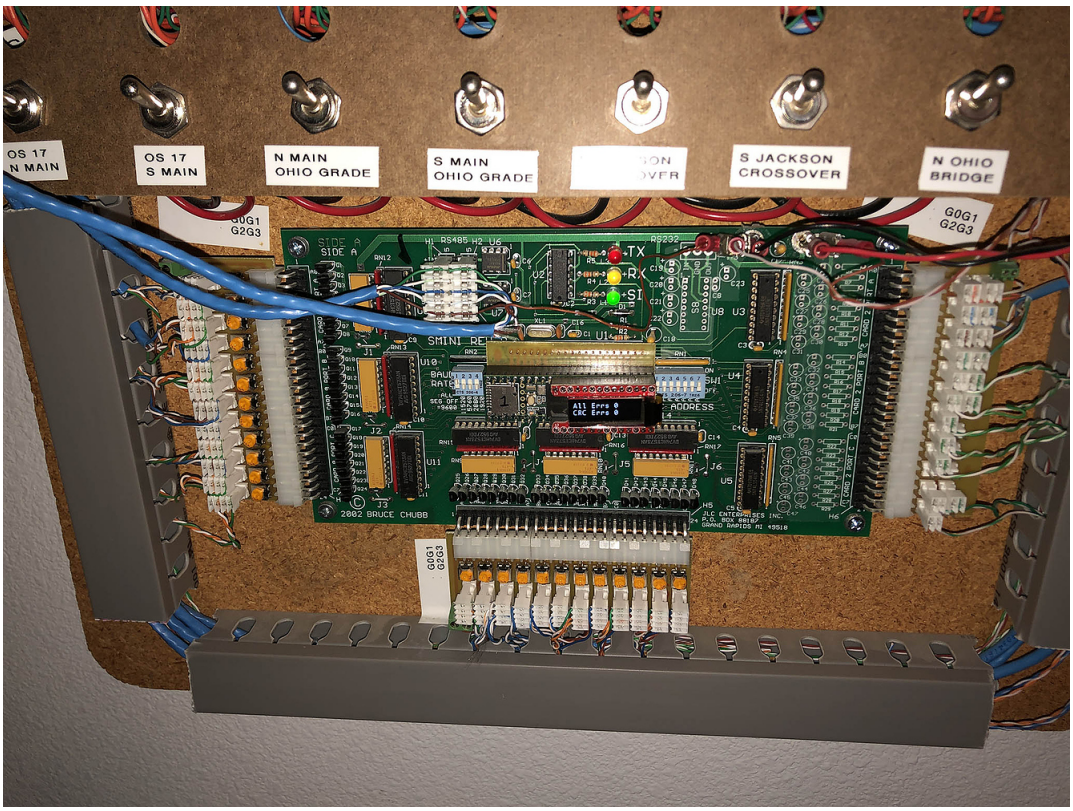
To borrow from a cheesy TV show of a former time,

"I love it when a plan comes together!"

This afternoon I installed all 5 of the Teensy 3.5-based "SMINI brain transplants" under the layout. Two minor firmware bugs were encountered, one in the CTC machine and one in the SMINI, both of which were easily fixed.

A major question in my mind was: will the revised SMINI finally run reliably at 115,200 baud, the highest “supported” rate? When I tested several SMINIs on the work bench, with only a 6 inch 485 cable, operation faster than 28,800 was never reliable. Over time several of us have witnessed momentary write errors in which a signal head or maintainer call light flashes incorrectly. A friend reports that the large C/MRI system at the Colorado Model Railroad Museum has *never* successfully operated faster than 9600 baud.

I initially installed the first brain in Linnwood, running at 28,800 baud. It interchanged just fine with the other 4 C/MRI cards with the original PIC processor. Based on that success, I replaced the remaining 4 processors and cranked the speed “to 11.” So here is one of the 5 SMINI cards running at 11 (see the blue switch to the left of the Teensy board.)



During today’s testing I observed no errors on any of the OLED displays, except for a single error triggered when I halted the CTC machine and loaded new firmware. A watchdog timer in the SMINI new brain detected a break in data transmission.

For the A&O this isn’t so much about running as *fast* as possible, but rather as *reliable* as possible. Any corruption of data bytes going to or from an SMINI should now be detected with a fairly high confidence so that any bad data can be ignored.

So what do I think was the original problem? I strongly suspect one or more bugs in the PIC processor firmware that were triggered more aggressively as at faster baud rates. In no way do I intend to be critical of Dr. Chubb or his excellent design. Every piece of non-trivial code I’ve ever

written had bugs, and that is universally true across the industry. That said, the PIC code is copyrighted and not open source, so it can't be maintained over time by anyone other that the Dr. himself. I had to replace the processor to work around the bug(s) and add error detection.

The error rate may climb above zero during an operating session, as locomotives create voltage spikes in the DCC signal that can interfere with the 485 bus. Time will tell.

And also of note, I did *not* include support for SMINI red/green "oscillation" to produce a yellow signal indication. The INIT command is parsed but ignored.

Bob