Theory of Operation - Signal system and Triple Turnout control

The club used SIC-24 controllers from Team Digital for 14 years until they were obsoleted and no longer available. Programming changes were always hard to upload. I decided to move to Arduino Mega controllers for the replacement. They are used in college for teaching tech classes and robotics, cheap, small, easy to program, reliable and easy to get. Easy interface with TTL logic. We use a lot at the club.

Each Arduino Mega ($16) and Proto-Terminal shield board cost about ($12) costs a total of $28. We are using 4 in the signal system and triple turnout control. Each Mega has 53 (51 usable) pins that can be configured as inputs or outputs. I save pins 0,1 to allow programming uploads without pulling off the shield board. Pins 0,1 are the USB serial bus pins. The board has a USB port to allow uploading program changes. The Arduino development environment runs on a windows PC (sure Apple too). The programming language is C lite. So far, I've used 10 instructions in the development I've done across 9 Arduino boards. The Compiler/Editor is very visual and easy to learn. I would recommend the following Book: Arduino Programming in 24 Hours, Sams Teach Yourself 1st Edition. One 12VDC 5 Amp supply can handle several Mega's. We use a 5 Amp 5VDC power supply to run the signal DBD22's.

Our signal system is still pre-CTC in the 1950's timeframe. This means we only show a Red signal for the block you are in. The rest of the time it's Green. We continue to use Team Digital DBD22 block detectors for occupancy. Each DBD22 has two sections and has a ferrite core for the track bus wire to pass through. This means if current is being drawn on the track it will show occupied (active low). Most of the cabooses have a LED light and most passenger cars have LED lights. This keeps the block occupied from the beginning to the end of the train.

At the time of writing this document we have 77 signal targets on the layout. About 70 use Arduino Mega controls. We have about 60 DBD22's in use for signal and staging. Signals are from Oregon Trails. We have two custom laser printed signal bridges made by a good friend to the layout (third to be install in 2021). The three triple turnouts require about 2/3 of a Mega. We do have some ground dwarfs on the layout. Some show turnout position while others show occupancy. We use the dwarfs because the tall mast could get easily broken. Signal breakage is a problem. If it's a single target it's always block occupancy. If it's a double or triple target then the top target is the turnout position (G/Y), Green is Closed and Yellow is Thrown. The second and third targets are occupancy (R/G). We have three double target signals around the two Helix's (leaving Victorville, entering the lower helix and entering the upper helix at La Junta. The top target is G/R and the bottom is Yellow. If it's Green and no yellow then no train is in the block. If it's Green and Yellow then a train is in the block but going away from you. If it's Red and Yellow then a train is in the block and is coming your direction. This set of relationships is created by tying the two Helix detector boxes into the signal system via optical isolators with some additional programing in the Mega. The two Helix occupancy light controllers maintain status (Open, East or West bound).

The programming of the Arduino Mega is very repetitive for the most part. Only a few signals have some type of interlocking protection. The DBD22 connects to the Arduino Mega with a 1.5K pullup resistor and a 100uf cap to ground to reduce noise. These parts are on the proto-shield board.

When programming the Arduino, Uno or Mega, you first define how you are going to use the input or output pins in the Setup section using the pinMode command. I include set of digitalWrite commands to set the LED's one way (Green) then the other (Red). You can add a 5 second delay command to give

you time to see them change. The board is fast. Then you put the code that does the work is in the loop section. You define variables. Next you use if statements to do digitalRead statements and based on the result you do a digitalWrite to set the LED the color you want. Two output pins are used for each signal head. Each signal LED has a 470-ohm resistor in series with the LED. All power to the LED's come from the Mega's. Only drive one LED per set of outputs. That's 70 sets of code for the signals. You can cut and paste to save typing, just change the pin numbers. The code is very readable.

The Excel spreadsheet (Signal and triple resources for Arduino Mega design) is key to understanding how it goes together. It is also easy to read.

I have two very old 3rdPlanit drawing that show the location of the block detectors and signal heads on the layout. I hope to get the Block Detector numbers and Signal target names added to the drawing as a layer.

The Arduino has one major functionality limitation. It can only do one thing at a time and it is not multi-threaded. It's constantly running the loop code. So, if it's reading an input from pin 10 and then using a pair of digitalWrite commands to change the color of a LED target then all other input changes will be ignored/delayed. This is not an issue as the code runs very fast 16MHZ. Because of the high clock speed all signals change in real-time. In the blink of your eye it has run all the loop code several time.

The layout of each Mega has been carefully planned to ensure all pins can be used on each board. In most cases each signal takes 3 to 5 pins (one input and two or four outputs) depending on if it's a target with one or two locations. If it has a logic test then it takes more pins. So, all input and output pins for a target must be on the same board. Code moved from board to board as the design of the system changed. It is stable now. In a perfect world the four Mega's would be tied together with Ethernet, however, this is very complex and would waste a lot of pins. The spreadsheet has a pin usage summary at the end. At this point all pins are in use on the four Mega's. The boards are located in the Sullivan's Curve pit and currently allow for a total of 6 Meg's (4 in use today).

Below is the new custom 3D printed 3 target signal bridge.