Model K-1 Controller for Model Trolley Car Operation
By Fred Miller, MMR

The Prototype

Trolleys were equipped with separate controls for speed and brakes. Many early trolleys used a 'K-Type' controller, where the motorman stood or sat next to the controller at the front of the car. The K controller was about waist high and had a long handle on top that rotated though points. Inside the controller, each point connects motors and resistors in a certain way allowing the car to accelerate. The controller allowed the motorman to control the acceleration and change the speed of the trolley car by running the operating power through various series/parallel resistor arrangements connected to the motors.

Trolleys were also equipped with an air braking system adequate to control its movement and to stop and hold it stationary in a safe manner under all conditions of passenger weight loading. The trolley also had an air gauge that indicates main reservoir pressure. The air gauge was mounted within the operator's immediate field of vision and readable at all times during operation.

TYPICAL PROTOTYPE CONTROLS

The Model

Operating a model trolley using conventional model railroad controls (DC or DCC) which typically have a single dial for speed do not emulate the operation of a prototype trolley car. I have designed and built a model K-Type controller with separate controls for speed steps (notches) and air braking action with Set, Lap and Release settings. My controller also has a Direction Lever, Air Brake pressure gauge and controls, door operation and Gong controls. The model controller plays sounds reflecting the operation of the throttle, air pump, door, circuit breaker and gong controls.

The model's circuit breaker will activate (with a snap and warning light) if the throttle is

moved up the notches too fast; or the brakes are still set; or the brake air pressure is below operating level. The breaker will also activate if the brakes are operated when the throttle is not in an off position; or the doors are opened if the car is moving. In all cases the car needs to be brought to a stop before the Circuit Breaker can be reset and power turned back on.

Although the throttle has only 3 run notches, speed of the operated car is gradually increased or decreased to the associated notch speed, simulating the momentum of the prototype. The brake lever has 3 positions: (1) apply, (2) lap and (3) release. The rate of the cars speed reduction is effected by the amount of time the brake is in the apply position. In the lap position the reduction of speed is constant. Each application of the brake reduces the air pressure in the brake line which is shown on the gauge. The air pressure also "bleeds" gradually even though the brakes are not been applied. The air pump is started (with appropriate sounds) when the air pressure is reduced to the bottom of the working range.

The controls are mounted in a manner similar to a K-Type controller, although the brake, air gauge, door and gong controls are also mounted on the top of the controller rather than separately as in the prototype.

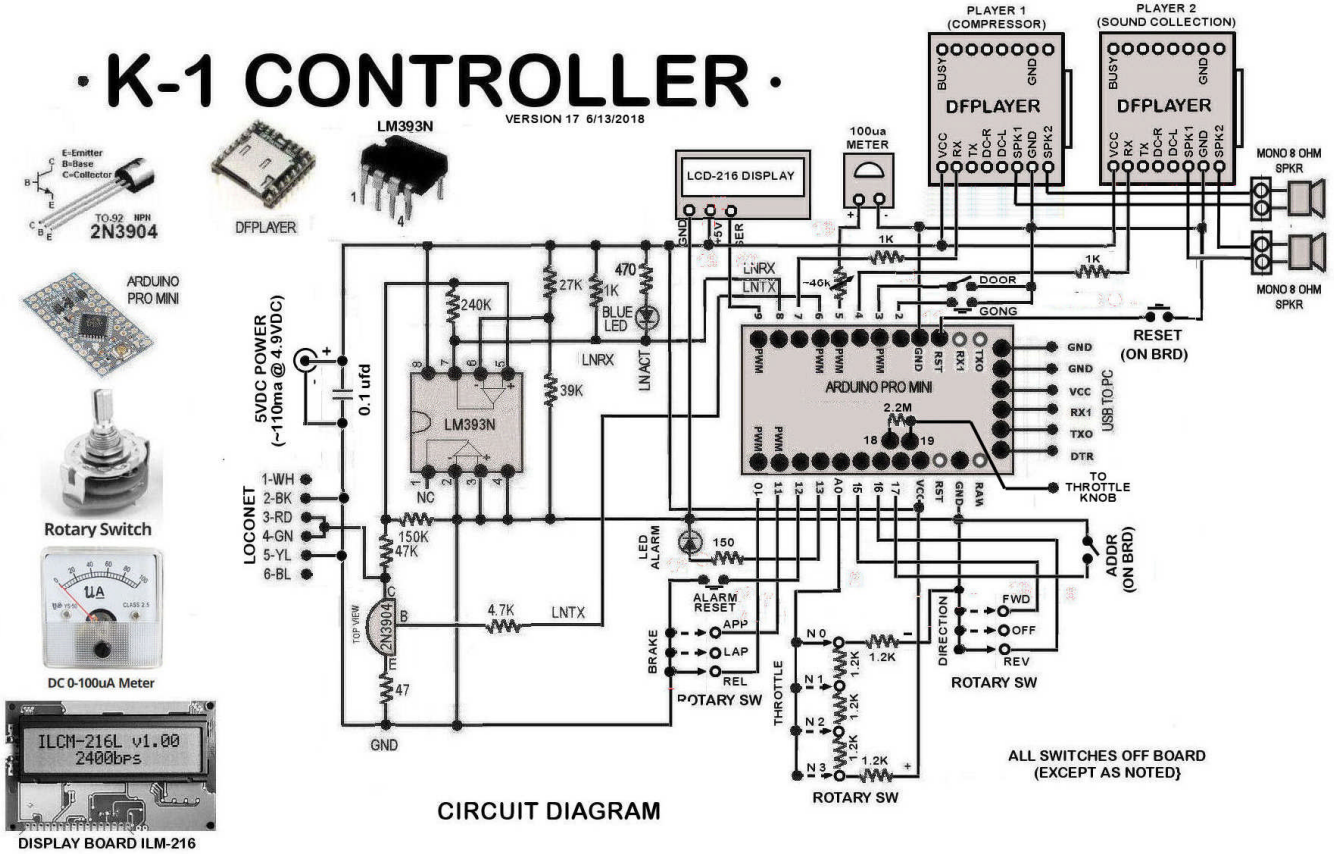
The controllers "dead-man" feature is implemented by a capacitive touch circuit which detects when the operator is holding onto the throttle knob. The Micro-controller software forces an immediate brake application if the operator's hand leaves the throttle knob when the throttle is in other than OFF position.

Design

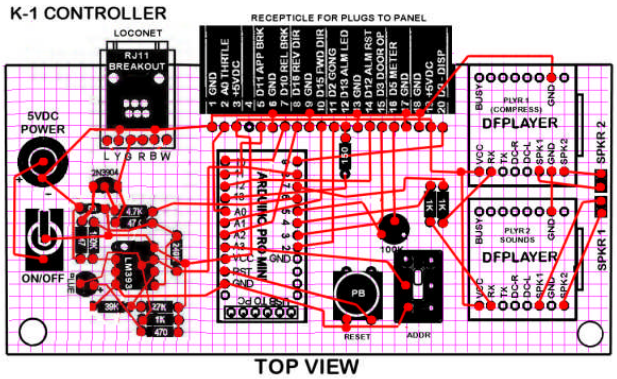
The model K-1 Controller was designed to operate on a Digitrax DCC powered layout. The controller makes use of an Arduino Pro Mini micro-controller in communication to the DCC system through Digitrax LocoNet. The micro-controller is programmed to respond to the various controls on the K-1 to develop speed and direction commands for the model trolley car. The program running in the micro-controller (called a sketch in the Arduino world) also monitors the other controls to issue appropriate sounds for the door, gong and air pump through two sound playing modules.

A switch on the back of the controller selects the LocoNet address for the car to be operated. A push button on the back also provides a micro-controller reset to restart the software.

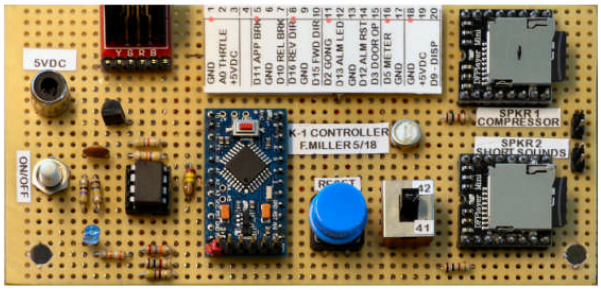
The controlling program was developed on an Arduino UNO and breadboard with the various control switches connected. The program was subsequently transferred to the Arduino Pro Mini and again tested on a breadboard arrangement. After successful operation on the breadboard the layout of components was developed in a graphics program and used as a wiring guide for the final control board.



K-1 CONTROLLER WIRING GUIDE & ACTUAL WIRED BOARD

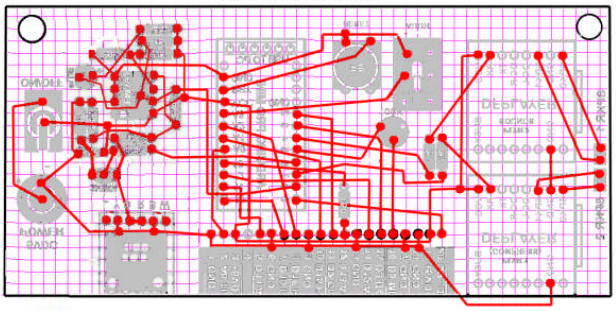


TOP VIEW

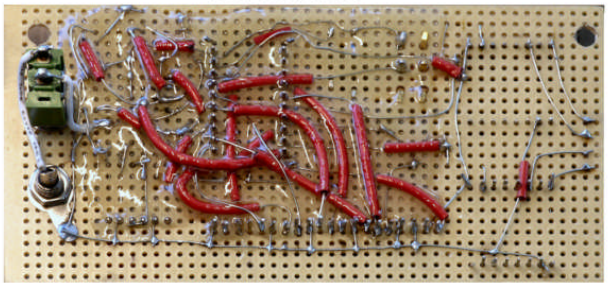


TOP VIEW

BOTTOM VIEW



BOTTOM VIEW



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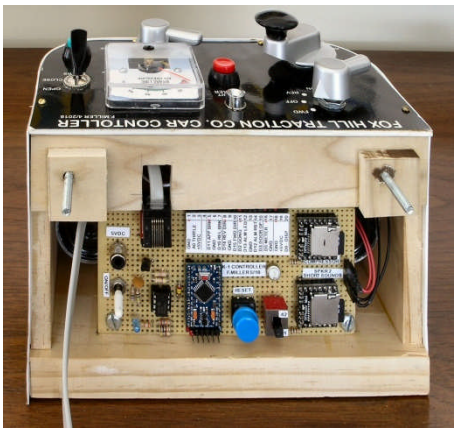
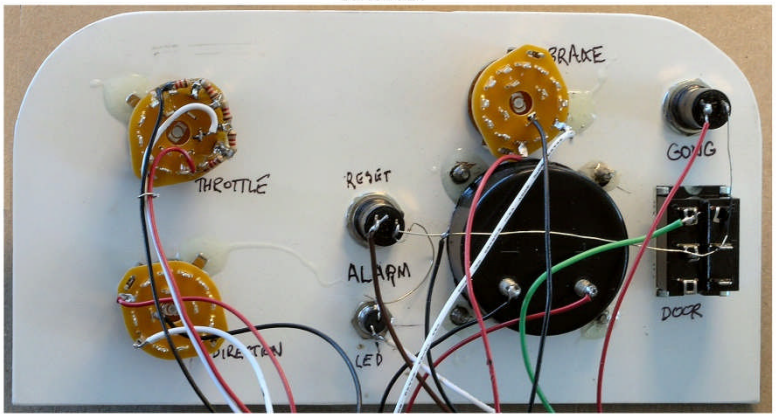


BOTTOM VIEW



The controller box is mounted on my layout's fascia strip, providing easy access and view of the controlled trolley cars.

Notes on the Circuit

The design makes use of rotary switches for the throttle and brake. In order to limit the number of input connections to the Mini Pro, a resistor ladder circuit is used on the throttle switch and an analog input is used to read the position.

K-1 CONTROLLER PARTS LIST

QTY	PART
	2N3904
	LM393N DUAL OP AMP
	0.1 ufd CAPACITOR
	2.2M RESISTOR
	240K RESISTOR
	27K RESISTOR
	39K RESISTOR
3	1K RESISTOR
5	1.2K RESISTOR
	470 RESISTOR
	150K RESISTOR
	47K RESISTOR
	47 RESISTOR
	4.7K RESISTOR
	150 OHM RESISTOR
	100K TRIMMER POT
	SPST TOGGLE SWITCH
	SPST PCB SLIDE SWITCH
	SPST PCB PUSH BUTTON
2	ROTARY SWITCHES 3-POS
	ROTARY SWITCH 4-POS
	RED LED (T1)
	BLUE LED (T1)
	8 PIN SOCKET
	ARDUINO PRO MINI
	DC 100ua ANALOG METER
	ILM-216 DISPLAY BOARD
2	DFPLAYER MODULES
2	8 OHM SPEAKERS
	MALE HEADERS
	FEMALE HEADERS
	RJ11 BREAKOUT BOARD
	RJ11 SOCKET
	LOCONET CABLE W/PLUG
	5VDC 1 AMP WALWART
	PERF BOARD (5"x2.5")

The air pressure gauge is a 100ua meter driven by a PWM output from the Mini Pro through a 100K pot adjustment trimmer. The face of the meter was modified with a custom graphic.

The sounds are stored on micro SDHC cards and played through DFPlayer sound modules. Since these modules can only play one sound track at a time, one module is used for the air pump which could run at any time, and the other is used for all other sounds stored on separate tracks. These include: Throttle notching, Circuit Breaker snap, Air brake hiss, car gong, and car Door open/close.

Most parts used for the model K-1 Controller are readily available from on-line parts suppliers such as Jameco, DigiKey, Mouser or SparkFun. I did make use of off-shore vendors (via Ali-Express) for availability and good prices for some of the parts. The control knobs and levers were "borrowed" from a Digitrax Zephyr. The throttle has a replacement metal knob for the touch sensitive detection.

Further information about the parts, circuit design and operation, and the Arduino Mini Pro program sketch is available from the author at:

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