Case Study: PUTRA Kelana Jaya Rail Line

Backgound

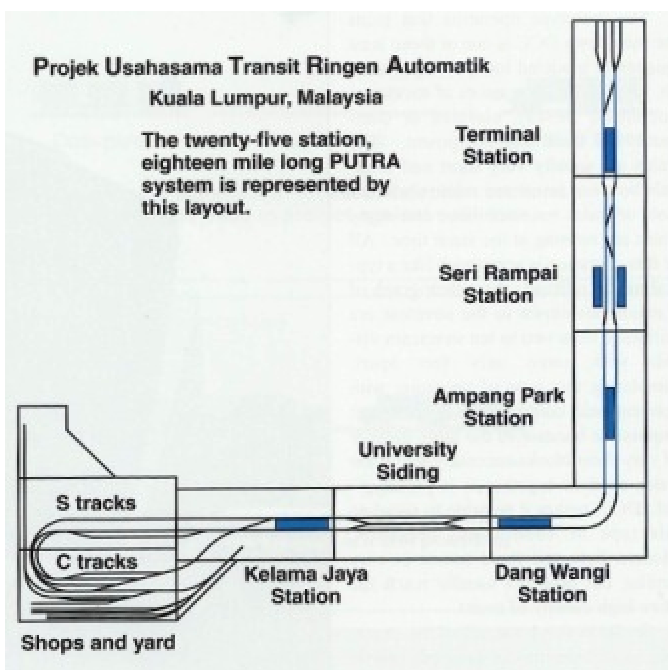
The prototype operation that gains the most from DCC is one of those least frequently modeled today: Rapid transit. Rapid transit consists of streetcars, interurban, subway, elevated or commuter rail track and equipment. The trains are usually very short and intervals between trains are relatively brief. Lots of trains run each hour and many trains are running at the same time. All of this operation is very much like a typical model railroad. Any photograph of a major downtown in the streetcar era will have from two to ten streetcars visible with some only feet apart. Simulating this type of operation with conventional control would be almost impossible because of the large number of very short blocks necessary to run the trains as close together as is prototypical. DCC makes it possible to simulate this type of control and operation. Modem light rail rapid transit is very similar, but does not usually reach the same high density of trains. Here is an example of a simulation of the prototype in a real world non-model environment, constructed as a commercial application of DCC technology. This case study shows the power of Digitrax command control and LocoNet. This railroad was built in the 1990's, and, as such, some of the hardware used in the construction of this example are now superseded by improved components. Yet, it remains an interesting study. PUTRA (Kelana Jaya Rail line)

PUTRA (Projek Usahasama Transit Ringen Automatik), now called the Kelana Jaya Rail Line, is the third rapid transit line built in Kuala Lumpur, the capital of Malaysia. This new rapid transit line, 29 kilometers (18 miles) long, was completed in early 1999. Part of a larger integrated rail and bus transportation network serving a city of 7 million, the PUTRA line is made up of twenty-five stations, including stations underground, at grade and elevated above grade. The line also includes a maintenance and storage yard and a reversing loop at one end of the line. The other end of the line is a simple stub terminal with four storage tracks. The line is completely computer controlled from a central control station by supervisors watching the line through remote cameras. The trains normally operate without drivers. Except for using completely automated computer control, the Kelana Jaya Rail Line operates like many US rapid transit lines. This kind of operation is used in San Francisco's BART, Atlanta's MARTA and Boston's MBTA. Each train has two operator's panels so that the trains can be controlled manually in the yard, in an emergency or under unusual circumstances. PUTRA decided to have a model built as a simulation of part of their system to: 1. simulate their operating practices 2. train their operators in the many aspects of manual operation 3. train their supervisors 4. simulate various emergency situations

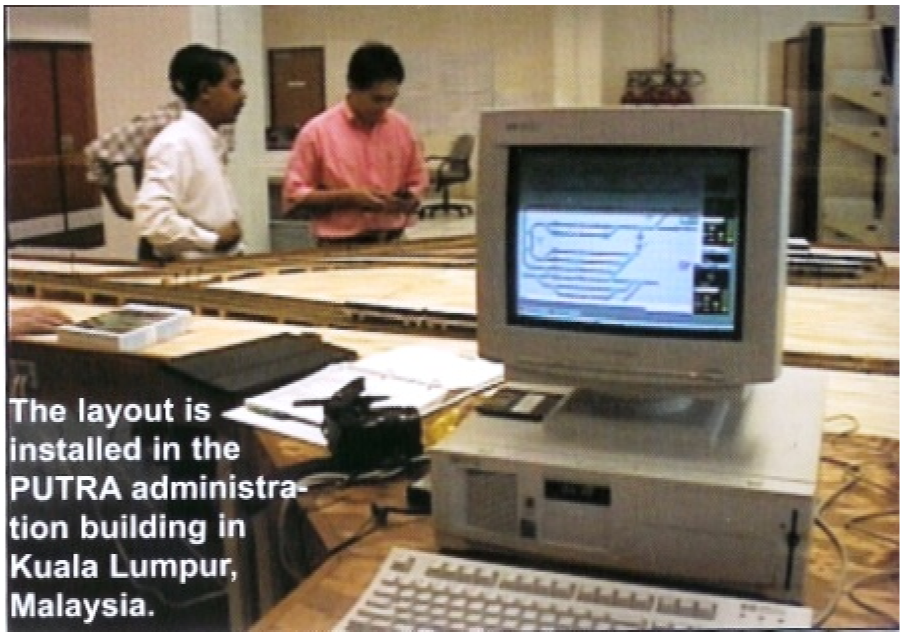
Armin Bacher, a long time Digitrax enthusiast, was selected by PUTRA to build the model in H0 scale. The model was built in nine 78 inch by 36 inch sections. Construction and testing was done in the USA, then the model was crated and shipped to Kuala Lumpur.

The Railroad

The track plan of the model Kelana Jaya Rail Line is shown below:



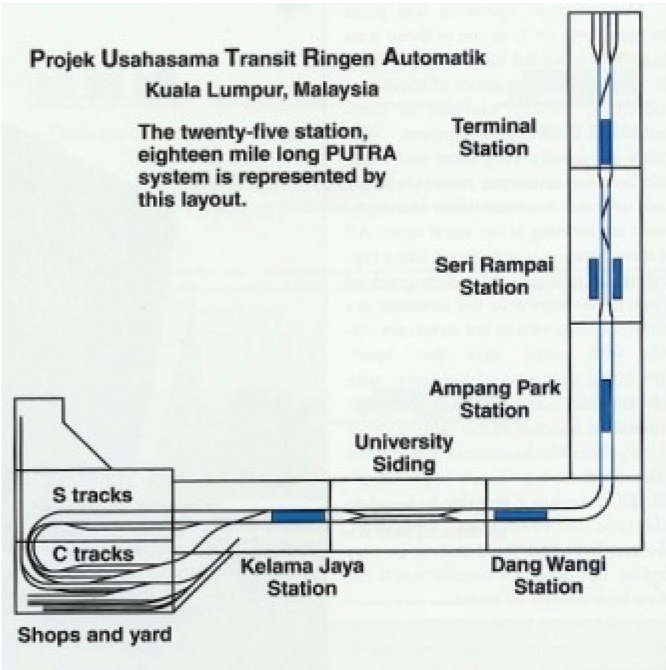
Included in the model is the double track mainline with crossovers, two elevated stations with center platforms, one at-grade station with outside platforms and two underground stations, also with center platforms. The storage yard, maintenance yard and reversing loop at one end of the system and the four track stub terminal at the other end of the system are also modeled. The yard, station tracks, crossing loops and distances between stations are all scaled to hold trains no larger than three cars. The layout is designed to operate eight trains simultaneously under normal conditions. The layout was delivered without scenery or buildings. PUTRA plans to add models of the stations, platforms and maintenance buildings to achieve a more realistic look.



The model is installed in the training section of the PUTRA administration building at the maintenance facility in Kuala Lumpur, Malaysia. Rolling stock consists of ten two car trains in AA configuration. Each car has its own decoder. Function 0 is used for forward white lights and reverse red lights on each end of the car. Function 1 operates indicator lights for opened doors on the right side of the car and function 3 operates indicator lights for opened doors on the left side of the car. The doors on the model cars do not actually operate like the prototype so, the lights are used to indicate the operation of the doors. There are also two powered B units each with its own decoder and door indicator lights. These B units are used to make up three car trains.

Power

The Kelana Jaya Rail Line model is a DCC intense layout, using many Digitrax command control components to achieve the goal of training operators of the actual rail line. The railroad was built in the 1990's and many of the Digitrax devices used for the Kelana Jaya Rail Line model have been superseded with improved units.



Components used for the Kelana Jaya layout:

- 28 Mainline turnouts
- 11 Yard turnouts
- 39 Tortoise switch machines
- 84 Dwarf signals (*yellow/green, red/green, red/yellow*)
- 38 Mainline block signals
- 38 Heavy duty SPDT switch relays

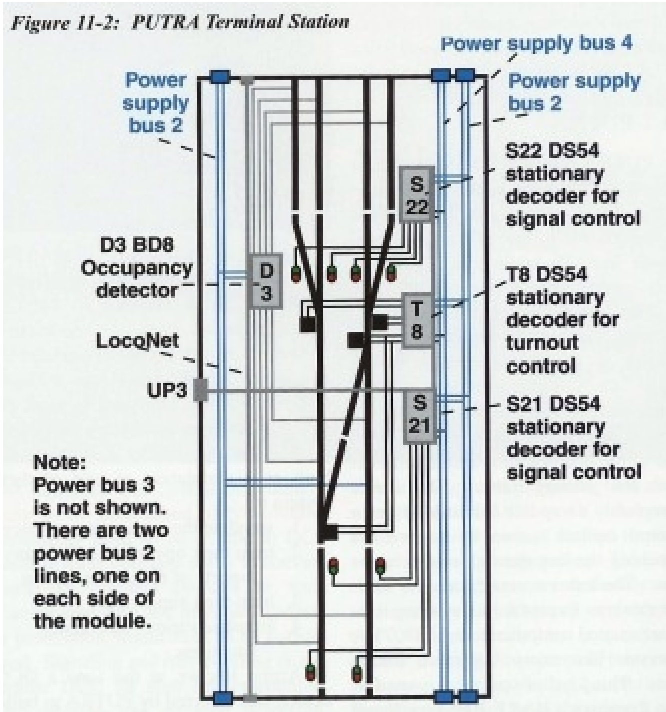
Digitrax Components Used for the Kelana Jaya layout:

- 1 DCS 100 (Super Chief) command station
- 4 DB100+ boosters
- 21 DS54 decoders for turnout control and computer feedback
- 8 BD8 block detector modules (produced by DigiToys)
- 3 BD1 block detector modules
- 12 UP3 LocoNet plug-in panels
- 5 DT100 handheld throttles
- 4 Regulated 13.8 VDC 7 amp power supplies

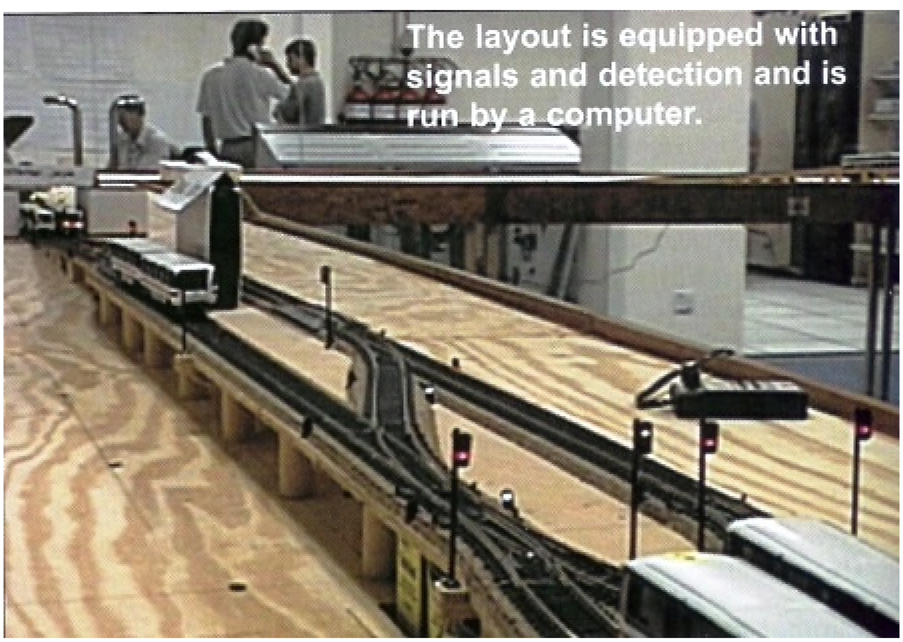
Readers will note that the DS54 stationary decoders have been replaced by the DS64, the BD8 block detector has been replaced by the BDL16, the BD1 block detector has been replaced by the BD4, the UP3 panels have been replaced with the UP5 and the DT100 has been replaced by the DT400 and the UT4 throttles. One net outcome of the improvements is that fewer block detector modules would be needed. Another net outcome is that the throttles are not tetherless, either via infrared or radio control.

The layout is controlled by a PC attached through LocoNet to a DCS100 Super Chief command station. Five DT100 throttles are used for manual control and the computer runs WinLok DCC software for automated control. The automated control is programmed to duplicate exactly the control system for the PUTRA prototype, modified only for the scaled down distances and the reduced number of stations. The automated control system is used by the supervisors and central control operators for training. It is programmed to simulate emergency conditions such as partial power failure, collision between trains, derailments and accidents involving people. Power is supplied to the layout and boosters by four separate power supplies, each providing regulated 13.8 volts DC supply at 7 amps. The 7 amp (11 amps peak) power supplies can easily handle up to three boosters each. Each booster is protected by a 5 amp circuit breaker. The reversing loop and its reversing section is a 30 inch long section of single track that will never draw more current than is used by a single train. The power requirements for the model were calculated based on 0.3 amps operating current per powered unit so that there is plenty of power to run the trains. **Power Distribution** The track on the layout is organized into four power districts:

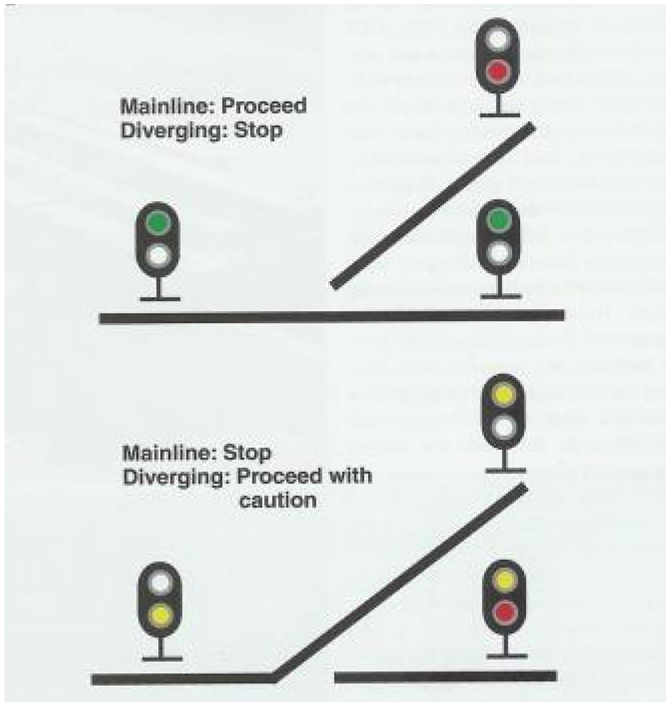
- Mainline west, yard, reversing loop
- Mainline east, DS54 dedicated booster
- Maintenance yard and signal lights
- Reversing Section The power bus is a 14 AWG wire harness with modular connectors that allow each section of the layout to be connected electrically. There is a separate power district for turnout control and separate power buses for auxiliary turnout power to the stationary decoders and for the signal light power. These two buses don't carry the DCC signal. The figure below shows the section of the layout which comprises the stub terminal and its associated control, turnout and signal wiring.



Operations



The layout uses twenty-eight turnouts on the mainline and an additional eleven turnouts in the yard. Each turnout is powered by a Tortoise slow motion turnout motor. Each of the twenty-eight mainline turnouts has three dwarf signals associated with it. The aspects of the signals are shown below.



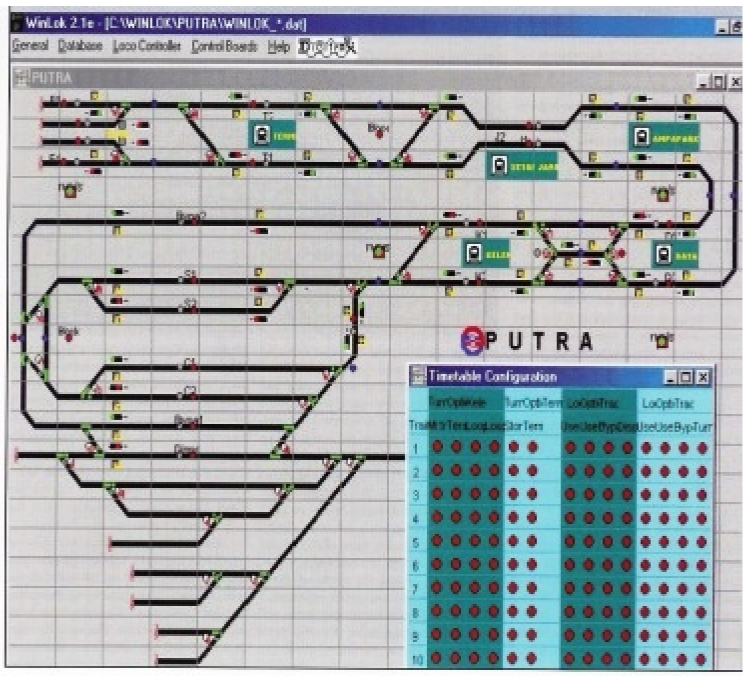
The indications of the signals are: Green = Proceed Yellow = Proceed with caution Red = Stop Each signal has one head with two LEDs. There are also thirty-eight mainline block signals (red/green) that are controlled by heavy duty single pole double throw relays. This makes a total of 122 signals. Since one LED is always lit in each signal, the total draw on power supply #3 which is used for the signals is an astonishing 3.5 amps. This shows how 122 small things can add up to a very big thing. The thirty-one switch motors are controlled by nine DS54 stationary decoders with a total of thirty-six function cells. Some of the turnouts form crossovers and are ganged together and controlled by a single function cell. Another twelve DS54s are used to control the thirty-eight SPDT relays that operate the block signals. Block occupancy detection on the mainline is controlled by eight BD8 block detection units with each unit containing eight block sensors. Three additional BD1 block detectors report the track status for the reversing loop. The block detectors feed back to the computer through the sensor inputs of the stationary decoders via LocoNet. Even when using manual control, the turnouts, detection and signal logic are all controlled by the computer using WinLok. Because of this, the DS54s are programmed for turnout control, positive feedback and signal control only. There are no local routes used by the DS54s and there are no routes in the DCS100 so, the DS54s do not execute any cascaded routes. The entire layout is built to heavy duty commercial standards and because of the service involved with this layout, it is not overkill. The layout has been designed for long life by operating every piece of equipment at much less than full power, with a view to the maximum reliability.

Computer Operations

The Kelana Jaya Rail Line model layout uses WinLok 2.1 running on a PC under Windows 98 to operate the trains, turnouts, signals and to use the feedback from the block detectors for train control.

This equipment was configured and programmed to PUTRA's specifications by Dr. Hans R. Tanner of DigiToys Systems. PUTRA specified the following capabilities for the control system used for the simulation: 1. Run eight trains at once in any combination of automated or manual control. 2. Define specific routings and be able to assign automatically or manually any route to any train at the time the train is dispatched from its terminal. 3. Protect interlocked train movements for every train on the layout, irrespective of its control method, automatic or manual. 4. Emulation of manual operation and communication for the simulation of train breakdowns and other emergencies. 5. Simulation of dispatching of trains to and from the maintenance facility. 6. Simulation of the prototype CTC-like control panel. To meet these requirements, WinLok combines four basic programming elements:

- CTC panel and logic
- Routes
- Signals and security flags
- A timetable **The CTC Panel** The first element is the CTC panel and its associated controls. The PUTRA CTC panel as a whole appears below:



This section of computer panel controls the stub terminal trackage:

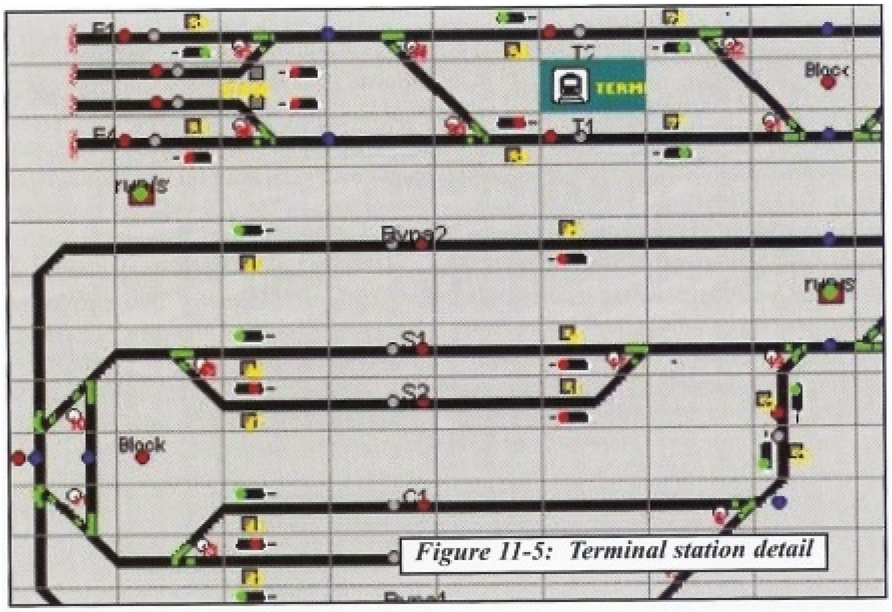


Figure 11-5: Terminal station detail

The track layout:

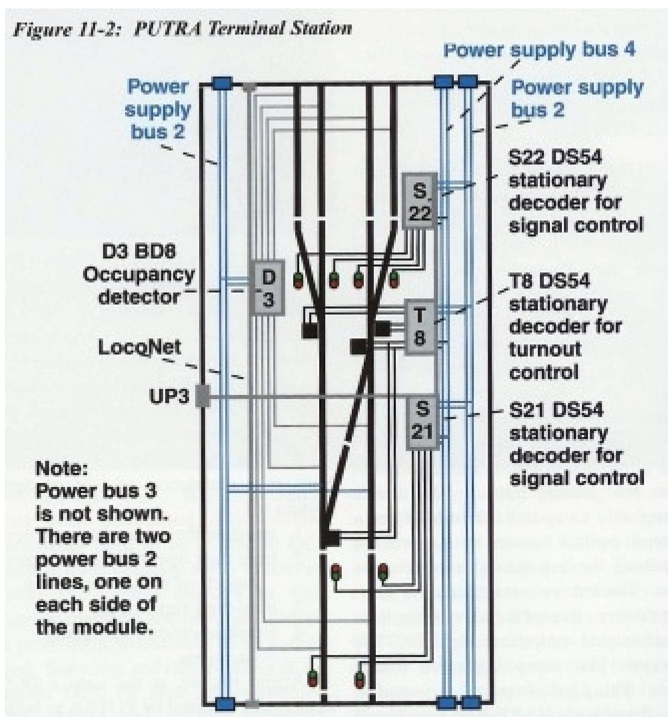


Figure 11-2: PUTRA Terminal Station

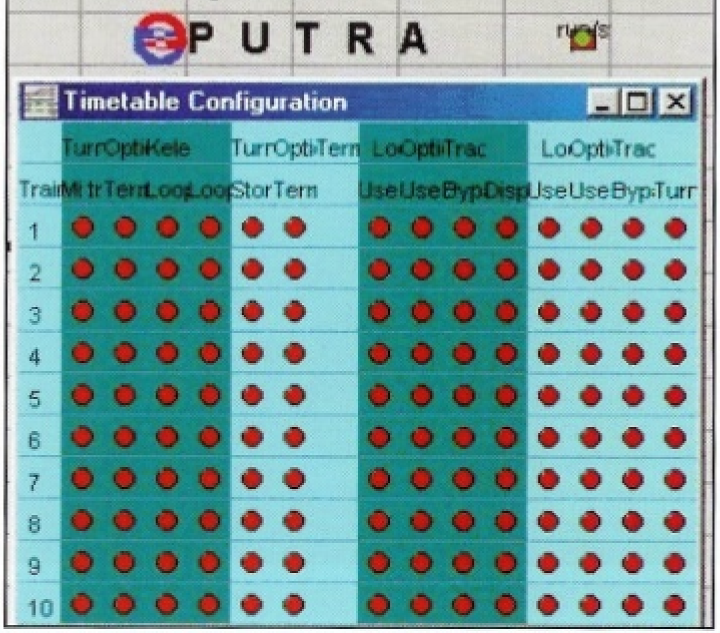
All of the buttons, controls, lights and indicators on this panel are simulated by the WinLok software. Each track segment has its own occupancy detector. Every track segment must have its type defined for the CTC panel. In particular all halting points are identified and numbered. These are places where a train is permitted to stop under normal circumstances and where it does not foul turnouts. For example, on Figure 11-5, El, Tl and Bypass 2 are all halting points. The CTC panel also includes block signal controls, occupancy detector feedback and numbered turnout controls. Also provided are a set of colored route selection buttons which control route establishment. Special control buttons are provided to hold trains at any halting point and to send trains automatically to their staging point for the next day. PUTRA shuts down at night. To simplify movements in the morning, four trains are staged at each end of the line: four in the EI-E4 tracks at the stub terminal and four at the yard complex. On the computer display panels, the yellow buttons by each halting point are used to show and control the reservation status of that section and can be used manually to reserve or release that segment of track. The blue buttons below the halting points toggle the direction of travel flag for the track. A blue arrow appears next to the button if the track has been set for a particular direction of travel. The block signals could be operated manually by the green button next to them. The turnouts are operated by the white numbered buttons next to them and the turnout state (thrown or closed) is shown on the track diagram. The red and gray buttons associated with the halting points are used to control train routes. Usually, the red button commands an eastbound route and the gray button commands a westbound route. These routes are commanded on a 'from'/'to' basis, so that two buttons must be pressed for the route to operate. This provides valuable security against accidental route selection. The 'Stack It' special button is used to park trains at the end of the line for the next day. The Run/Stop button will send all trains to the yard for manual storage if set to Stop.

Routes The second element is the underlying framework of routes. These routes are defined for every permissible train movement. Each route consists of smaller elements that run from halting point to halting point. Each halting point has a switch for reservation or occupancy and for direction of travel. Track segments between halting points have a switch which describes the desired direction of movement. From these components a route is assembled. When a route is activated, the direction switch is set for all other track sections for the duration of the train movement. All other direction switches are set for other tracks to protect against routes which might cross the selected route. The turnouts are then set for the requested route starting with the most distant turnout. Finally, the most distant available halting point is reserved. As the train travels along the route, it clears control of the various track segments it has used. If necessary, the trains will wait at a halting point for the route ahead of it to become available. Interlocking is handled by the CTC panel configuration and the security flags. The software prevents a 'deadlock' condition where two trains try to grab control of the same section of track at exactly the same time so that neither can take control. It also prevents a 'deadly embrace' where two trains each control a section of track that the other one needs, but neither can release the track it has until it gets control of the other train's track.

Signals and Security Flags Dwarf signals reflect the turnout state and the block signals are provided for visual feedback of the state of the next block. The signals are controlled by the CTC panel logic and the track occupancy detectors. The security flags are used for the reservation and occupancy status of track segments and to ensure that the train is traveling on track reserved for it in its actual direction of travel. Security flags also protect other track and routes which are temporarily unavailable while a particular route is active. The PUTRA prototype uses signals which default to green. Thus, if a track section is not occupied and has no 'preset direction, then both eastbound and westbound signals will show green. Signals will show red if the next track section for that direction of movement is occupied or if the switch at the end of the block is aligned against the direction of travel.

Timetable Figure 11-6 shows the timetable configuration panel:

Figure 11-6: PUTRA Timetable Panel



The display shows the configuration capabilities for ten individual trains, one train on each row of the panel. The first band of columns defines the behavior of the train in the Kelana Jaya station area if the train is approaching from the Dang Wangi station. Possible options according to the required routes of the PUTRA system are: 1. Use middle track of University, change direction and return to Dang Wangi. 2. Use any free track at Kelana Jaya, change direction and return to Dang Wangi. 3. Use any free track at Kelana Jaya and proceed to C tracks in Yard using the reversing loop. 4. Use any free track at Kelana Jaya and proceed to S tracks in Yard using the reversing loop. The second band of columns defines the behavior of a train at Terminal station if the train is approaching from Seri Rampai. Possible options are: 1. Use any free track at Terminal, change direction and return to Seri Rampai. 2. Use any free track at Terminal, then proceed to storage in any of E1 to E4. The remaining bands of columns control other locations. The locomotive timetable controls the movement of the assigned train. It establishes the routing for that train, the first available train at a given location for an available route. The train will then move and stop according to the timetable. All trains are able stop at all stations, but they are not required to do so. If a train is being operated manually, the operator uses a DT100 hand held throttle to control the model. The system dispatcher controls the track using the CTC panel displayed on the computer. The following sequence of operation is followed: 1. The train operator radios the dispatcher requesting permission to proceed to the next station. 2. The dispatcher sets up the route to that station using the 'from' and 'to' route buttons on the panel. 3. The dispatcher gives permission for the train to proceed and the operator acknowledges. 4. The train is moved to the destination and the operator radios to the dispatcher when it arrives there or otherwise stops for any reason. This discussion provides a brief overview of the PUTRA system. It illustrates how computer control and CTC in general can be implemented using WinLok and DCC. Several DCC software packages are available that will accomplish the same tasks shown here. You may find a software package that is better suited to your needs but you will find that the principles used here can be applied to almost any model railroad application. In this layout, the only connection between the computer and the layout is the LocoNet cable. Since the CTC board is a computer simulation, no other wiring between the layout and the computer is necessary.

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