MAE - N/TRAK SYSTEM OVERVIEW

This book is a collection of articles concerning various aspects of the computerization of Princeton's modular N-scale (1:160) model railroad layout. The model railroad is the class project for MAE 412, an undergraduate course on microcomputer control.

At the core of our computerized network is the Hornby ZERO ONE system (see attached advertisement), a commercial system developed for the control of model trains. Microcomputers are used in all parts of this system including the master controller and the on-board receivers that control speed and direction of each locomotive. The railroad tracks are used in a clever way to convey both power and control information to the devices on the layout. The technical concepts used in the Hornby system are described in Chapters 2 and 3. The modular aspect of the MAE-N/TRAK system has been modelled after the N/TRAK system described in Chapter 4.

Through the efforts of MAE 412 students and independent study students, we have embellished Hornby's concept of control. Our network is made up of modularized projects, each of which is controlled by a student-built computer. The primary function of the project computer is to implement a scenario of operations. Several representative projects are described in Chapters 11-13.

One of the important features of the MAE-N/TRAK system is that the master controller can be used to send "command codes" to any of the project computers. As with the locomotive computers, the project computers receive information from the tracks. To establish this communications link, a subroutine is provided which runs as a background task (under interrupt control) on each project computer. (The interrupt control routine is described in Chapter 5.) Each project computer, in addition, is provided with the software necessary to automatically control block-entry signals, to read locomotive bar-codes, and to prevent collisions between trains. (The block signal and sensor system is described thoroughly in Chapter 6.)

Chapters 7, 8, and 9 describe a system for the automation of the Hornby controller. Chapter 10 describes PAL implementation as used by the student computers for address decoding.

The Reference section at the end of this book contains additional information pertaining to project construction and implementation.

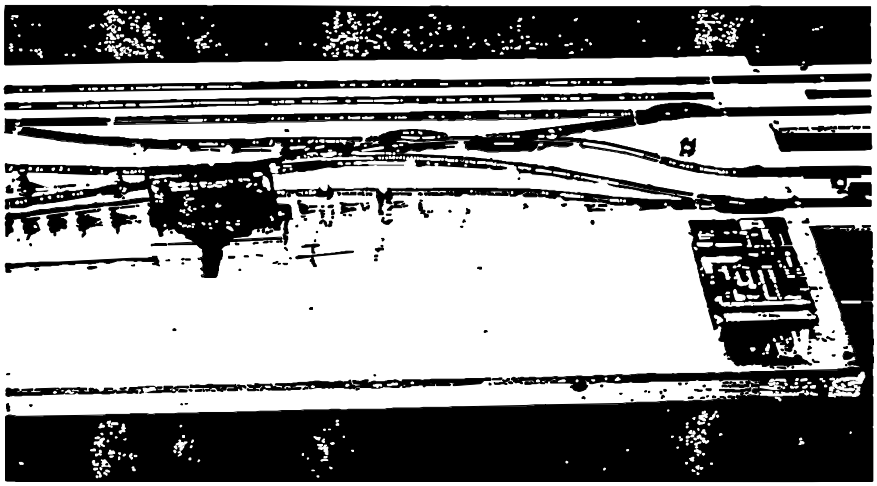
COMPUTERISED MODEL RAILROAD

at

Princeton University

Michael Littman

Our computerised N-scale model railroad is the class project for Course MAE 412 (Mechanical and Aerospace Engineering), an undergraduate laboratory course on microcomputer control. The course is offered to advanced engineering students at Princeton who have only a minimal background in electronics and computers.

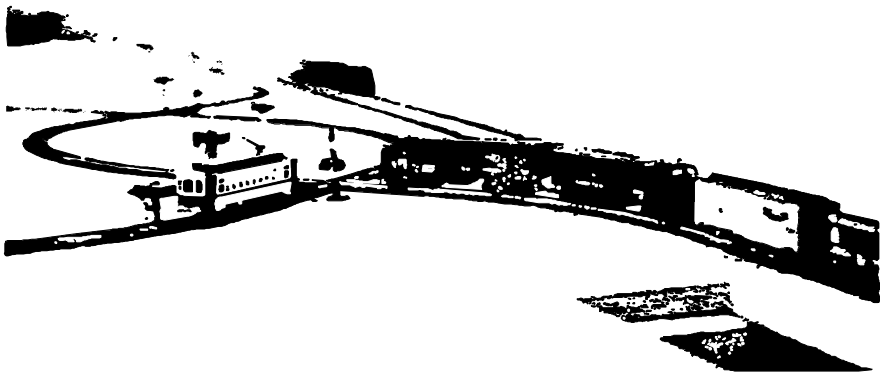


Rotary coal dumper project.

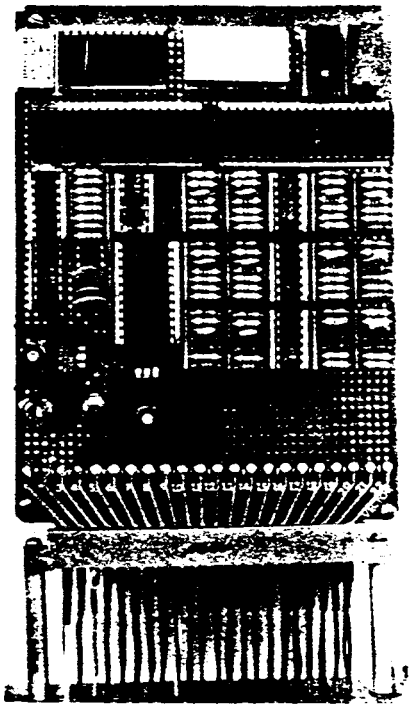
At the core of our computerised model railroad is the Hornby *Zero One* system, a commercial device developed for the control of model trains. Microcomputers are used in all parts of this system, including the master controller and the local receivers that control speed and direction of individual locomotives. The Hornby system uses the railroad tracks in a clever way to convey both power and control information to each of the devices on the layout. The Hornby control system is described in the following article.

Through the efforts of MAE 412 students and independent study students, we have modified and added to Hornby's system of control. Our railroad consists of modular projects which are controlled locally by student-built computers. The student computers include 6502 microprocessor, 4K x 8 EPROM, 2k x 8 RAM and 6522 Versatile Interface Adapter. The primary function of the local computer is to control a *scenario* of operations on a given module. In addition, each of the local computers has the capability of receiving several different 'command codes' from the Hornby master controller. The 'command codes' are actually codes meant for Hornby accessories – we have simply redefined their function. Each module is functionally a railroad block and, as an added feature of computer control, we have allowed for automatic signalling, bar-code identification of locomotives and collison-avoidance metering of trains by each module.

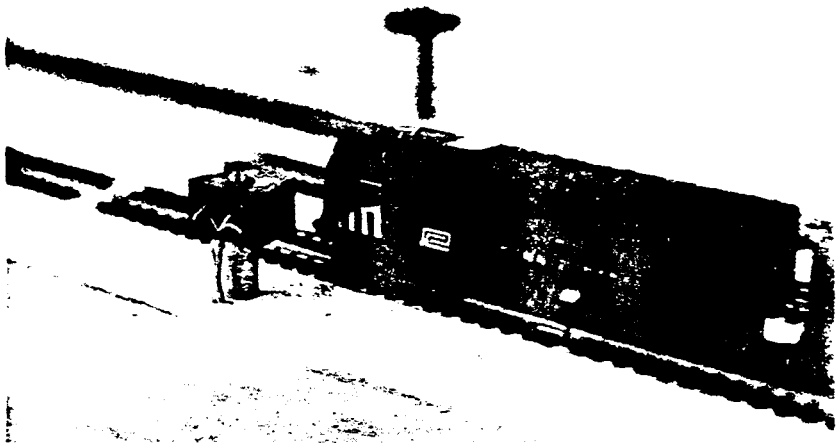
As an example, one of the simpler projects automates a trolley (tramway)/train intersection. Here the trolley crosses the railroad main track at two locations. The function of the local computer is to run the trolley around the loop and avoid collisions with any trains that are passing through. The local computer halts the trolley for a brief period of time just before it reaches each intersection. If a train is present on the main track within the limits of the project board (*i.e.* railroad block), the computer activates the crossing lights and causes the trolley to wait for the intersection to clear. (Trains are delimited with 'bar-code' labels at the front of each train and 'clear' labels at the rear of each train.) In addition, the local computer accepts a number of 'command codes' from the Hornby master controller. One command code is reserved to enable



Trolley (tramway)/railroad crossing.



One of the student-built computers and interface.



Bar-code reader beside the track.

the stopping of the trolley at an extra location (*i.e.* a trolley stop) on each revolution of the loop. Other command codes set the speed of the trolley around the loop. Besides these features, the local computer drives our standardised system for block signalling, bar-code and clear sensing and collision avoidance. A more detailed article will appear in a future issue.

A more elaborate project is an automated car-sorting yard and rotary coal dumper. Here a particular train, as determined by the bar-code, is diverted onto a siding and stepped through a sorting/unloading sequence. Other student projects to date include: containerised freight unloading/loading yards, hump yards, interlockings, reversing loops, turntables, transfer tables, lift bridges, coal loaders and unloaders.

Another related project is an RS232C interface, *i.e.* the EIA standard serial link with computers, to the Hornby master controller. This device was developed by an independent study student and it allows for a personal computer to send speed, direction, or accessory codes *via* the Hornby controller. A far more elaborate multi-tasking network controller, which serves to co-ordinate numerous projects simultaneously, has also been developed. This project supports a variety of features including train position-finding and graphic display of the layout status. A description of this project, however, is beyond the scope of this short summary.

While the purpose of our model railroad is primarily academic, *i.e.* to provide an exercise ground on which students can learn to apply the techniques of microcomputer control which they will later use in real-life industry and commerce, it has also been the means by which several students have gotten the model railroading bug!

ZERO 1. THE REVOLUTION IN MODEL RAILROADING.

Hornby's Zero 1 is going to change the face of model railroading not only because of what it does, but also because of the way it does it.

With only four basic elements you will be able to create and control a more authentic railroad system than ever before.

The heart of Zero 1 is the master unit, a digital microprocessor with a four amp transformer, a 17 button-punch keyboard, and a slide speed control.

With its unique memory control you can run up to 15 trains on user preprogrammed speeds and direction whilst operating a 16th on real time speed and direction.

The master control allows you to allocate four inertia or momentum factors to each loco from slow acceleration and braking for heavy freight trains right up to fast acceleration and braking for expresses.

It allows you to double-head and to run two or more locos on the same stretch of track at different speeds and in opposite directions.

The master control comes with a built-in fail-safe system. It has a power-on light, an overload light in case of a short circuit or when power drain exceeds the master's four amp limit, and it has an error light which shows a mistake has been made in programming (the master will refuse to commit the mistake to memory).

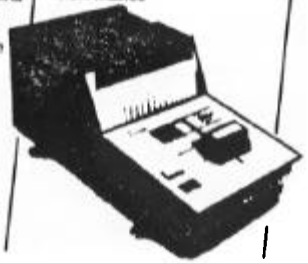
The master control can be used with existing wiring in complex systems. But in building a new system it will enable the most complex of layout to be created with the simplest wiring. Just two wires connect it to the track.

Perhaps the most sophisticated part of the system is the smallest, the loco module, a rectangular chip, 9/16 x 1/2 x 5/16 inches small, created by Texas Instruments to Hornby specifications. It has leads long enough to be connected from tender drive units and it connecting points are made of

gold to give perfect contact.

The loco module converts the 20 volts AC current (which is in the track at all times) into 12 volts DC while at the same time regulating the amount of current which reaches the engine. The chip responds only to the instructions which are sent to it by the master control which means that each loco becomes independently controllable no matter where it is on the track or in which direction it is facing.

The slave unit enables you to broaden the scale of your operation. Each unit has its individual speed, direction and inertia controls. A simple 15 pin plug joins it to the master. (The slave is not connected to the track.) Each slave will handle 1 loco, with a maximum of three slaves being coupled to the master.



The last part of the system is the accessory control module, a small box which can be hidden in the scenery, fitted into a signal box, or easily screwed underneath your layout. Each module will operate four individual accessories and each outlet can be programmed for continuous or burst, which

means you can run lights and switches off the same module.

One of the great advantages of the system is that when new items are introduced (next year there will be a mimic diagram) they will be compatible with the present units.

But with only the four items available now you will be able to do everything which is mentioned on the previous two pages. And that can mean a complete revolution in model railroading from doing things you've never achieved before.

The only way to prove how simple this amazingly advanced and sophisticated system is, is to see it in action. You can start with the barest minimum, a master control unit and one loco module and gradually build up the range as you go along. Or you can order a complete system with enough modules to fit every one of your locos and accessories.

Fill in the coupon today

TECHNICAL SPECIFICATIONS

Master Control Unit

Electrical input: 110-120 volts AC 60 Hz. Rated output voltage: Track (terminals A and B) 18 volts AC square wave. Track voltage when measured by a conventional meter can read up to 25 volts AC.

amps.

Loco Operating Module

Maximum rated output: 1 amp continuous (when used with Master Controller).

Accessory Operating Module

Maximum rated output: 1amp continuous per channel (when used with Master Controller).

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P.O. Box 160, Goshen, Kentucky 40026

When completing your order, please add postage, handling and insurance charge as shown in parentheses ( ) following each item. These charges are per item.

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R946	Zero 1 Points/Accessory Module* ($1.35)		$49.95		
R947	Zero 1 Loco Module* ($1.35) For C.O.D. $2.00		$24.95		
	Kentucky Residents Add 5% Sales Tax				
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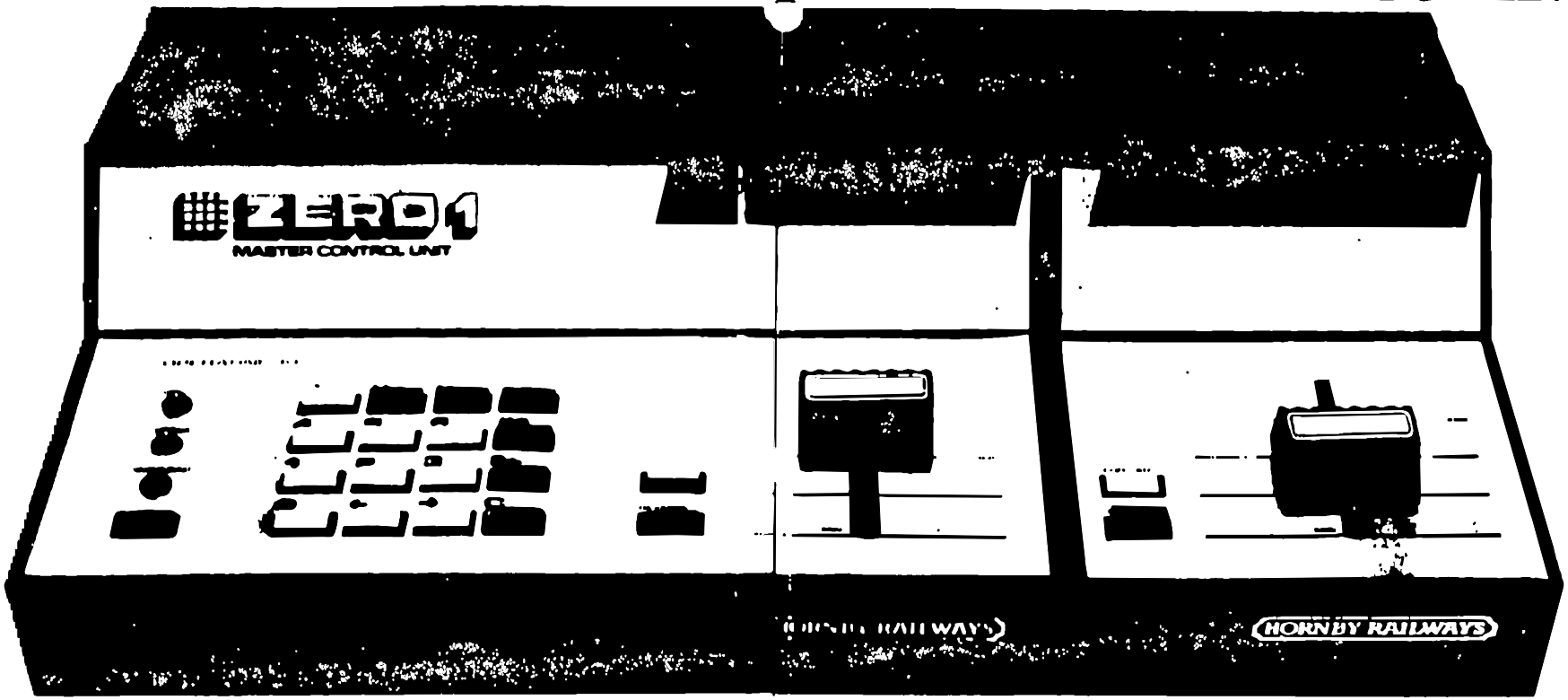
ZERO 1

THE ULTIMATE CONTROL SYSTEM FROM HORNBY RAILWAYS

THE MOST ADVANCED CONTROL SYSTEM IN THE WORLD.



Hornby Railways of England have developed the world's most advanced model railway control system by using computer micro-technology.

It's called the Zero 1; a system which allows you to create and control the most sophisticated layout with consummate ease.

Basically, here's what it will enable you to do:

Run up to 16 locos simultaneously (depending on power and consumption of locos).

Program 12 locos to run at pre-set speeds, and at the same time operate 4 locos under direct control.

Run two or more locos on the same track at different speeds and in opposite directions.

Program locos with 4 different levels of inertia from slow acceleration for heavy freight trains to rapid acceleration for streamliners.

Operate 99 different accessories including continuous lights, and intermittent switches and junctions.

IT'S ALSO THE SIMPLEST.

You might think that a system with such prodigious output would be a monster of knobs and wires.

Not the Zero 1. In its simplest form, all that's required is 2 wires from the master control to the track, because the power is regulated in the locos and at the points instead of through the current in the track.

The control panel is a perfect understatement of simplicity; 17 button punch encoders and a graduated speed slide.

It's this simplicity of operation combined with the amount of work the Zero 1 gets through which makes it the ultimate control system for any model railroad.

But more importantly, it allows you to play with trains like you've never played before.

On the next two pages we show you how.