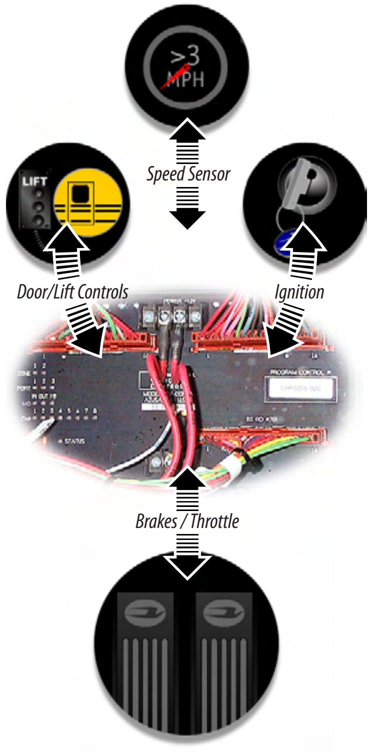
Overview

Many of the Blue Bird Vision's electrical circuits communicate and interact with each other through an advanced Multiplex control system. This solid-state system provides significant advantages over traditional wiring:

- Multiplex simplifies the system by replacing multiple mechanical relays and switches with reliable solid-state components.
- Multiplex provides intelligent programmed (rather than mechanical) interaction between components. Multiple component signals are transmitted simultaneously along a common data bus, and are monitored and controlled by a digital microprocessor.
- The Multiplex module also serves as a centralized troubleshooting tool which simplifies the process of isolating causes of electrical malfunctions, without requiring special diagnostic hardware/software interfaces.



Multiplex System

The Brake & Throttle Interlock system is an example of how multiplexing handles simultaneous communications between seemingly unrelated components.

The Multiplex system may be thought of as similar in purpose and function to already-familiar electronic control devices such as the engine ECU, or the Weldon warning light control module. The main differences are that the programmable module(s) of a multiplex system are programmed for specific vehicles, and provides information to the technician by means of a series of visible LED indicators rather than by means of special diagnostic interface ports.

The Multiplex systems installed on the Blue BIrd Vision is relatively simple. It primarily controls chassis-related on/off state devices. Most body circuits are wired conventionally. (Some chassis circuits receive Inputs from body components such as vandal locks and door signal switches.) Although the modular nature of Multiplex components allows it to be configured for complex systems using multiple modules located in several control "zones", the Vision's Multiplex system consists of one zone with a single control module.

The central component of the Multiplex system is the MPX Module, the microprocessor which handles communication between various circuits. The role of the MPX Module is similar to that of a telephone switchboard which makes and breaks connections for multiple individual "calls" (between two components) and/or "conference calls" (between several components), simultaneously. Input signals from various circuits arrive at the MPX Module. Inside the Module, the Inputs trigger Output signals which activate/deactivate other components or circuits. The programming of the MPX Module determines which Input (or combination of Inputs) results in any particular Output. The Module also internally generates a Feedback signal for each load circuit, and continually monitors the Feedback signals to verify the integrity of the circuits, much as a technician would use an Ohm meter to test continuity.

An array of Light Emitting Diodes (LEDs) on the MPX Module provides the means by which a technician can visually monitor the status of individual Inputs, Outputs, and Feedbacks. The technician uses a dash-mounted Diagnostic Switch to select which circuits the LEDs display, and whether they indicate Inputs, Outputs, or Feedback.

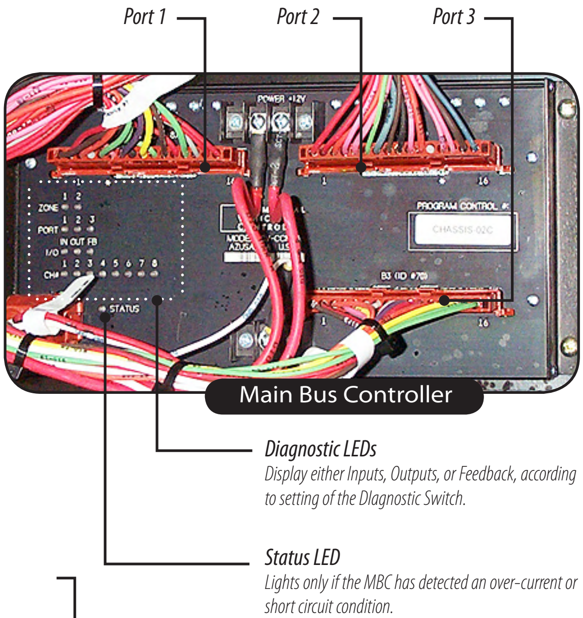
To interpret the LEDs, the technician refers primarily to two printed references presented later in this chapter: the Input/Output charts and the Ladder Logic diagrams.

As with any new technology, troubleshooting and servicing a Multiplex system requires an initial familiarization, a firm conceptual understanding, and the acquisition of new skills (such as reading Ladder Logic diagrams). However, Multiplexing does not supersede or invalidate what a qualified electrical technician already knows about troubleshooting and diagnosis. Rather, it provides a new and valuable tool to assist the qualified technician in narrowing down the source of a problem, thereby minimizing downtime and reducing operating costs.

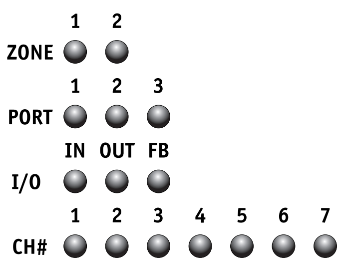
MPX Module

The CV-CCM-A Main Bus Controller (MPX Module) is mounted in the Power Distribution Unit to the right of the driver's area. The Module is powered by "clean" 12 volt power from the battery bus bar, which isolates it from the normal current fluctuation or "line noise" of power circuits affected by the alternator. Three 16-pin connectors (Ports) on the module labeled B1, B2, and B3, receive Inputs from sensors and switches, and convey Outputs to actuators, lamp loads, and other devices.

Four rows of LEDs indicate the status of the controlled circuits:



Zone: The top row consists of two LEDs, labeled 1 and 2. The Blue Bird Vision's single-zone Multiplex System is contained within Zone 2. (Note that all of the addresses shown in the Input and Output charts begin with "B". This corresponds to Zone 2.) The Zone 1 LED lights only when the Multiplex System enters Sleep Mode (explained later in this chapter). When power is first applied to the system, all the LEDs come on momentarily, and then go off. The Zone 2 LED then blinks a number of times, corresponding to the revision version of the software installed. Finally, the Zone 2 LED goes off and the system is in its normal operating mode.



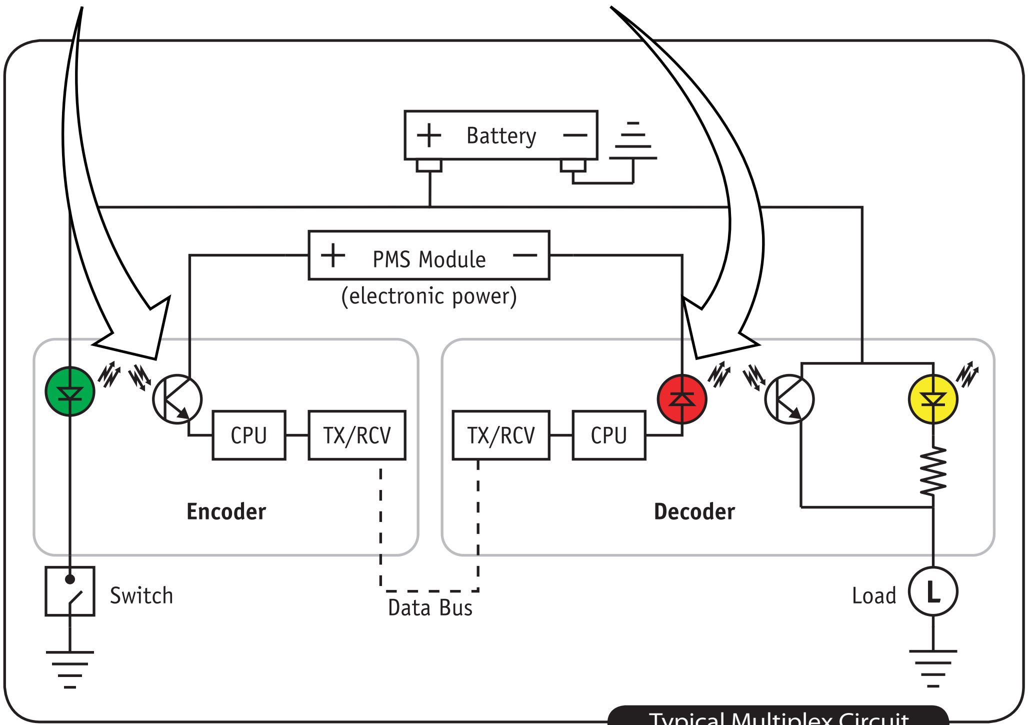
Port: The three LEDs in this row correspond to the three 16-pin connector Ports. (Each connector provides eight Input and eight Output pins.) When the MPX Module has been put in diagnostic mode by pressing the Diagnostic Switch, these LEDs indicate which Port the rows of I/O and CH# LEDs are presently indicating.

I/O: When in diagnostic mode, the three LEDs in this row, labeled IN, OUT, and FB, indicate whether the row of CH# LEDs immediately below are presently indicating Inputs, Outputs, or Feedback.

CH#: When in diagnostic mode, the bottom row of eight LEDs indicate the current state (active or inactive) of each of the Inputs, Outputs, or Feedback (depending upon which I/O LED is on) of the Port presently indicated by the Port LEDs.

The LEDs serve as visual indicators. However, they also represent the type of mechanism by which Output circuits are "notified" of the presence of particular Inputs. Inside the MPX Module, an LED in a given Input circuit turns on when the circuit is Active. Nearby, a solid state photo sensor in the Output circuit detects the internal light source and either closes or opens an Output Circuit according to the programming of the Module. In turn, the status of the Output Circuit is similarly sensed by a photo sensor in the load circuit. In this sense, the LEDs can be thought of as actually performing the function of electrical relays.

LEDs As Circuit Relays. . .
The CPU "watches" Input LEDs with photosensors. . . *. . . and activates the appropriate Output(s).*



Typical Multiplex Circuit

Status LED

The Status LED, located next to the MBC port, is normally off. Rather than having fuses, the MBC provides solid state circuit protection. If an Output is turned on and is drawing too much current (as in the case of a short circuit), the Module turns the Output off before there can be any damage to the Output transistor and circuit. When this occurs, the Status LED lights to indicate the detection of a fault.

Feedback Circuits

Internal Feedback circuits in the MPX Module are connected in parallel to the load side of Output circuits. A Feedback circuit conducts a faint current through the load, a resistor, and the Feedback LED. Thus, when the module is set to display Feedbacks, each of the bottom row LEDs acts much like a conventional ohm meter, indicating the integrity (continuity) of the load side of the circuit it monitors.

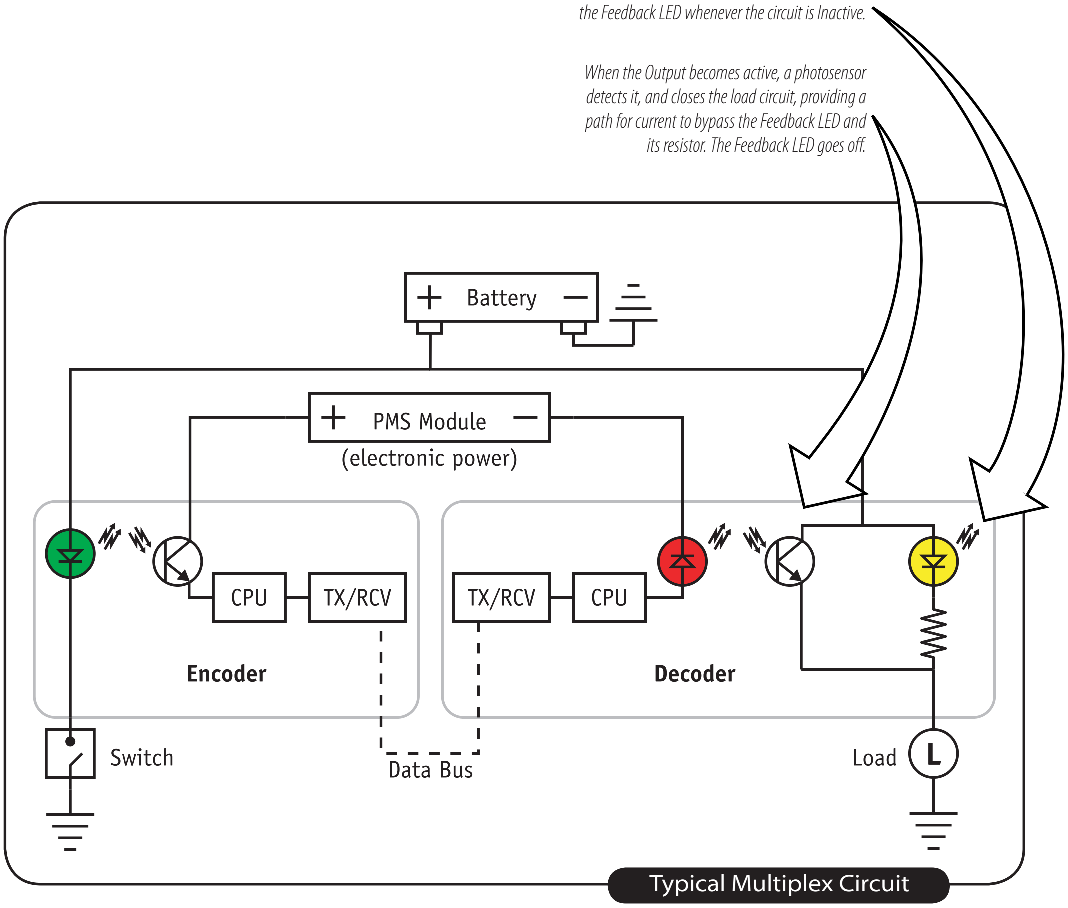
When the load circuit is switched on, full working current is able to bypass the Feedback LED circuit. This removes the voltage differential across the LED and resistor, and the LED goes off.

Thus, in a properly performing load circuit, the Feedback LED should be on (indicating that the circuit is ready) when the circuit is Inactive; and should be off when the circuit is Active. If the Feedback LED is on while the circuit is Active, this is an indication of a short in the load side of the circuit.

LEDs As Circuit Testers

A signal current passing through the load lights the Feedback LED whenever the circuit is Inactive.

When the Output becomes active, a photosensor detects it, and closes the load circuit, providing a path for current to bypass the Feedback LED and its resistor. The Feedback LED goes off.



Typical Multiplex Circuit

Sleep Mode

The Feedbacks and normal monitoring functions of the MPX Module draw a small current from the vehicle batteries. To minimize battery drain while the bus is parked for prolonged periods, the Multiplex system automatically goes into Sleep Mode.

Unless the Module is in Diagnostic Mode, Sleep Mode occurs when both the ignition switch and hazard flashers are off, and the module has received no other Input activity for15 minutes. Turning off the ignition (assuming hazard flashers are also off) starts an internal timer function. During this 15 minute delay, all of the LEDs remain off.

After the 15 minutes have ellapsed, the MPX Module enters Sleep Mode and all Outputs are turned off to conserve battery power. The Zone 1 LED comes on to indicate that the system is in Sleep mode.

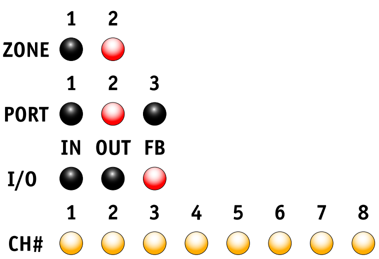
The Module awakens from Sleep Mode when either the ignition switch or the

Diagnostic Mode

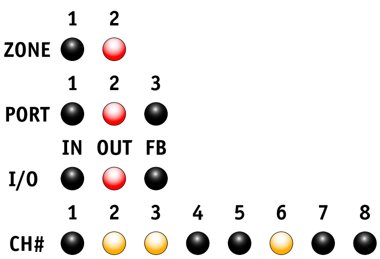
Except for the Zone 1 LED (which indicates Sleep Mode), the other LEDs only light when the MPX Module has been put into Diagnostic mode by pressing the Diagnostic switch. Each subsequent press of the switch cycles through the Ports and I/O options in the following order:

Diagnostic Mode Switch
Cycles the MBC's display through Ports, Inputs, Outputs, and Feedbacks.

1st press: Puts the Module in Diagnostic Mode, displaying Port 1 Inputs.
2nd press: Port 1 Outputs.
3rd press: Port 1 Feedbacks.
4th press: Port 2 Inputs.
5th press: Port 2 Outputs.
6th press: Port 2 Feedbacks.
7th press: Port 3 Inputs.
8th press: Port 3 Outputs.
9th press: Port 3 Feedbacks.
10th press: Ends Diagnostic Mode. Only the Zone 2 LED remains on.



In this example, the LEDs are indicating the B2 Feedbacks. . .



. . . and here, the B2 Outputs.

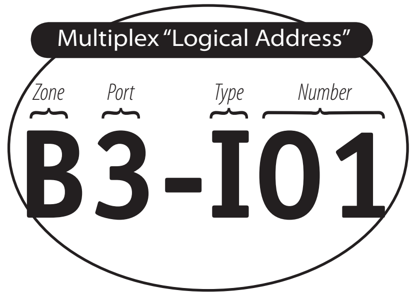
627

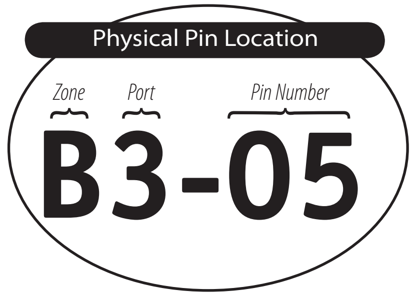
Multiplex References

Two printed references are provided to assist the technician in interpreting the Main Bus Controller's LEDs:

Input and Output Tables

Generally speaking, the first step in troubleshooting an electrical problem is to determine whether the affected or suspected circuit is part of the Multiplex system. The Input and Output Tables included in this chapter list the circuits with which the Multiplex system interacts.





Multiplex Inputs Table. The Inputs Table lists the circuits from which the Main Bus Controller receives Input signals.

The second column (Zone/Port-Input#) shows the Multiplex "logical address" of each Input circuit. These addresses are not circuit/pin locations, but relate directly to the Ladder Logic diagrams. For example, the Accessory Switch address is B3-I01 (Zone 2, Port 3-Input number 01).

The third column (Port-Pin) shows the physical pin location of the circuits; which Pin of which Port Connector on the MPX Module to which the Input circuits are wired. For example, the Input wire leading from the Accessory Switch is connected to the Module at B3-05 (Port 3, Pin 5).

The third and fourth columns list the wire color and whether the Input is a ground-side or a 12 volt connection.

Outputs Table. The Outputs table lists the circuits for which the Main Bus Controller issues Outputs. This table is organized similarly to the Inputs table:

The second column (Zone/Port-Input#) shows the Multiplex "address" of each Output circuit. These addresses are not circuit/pin locations, but relate directly to the Ladder Logic diagrams. For example, the Accessory Hot Output's address is B2-O08 (Zone 2, Port 2-Output number 08).

The third column (Port-Pin) shows the physical pin location of the circuits; which Pin of which Port Connector on the MPX Module to which the Output circuits are wired. For example, the Accessory Hot Output signal wire is connected to the Module at B2-15 (Port 2, Pin 15).

The third and fourth columns list the wire color and whether the Output is a ground-side or a 12 volt connection.

The Outputs Table has a sixth column labeled Ladder Chart Line. This is the line of the Ladder Logic chart which describes the requirements for the specific Output. For example, to troubleshoot the Accessory Hot Output, you would refer to the Ladder Logic line 17, which describes the requirements for an Accessory Hot Output. (Note that the Zone/Port-Output# address of the Accessory Hot Output is the item at the right end of the Logic Line 17.)

Ladder Logic Diagrams

The Ladder Logic Charts are not wiring schematics. They are diagrams of the "logic," or rules which the Multiplex program follows to determine which set of Inputs and/

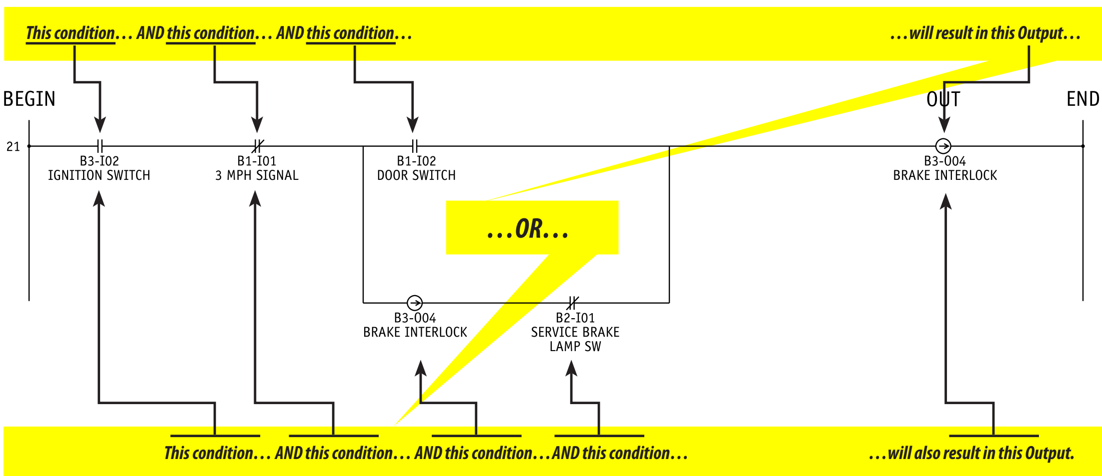
or other conditions results in each particular Output. Each horizontal "rung" of the diagrams graphically describes a set of requirements for the Output indicated at the right end of the line. Most of the requirements are either Inputs or other Outputs. (There are occasional requirements for signals which are generated internally by the MPX Module's internal circuitry or programming, rather than by a physical component on the bus.)

Each symbol on a logic line represents one particular requirement for the Output indicated at the right end of the line. Reading a line from left to right, *all* of the requirements encountered along the path must be satisfied in order for the Output at the right end of the line to occur. Thus, the horizontal lines between requirement symbols may be thought of as logical "and" statements. (An important basic principle of Ladder Logic is that a symbol can denote a requirement for either the presence *or absence* of a condition or signal.)

Some Logic diagrams provide alternate paths by which to reach the Output at the right end. These alternate paths may be thought of as logical "or" statements. If a requirement on the uppermost path is not met, the Output may still be achieved if all of the requirements of an alternate path are met.

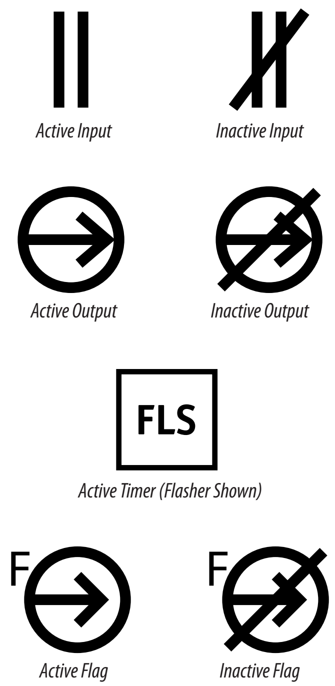
Thus, troubleshooting a circuit which interacts with the Multiplex system involves finding the Ladder Logic diagram for the desired Output; and then systematically verifying each of its requirements by comparing the chart to what is actually happening according to the LEDs on the MPX Module. When a discrepancy is found, it is an indication that the problem exists "upstream" from that point in the Logic. This will become clearer as you continue through this chapter.

Reading Ladder Logic



Ladder Logic Symbols

Following is a description of the symbols which appear on the Ladder Logic charts:



Inputs. A Logic Ladder diagram may require a particular Input to be either Active or Inactive. Active Inputs are symbolized by two vertical lines. Inactive Inputs are indicated by the same symbol, but with a diagonal slash.

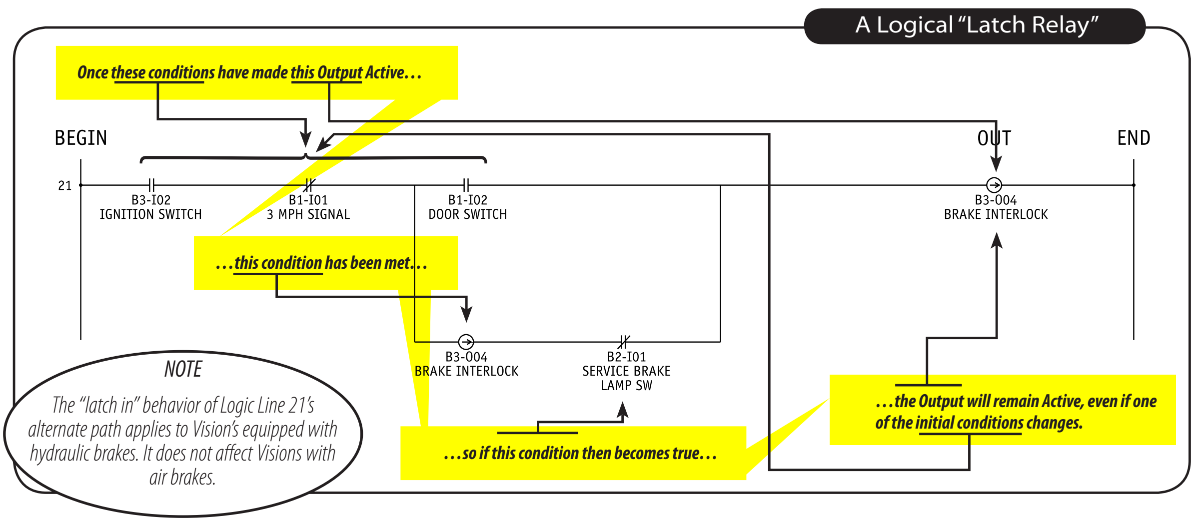
Outputs. Outputs do not only occur at the right end of Logic diagrams. A particular Output (or its absence) can also be a requirement for another Output. Therefore, symbols exist for both Active and Inactive Outputs. An Active Output is symbolized by a right-pointing arrow inside a circle. The same symbol with a diagonal slash indicates an Inactive Output.

Timers. A Timer is an internal signal generated by the Multiplex program. Timers are represented as rectangles containing abbreviated labels, such as the Turn Signal Flasher at address B1-I01, labeled FLS.

Flags. A Flag symbol is identical to an Output symbol (right-pointing arrow inside a circle), but with a letter F next to it. A Flag may be thought of as similar to a function in programming; a "shorthand" way to refer to another "mini-program", or set of commands. Thus, a Flags is a kind of Output, and has its own Ladder Logic diagram. When a Flag is encountered somewhere along a Logic Line, its own Logic diagram must be examined in turn to fully investigate the circuit.

Logical "Latch Relays"

Occasionally, a particular Output may appear to be a requirement for itself. In such situations, it is helpful to realize that the Multiplex program performs the horizontal "rungs" of a Ladder in sequence, not all at once. If an initial set of conditions has made an Output true, that Output may then become one of a second set of conditions which will *keep* the Output true—even if one or all of the initial conditions changes. The Brake Interlock circuit is an example of this kind of Logic Line.



Vision MPX Simulator

Blue Bird has provided another reference tool to help technicians become more quickly acquainted with the Vision's Multiplex system. On the CD included with this manual is a file named **VisionMPXSimulator.exe.** This is a small self-running Macromedia® Flash®-based application, suitable for use on most current Windows® computers.

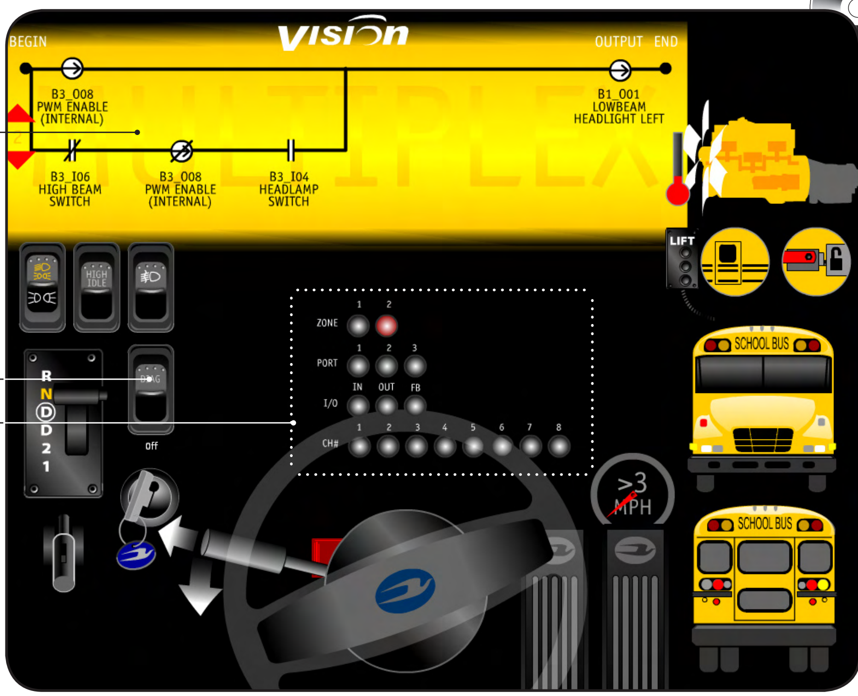
The Vision Multiplex Simulator is provided as a reference tool to help service technicians become more quickly familiar with the Blue Bird Vision's Multiplex system. It is intended for training/learning purposes only (not for actual troubleshooting). The software is only a SIMULATION of the Blue Bird Vision's Multiplex system. Although it imitates the behavior of the Vision's Multiplex Module, it does not contain the actual multiplex program. Because the actual program installed on buses is subject to change at the factory, the behavior of the Vision MPX Simulator may not exactly match that of your particular Vision unit(s).

The Vision MPX Simulator operates upon a script which imitates the logic of the Ladder Logic diagrams. Interactive on-screen controls represent the driver controls which generate Multiplex Inputs. Other animated graphic elements indicate the results of most Multiplex Outputs, as they are generated in response to the Inputs. An on-screen Diagnostic Switch allows the user to cycle the bank of "LEDs" to display Inputs, Outputs, or Feedbacks, simulating the behavior of the actual MPX Module. For reference while observing the behaviors of the LEDs, at the top of the screen is a scrolling list of the same set of Ladder Logic charts printed in this manual.

Scrollable Logic Charts

Diagnostic Switch

MBC LEDs

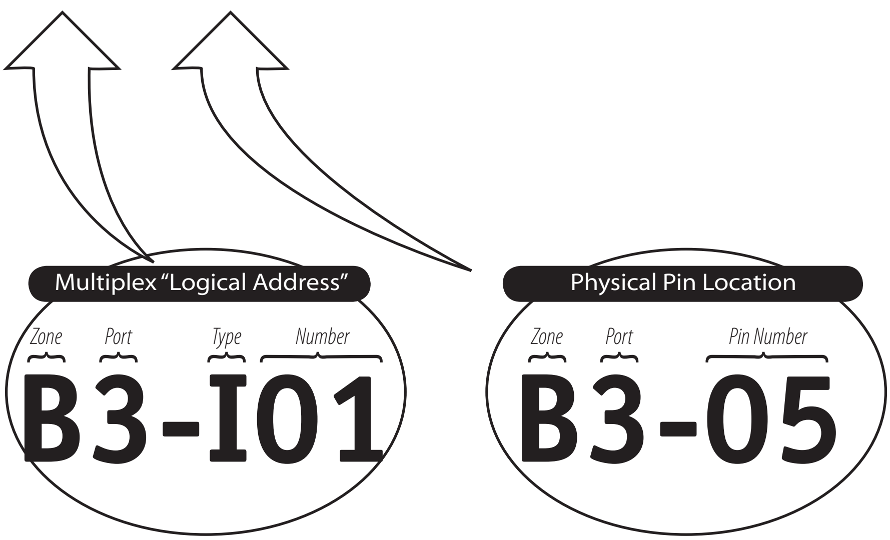


VisionMPXSimulator.exe

Input / Output Tables

Multiplex Inputs Table

	Circuit Description	Input LED	Port-Pin	Wire Color	Intput
1	Accessory Switch	B3-I 03	B3-05	Yellow	Ground
2	Brake Light Switch	B2-I 01	B2-02	Red	12 Volts
3	Diagnostic Switch	B2-I 03	B2-06	Green	Ground
4	Door Signal	B1-I 02	B1-06	Pink	Ground
5	Fan, Cooling Disable	B2-I 05	B2-10	Pink	12 Volts
6	Headlight Switch	B3-I 04	B3-08	Orange	Ground
7	High Beam Switch	B3-I 06	B3-12	Orange	Ground
8	High Idle	B1-I 04	B1-10	Green	Ground
9	Horn Signal	B1-I 06	B1-14	Grey	Ground
10	Ignition Switch	B3-I 02	B3-04	Pink	Ground
11	Interlock Feedback	B1-I 03	B1-08	Black	Ground
12	Fog Light	B1-I 07	B1-16	Red	Ground
13	Neutral Signal	B1-I 05	B1-12	Red	12 Volts
14	Park/Tail Light Switch	B2-I 04	B2-08	Brown	Ground
15	Park Brake Switch	B2-I 02	B2-04	Pink	Ground
16	Reverse Signal	B2-I 07	B2-16	Blue	Ground
17	Speed Signal	B1-I 01	B1-02	Red	Ground
18	Starter Lockout Signal	B3-I 01	B3-02	Red	12 Volts
19	Starter Switch	B3-I 05	B3-10	Purple	Ground
20	Turn Signal, Left	B3-I 07	B3-14	Yellow	Ground
21	Turn Signal, Right	B3-I 08	B3-16	Green	Ground
22	Vandal Lock	B2-I 06	B2-14	Pink	Ground
23	Spare	B1-I 08			
24	Spare	B2-I 08			



BLUE BIRD

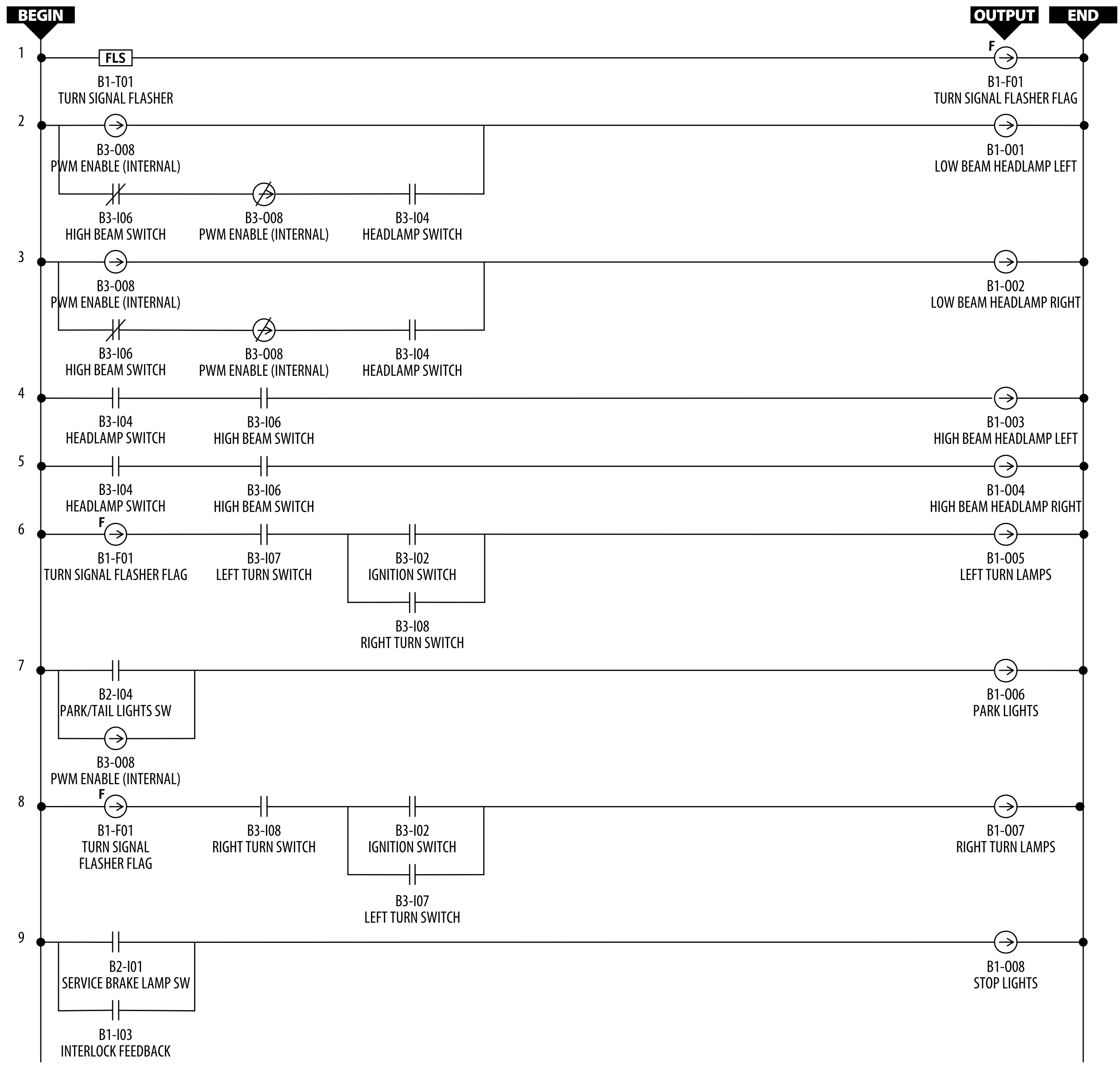
Multiplex Outputs Table

	Circuit Description	Output LED	Port-Pin	Wire Color	Output	Ladder Chart Line
1	Accessory Hot	B2-0 08	B2-15	Brown	12 Volts	17
2	Back up Lights	B2-0 04	B2-07	Black	12 Volts	13
3	Brake Interlock	B3-0 04	B3-09	White	Ground	21
4	Fan Control Power	B2-0 02	B2-03	Orange	12 Volts	11
5	Fast Idle	B3-0 02	B3-03	Orange	Ground	19, (26)
6	Fog Lights	B2-0 01	B2-01	Red	12 Volts	10
7	Headlight, High Left	B1-0 03	B1-05	Green	12 Volts	4
8	Headlight, High Right	B1-0 04	B1-07	Purple	12 Volts	5
9	Headlight, Low Left	B1-0 01	B1-01	Brown	12 Volts	2
10	Headlight, Low Right	B1-0 02	B1-03	Orange	12 Volts	3
11	Horn	B2-0 05	B2-09	Black	12 Volts	14
12	Ignition	B2-0 06	B2-11	Orange	12 Volts	15
13	Ignition Dropout	B2-0 03	B2-05	Pink	12 Volts	12
14	Park Brake	B2-0 07	B2-13	Pink	12 Volts	16
15	Park Lights	B1-0 06	B1-11	Brown	12 Volts	7
16	Shift Inhibit Signal	B3-0 07	B3-15	Green	Ground	23, (29)
17	Lift Enable	B3-0 05	B3-11			22, (28)
18	Spare	B3-0 06	B3-13			
19	Daytime Running Lights	B3-0 08				24, (30)
20	Starter Signal	B3-0 03	B3-07	White	Ground	20, (27)
21	Stop Lights	B1-0 08	B1-15	Red	12 Volts	9
22	Throttle Interlock	B3-0 01	B3-01	Brown	Ground	18, (25)
23	Turn Signal, Left	B1-0 05	B1-09	Yellow	12 Volts	6
24	Turn Signal, Right	B1-0 07	B1-13	Green	12 Volts	8

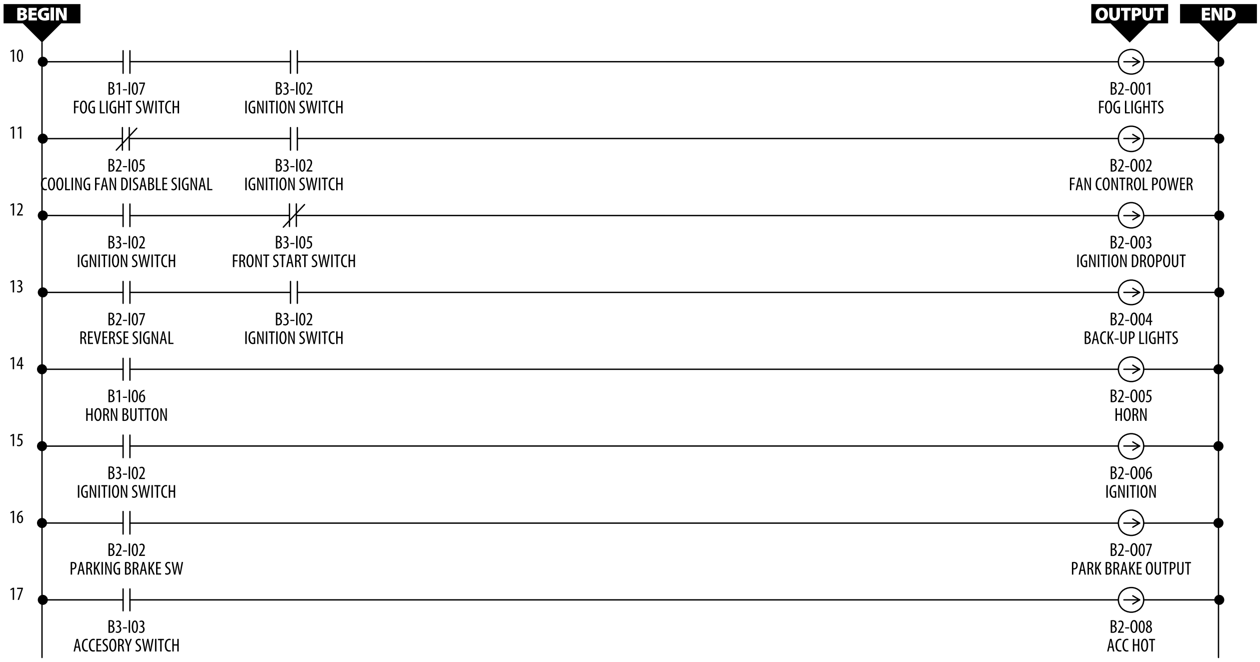
Ladder Logic Diagrams

Symbols Key

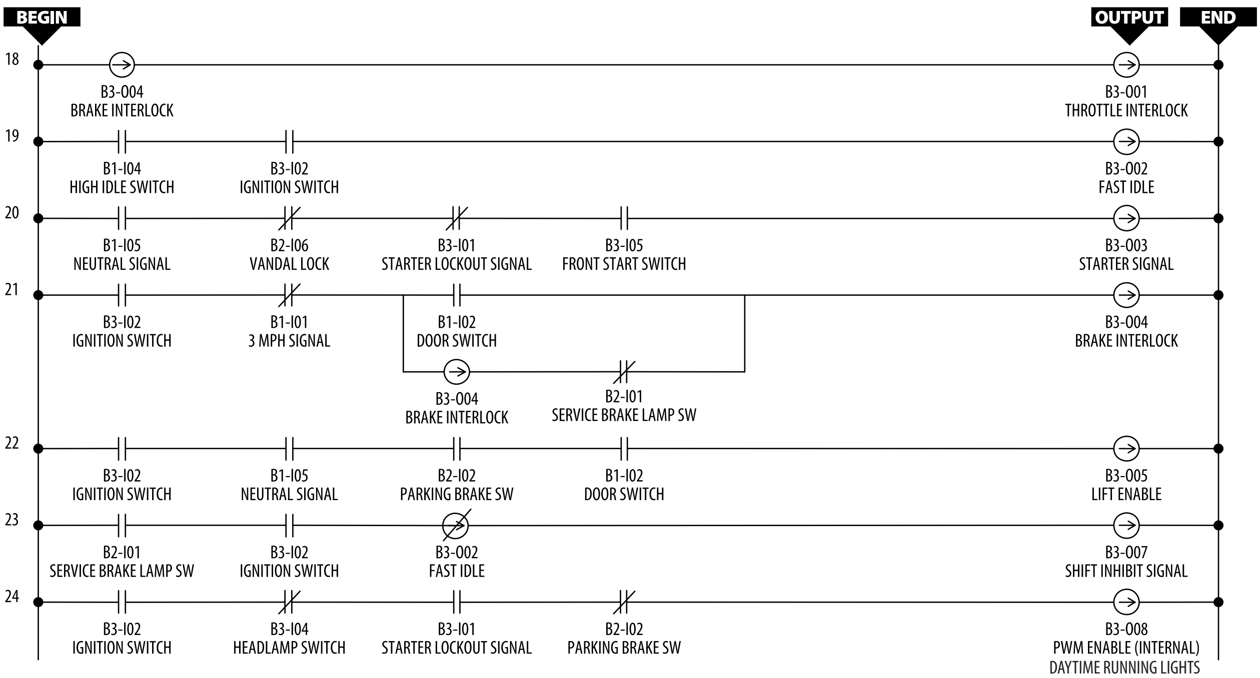
Logic Lines for B1 Outputs



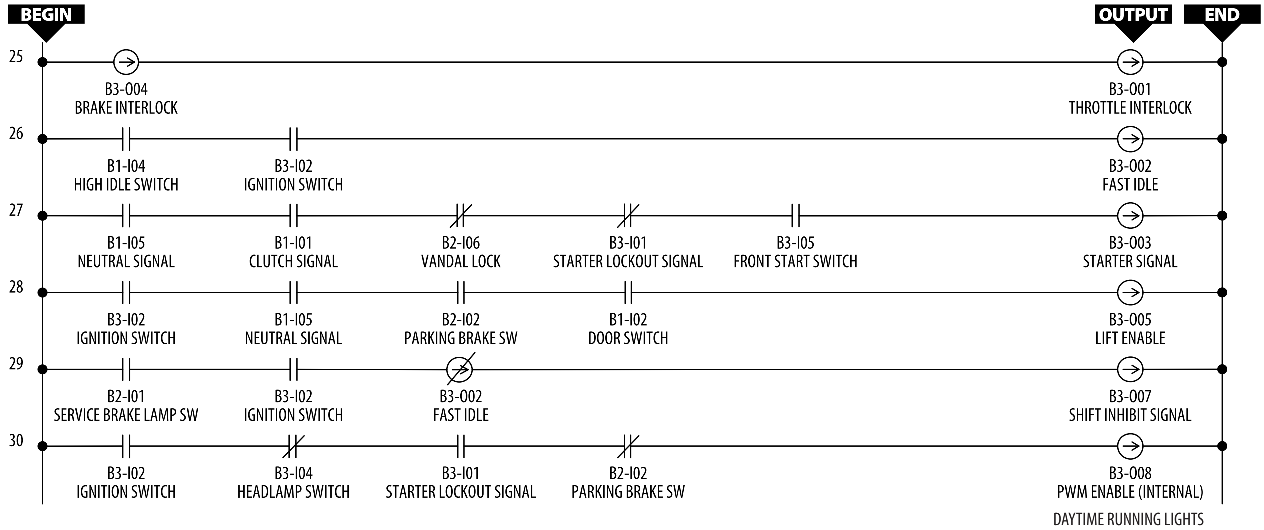
Logic Lines for B2 Outputs



Logic Lines for B3 Outputs



Logic Lines for B1 Outputs (With Manual Transmission)



Troubleshooting In Diagnostic Mode

General Approach

A systematic approach to electrical troubleshooting of the Blue Bird Vision follows these general steps:

1. **Check the Inputs and Outputs Tables.** First determine if the affected circuit is one which interacts with or is controlled by the Multiplex system. Note the circuit's logical address (Zone-Port-Input/Output #) and its physical location (Port Pin). (If the issue is not a Multiplex circuit, refer to the Electrical System chapter and appropriate wiring schematics to troubleshoot conventionally.)

2. **Check the Output.** Operate the appropriate bus controls or switches to set the conditions which are required for the circuit's Output to be Active. (Refer to the Ladder Logic Diagrams to determine the required conditions.) If the MPX Module is generating an Active Output signal, but the circuit is not operational, at least part of the problem exists "downstream" of the Multiplex logic; probably in the Output's own load circuit. That is, since the Output signal is present, there is no reason at this point to suspect the "upstream" circuits of Inputs or other Outputs which are requirements of the desired Output. Troubleshooting efforts should be focussed upon the circuit beginning from the Output's Port Pin, through the load, and to ground.

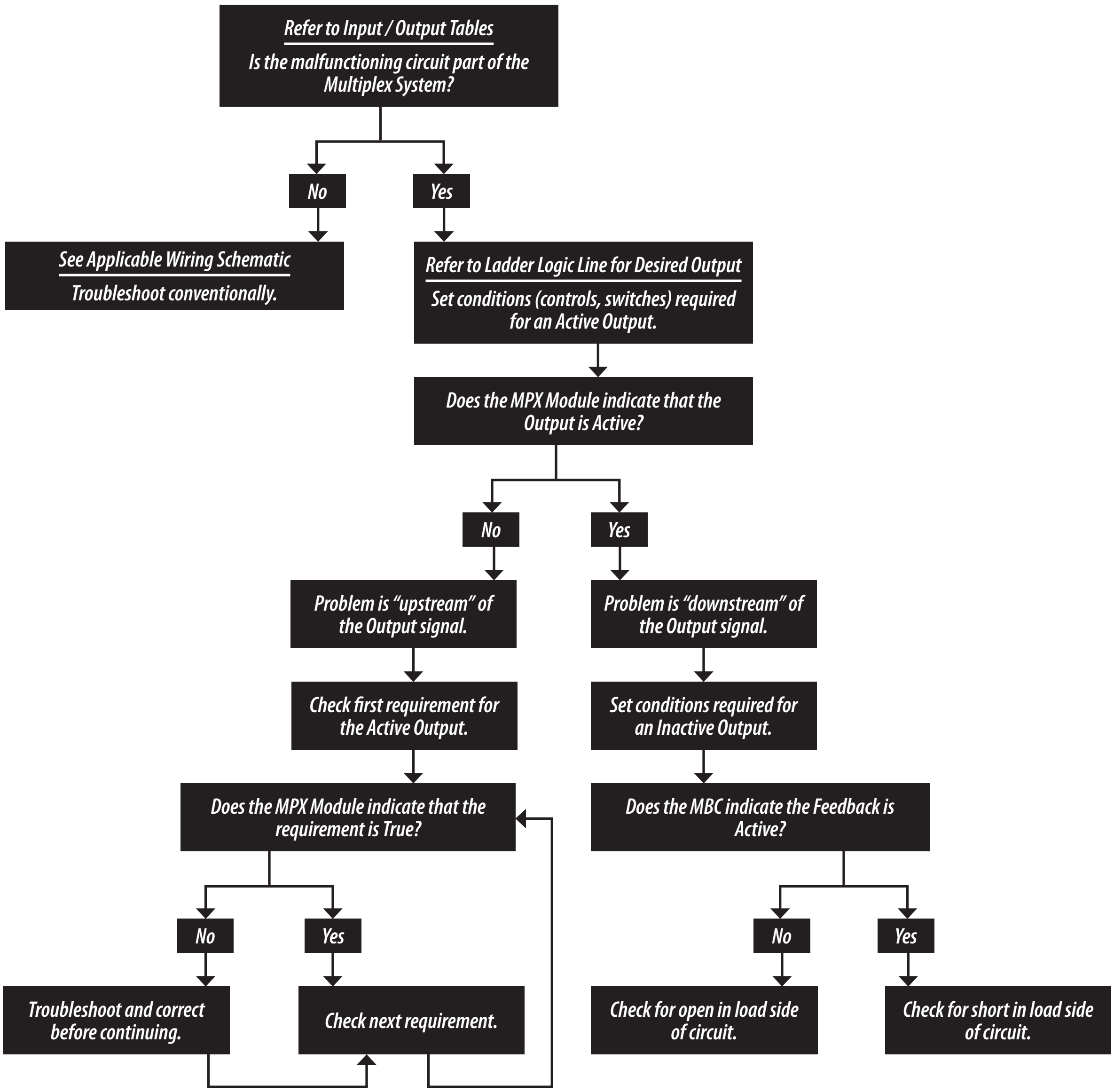
3. **Check the Feedback.** To further verify that the problem exists in the load circuit, and to possibly gain additional information about its nature, create conditions (turn off switches, etc.) which should cause the Output to be Inactive. Then verify that the circuit's Feedback LED is on. If the Feedback LED is off when the Output is Inactive, an open is indicated in the load circuit, because the Feedback signal is not being conducted through the load. If the Feedback LED of a malfunctioning load circuit is on when the Output is Inactive (as it is in a correctly functioning circuit), the Feedback signal is being conducted, and you at least have an indication of continuity. If the Feedback LED is on while the Output is Active, a short in the load circuit is indicated.

4. **Check Each Requirement.** If the desired Output is shown by the MPX Module to be Inactive when it should be Active, the problem should be assumed to be "upstream" of the Output signal; at least one of the conditions required for an Active Output signal is absent. Referring to the Ladder Logic Diagrams, begin checking each requirement's LED to verify it is correctly Active or Inactive. If a discrepancy is found, a malfunction is indicated "upstream" of that point in the logic. Thus, comparing the states of the MPX Module's LEDs against the requirements of the Ladder Logic Diagrams enables the technician to quickly "narrow down" the source of the problem.

As you proceed, remember that:

- The Logic Line for a particular Active Output may require that certain Inputs are Active while other Inputs are *In*active. It is helpful, therefore, to think of each item encountered on the Logic Line as a "statement" which is either *true* or *false* (This Input active=true; This Input inactive=true; This Input inactive=false). You seek to find and correct the false "statements."

- The set of requirements for an Active Output may include requirements that other Outputs—which have their own Logic Lines—are either Active or Inactive. In such cases, the required Output states must also be investigated according to their own Logic Lines.



Troubleshooting Example

The following example steps through a typical examination of a Ladder Logic diagram, using the Vision MPX Simulator for illustrative purposes. DoubleClick the VisionMPXSimulator.exe icon to launch it.

The Problem. This example assumes a problem with starting the bus. It will walk through an investigation of the Multiplex logic which affects starting.

1. **Refer to Input/Output Tables.** The tables reveal that the Multiplex system does indeed contains logic affecting several circuits having to do with starting the bus. The MPX Module receives Inputs named Ignition Switch, Starter Lockout Signal, and Front Starter Switch. Outputs are generated by the MPX Module named Ignition, Ignition Dropout, and Starter Solenoid. Often, by merely considering these listings we can gain "hints" regarding how the Multiplex system comes into play: For example, it is easy to "guess" that the Starter Lockout Signal must be Inactive in order to start the bus.

   In this scenario, we'll assume the starter is not turning, and therefore begin our investigation with the Starter Signal Output. We note that the physical pin location for this Output is B1-15 (Port 1, pin number 15). The Outputs Table lists the logical address of the Starter Solenoid Output as B3-O03 (Port 3, Ouput number 3), and also shows that that Output is on line #20 of the Ladder Logic diagrams.

Multiplex Inputs

	Circuit Description	Zone/Port-Input #	Port-Pin
1	Accessory Switch	B3-I 03	[illegible]
2	Brake Light Switch	B2-I 01	[illegible]
3	Diagnostic Switch	B2-I 03	[illegible]
4	Door Signal	B1-I 02	[illegible]
5	Fan, Cooling Disable	B2-I 05	[illegible]
6	Headlight Switch	B3-I 04	[illegible]
7	High Beam Switch	B3-I 06	[illegible]
8	High Idle	B1-I 04	[illegible]
9	Horn Signal	B1-I 06	[illegible]
10	Ignition Switch	B3-I 02	[illegible]
11	Interlock Feedback	B1-I 03	B1-08
12	Fog Light	B1-I 07	[illegible]
13	Neutral Signal	B1-I 05	[illegible]
14	Park/Tail Light Switch	B2-I 04	[illegible]
15	Park Brake Switch	B2-I 02	[illegible]
16	Reverse Signal	B2-I 07	[illegible]
17	Speed Signal	B1-I 01	[illegible]
18	Starter Lockout Signal	B3-I 01	B3-02
19	Starter Switch	B3-I 05	B3-10
20	Turn Signal, Left	B3-I 07	[illegible]

Multiplex Outputs

	Circuit Description	Zone/Port-Output #	Port-Pin	[illegible]
1	Accessory Hot	B2-0 08	B2-15	[illegible]
2	Back up Lights	B2-0 04	B2-07	[illegible]
3	Brake Interlock	B3-0 04	B3-09	[illegible]
4	Fan Control Power	B2-0 02	B2-03	[illegible]
5	Fast Idle	B3-0 02	B3-03	[illegible]
6	Fog Lights	B2-0 01	B2-01	[illegible]
7	Headlight, High Left	B1-0 03	B1-05	[illegible]
8	Headlight, High Right	B1-0 04	B1-07	[illegible]
9	Headlight, Low Left	B1-0 01	B1-01	[illegible]
10	Headlight, Low Right	B1-0 02	B1-03	[illegible]
11	Horn	B2-0 05	B2-09	[illegible]
12	Ignition	B2-0 06	B2-11	[illegible]
13	Ignition Dropout	B2-0 03	B2-05	[illegible]
14	Park Brake	B2-0 07	B2-13	[illegible]
15	Park Lights	B1-0 06	B1-11	[illegible]
16	Shift Inhibit Signal	B3-0 07	B3-15	[illegible]
17	Spare	B3-0 05	B3-11	
18	Spare	B3-0 06	B3-13	
19	Spare	B3-0 08		
20	Starter Signal	B3-0 03	B3-07	[illegible]
21	Stop Lights	B1-0 08	B1-15	[illegible]
22	Throttle Interlock	B3-0 01	B3-01	[illegible]
23	Turn Signal, Left	B1-0 05	B1-09	[illegible]
24	Turn Signal, Right	B1-0 07	B1-13	[illegible]

2. **Check the Output.** To check the status of a desired Output, we must first put the MPX Module in Diagnostic Mode and cycle it to display Outputs for the appropriate Port. Press the Diagnostic Switch repeatedly until the Port 3 LED (in the PORT row) is on, and then until the Output LED (in the I/O row) is on. Click the ignition switch and note whether the #3 LED (in the CH# row) comes on when attempting to start the engine.

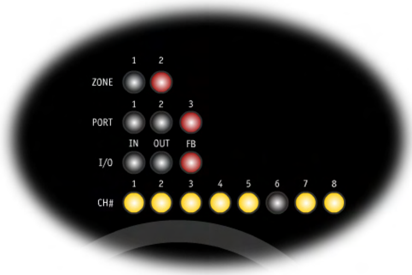
In the Vision MPX Simulator, if you try to start the engine without first applying the parking brake, the B3-003 (Starter Signal) LED will not come on. This is because the Park Brake Signal is one of the logical requirements for an Active Starter Solenoid Output.

Apply the park brake and try the ignition switch again. The B3-003 LED will flash on, providing the signal to start the engine.

3. **Check the Feedback.** If the B3-O03 LED lights when trying to start the engine, we know that the MPX Module is generating an Active Starter Signal Output. If the starter failed to operate despite the Output being Active, the cause would most likely be "downstream" of the multiplex system, in the load circuit itself (i.e.; relay, solenoid, etc.) That is, there would be no reason at this point to suspect the various circuits which are required for an Active Starter Signal Output, because the Output is Active. Even in such a case, though, further insight into the nature of a problem may be gained by checking the Feedback LED.

   Press the Diagnostic Switch once more to cycle the MPX Module to display the Feedbacks for the B3 Port circuits. In our scenario, if the Starter Solenoid's Feedback LED were on while its Output is Active, then the operating current would not be finding the lower-resistance path around the Feedback circuit. It would, therefore, be reasonable to suspect an open in the Starter Solenoid itself, or in the wiring between it and its port pin on the MPX Module (pin B3-07).

   If, as is normal, the Feedback LED is off while the Output is Active, then the circuit should be operative because full working current is bypassing the Feedback resistor. If the Starter Solenoid is not operating during these indications, then it would be reasonable to suspect that the current is finding another path by which to bypass the Feedback circuit; in other words, a short may be present in the Starter Signal Output circuit.



Here, the LEDs are displaying Feedbacks for the B3 Outputs. The #3 LED is on, because the B3-001 Output (Starter Signal) is Inactive. The presence of the Feedback LED is indicating that the load side ciruit has continuity.

If you try to start the bus without first applying the parking brake, the #3 LED will simply remain on, because the Starter Signal Output does not go Active.

Apply the park brake and try the ignition switch again. You will see the #3 Feedback LED flash off while the engine starts. This indicates that operating current for the starter has been provided a lower-resistance path by which to bypass the Feedback resistor (and start the engine).

Thus, in cases where the desired Output is Active, but the circuit is still inoperative, the Feedback LED can help indicate whether the probable cause is an open or a short.

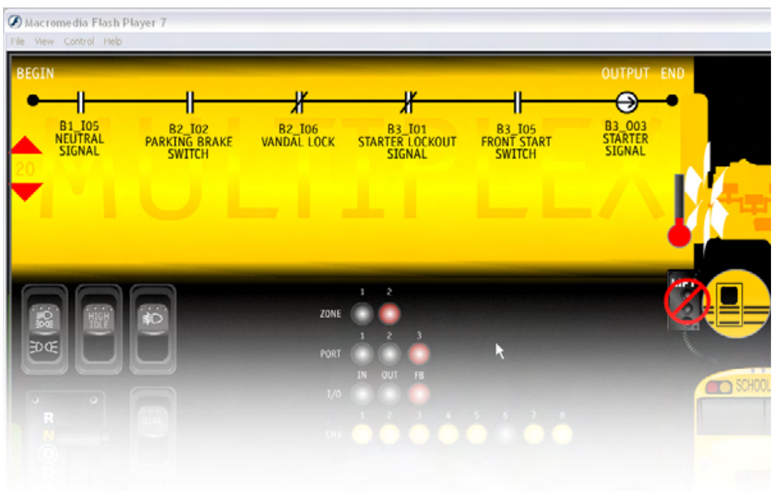
But what if a desired Output is Inactive? Even then it is still good practice to check the Feedback LED before proceeding to verify the presence of each requirement for an Active Output. In our example, we know that if the Starter Signal is Inactive, we should see its Feedback LED on, indicating that continuity exists in the Starter circuit, and that it should become operative when the Output becomes Active. But if the Feedback LED were off while the Output is Inactive, then we would already have an indication of an open in the Starter circuit, and that the Starter will not work even when the requirements for an Active Starter Signal Ouput are met.

4. **Check Each Requirement.** At this point in our example, we assume that the Starter Solenoid Output is Inactive, and that the Feedback LED is on, as it should be. It is now safe to assume that any starting problem must be "upstream" of the load circuit itself. We must begin to systematically ensure that each of the requirements for the Starter Solenoid Output be active is met. It is now time to refer to the Ladder Logic diagram.

   As indicated in the Output Table, Logic Line # 20 is the one which leads to an Active Starter Signal Output. Click the yellow tab at the upper left of the Vision MPX Simulator to reveal a scrolling list of the Ladder Logic diagrams. Click the red down arrow to scroll down to line 20.

   Reading from left to right, we see that the requirements for an Active Starter Signal are:

   - The Neutral Signal Input at logical address B1-I05 must be Active.
   - The Parking Brake Switch Input at B2-I02 must be Active.
   - The Vandal Lock Input at B2-I06 must be Inactive.
   - The Starter Lockout Signal Input at B3-I01 must be Inactive.
   - The Front Start Switch Input at B3-I05 must be Active.



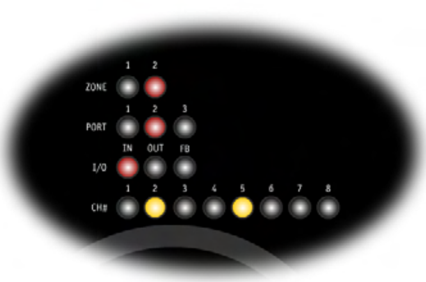
The Vision MPX Simulator includes a scrolling display of Ladder Logic diagrams.

Our procedure, then, is to systematically set the controls which operate each of these requirements and verify their Active or Inactive status:

4.1. Verify that the transmission shift lever is in Neutral. Press the Diagnostic Switch enough times to cycle the MPX Module LEDs to display B1 Inputs. If the #5 Input LED were not on, at least part of the problem would have already been isolated. In this case, you would then refer to the wiring schematic for the Neutral signal switch and troubleshoot that circuit. Since the B1-I05 LED is on, the Input is Active as it should be, and we proceed to step 2.

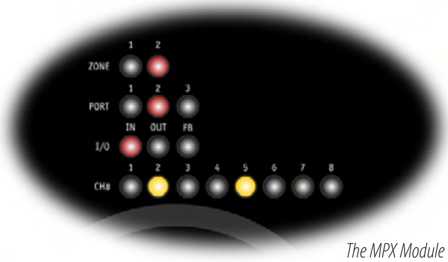
The MPX Module is displaying B1 Inputs. Input #5 (Neutral Signal) is Active.

4.2 Apply the Parking Brake. Press the Diagnostic Switch until the LEDs are displaying B2 Inputs. You will see that the #2 LED is on. Click the parking brake a few times to see that the #2 LED is on whenever the park brake is applied. If it were not, an examination of the Park Brake Switch and its wiring would be in order.



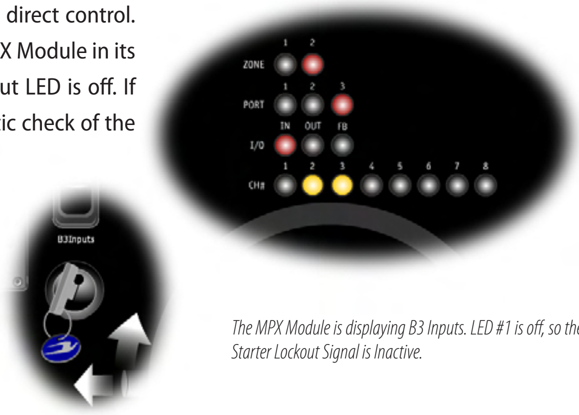
The MPX Module is displaying B2 Inputs. Input #2 (Parking Brake Switch) is Active.

4.3 Make sure the Vandal Lock is not on. This is another B2 Input, so the MPX Module is already in the proper display mode from Step 2, above. However, now we are looking for an *In*active Input, not an Active one. Verify that the #6 Input LED is off. If the B2-I06 Input LED were to stay on while the Vandal Lock was unlocked, it might be suggestive of a stuck or shorted Vandal Lock signal switch. Again, you would refer to the appropriate wiring schematic and troubleshoot that circuit.



The MPX Module is displaying B2 Inputs. LED #6 (Vandal Lock Signal) is off—satisfying a requirement for an Inactive Input.

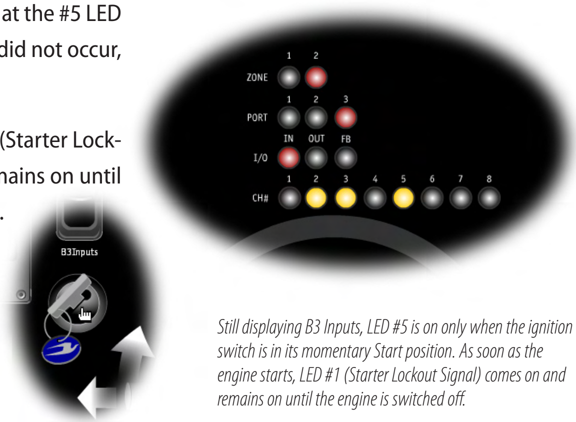
4.4 The fourth requirement is also for an Inactive Input; the Starter Lockout Signal. The Starter Lockout Signal is generated by the engine ECU to prevent the starter from engaging if the engine is already running. Therefore, it is not an Input over which the Driver has direct control. He controls it indirectly by starting the bus. Put the MPX Module in its display mode for B3 Inputs and verify that the #1 Input LED is off. If it were on when the engine is not running, a diagnostic check of the engine ECU would be in order.



The MPX Module is displaying B3 Inputs. LED #1 is off, so the Starter Lockout Signal is Inactive.

4.5 Finally, the Front Start Switch Input must be Active. This is a signal from the ignition switch when it is turned to the Start position. The MPX Module is already displaying B3 Inputs, and the #5 Input LED is off. Press and hold the ignition switch and you will see that the #5 LED comes on while the switch is in the Start Position. If this did not occur, the ignition switch or its wiring would be suspect.

Notice also that as soon as the engine starts, the #1 LED (Starter Lockout Signal, described above in Step 4) comes on and remains on until you click the ignition switch again to turn off the engine.



Still displaying B3 Inputs, LED #5 is on only when the ignition switch is in its momentary Start position. As soon as the engine starts, LED #1 (Starter Lockout Signal) comes on and remains on until the engine is switched off.

At this point, you have verified the presence of a full set of conditions required for an Active Starter Signal Output, and the starting circuit should be functional. If you experiment with the MPX Simulator by changing any of the required conditions, you will see that when any of the requirements are not met, the B3-O03 Output will not be Active, and the engine will not start. This example has shown that the Multiplex Diagnostic Mode can be used to quickly isolate the location of an electrical system malfunction in a circuit with which the MPX Module interacts. (For example, consider how much time might be spent in determining that the cause of a starting problem is a damaged parking brake switch, without the benefit of multiplex.) Note that the use of Multiplex does not negate or invalidate traditional means of tracing and troubleshooting circuits, but serves to eliminate much of the preliminary guesswork in determining which circuit(s) to investigate.

In a real-case scenario, only after verifying all the required conditions, yet still finding the Output to be Inactive and/or the circuit inoperative, should there be reason to suspect a failure of the MPX Module itself. Remember that all Input and Outputs can be verified using a multimeter at the associated port/pin locations. In the unlikely case that you have thorougly investigated the Multiplex Logic and have come to suspect a defective MPX Module, you may wish to contact your Blue Bird Distributor's service technicians for a second opinion verification of your troubleshooting.

Shared Logic

To avoid confusion when reading Ladder Logic and trobleshooting, remember that the requirements shown on a Ladder Logic line are only requirements for the MPX Module to make the Output indicated at the end of the line Active. It is possible for other conditions to be required beyond the scope of the Multiplex system. In the present implementation of Multiplex on the Blue Bird Vision, one such "special case" is the Fast Idle logic, shown on line 19 of the Ladder Logic charts.

Line 19 shows two requirements for an Active Fast Idle Output: an Active High Idle Switch Input and an Active Ignition Switch Input. Technicians familiar with High Idle may notice the absense of other conditions which must exist in order for High Idle to actually occur: the park brake must be applied, and the transmission must be in neutral. This apparent omission is explained by the fact that the Caterpillar ECM, not the MPX Module, actually controls the idle speed. The Active Fast Idle Output from the MPX Module is one of three signals which the Caterpillar ECM requires before it engages Fast Idle: the other two are the "missing" requirements which it receives directly from the transmission and brake system.

In other words, Logic Line 19 is correct because only the High Idle Switch and Ignition Switch are required for the MPX Module to generate an Active Fast Idle Output; but Neutral and Park Brake are also required for the engine ECM to cause High Idle to actually occur. In this sense, even though the MPX Module and engine ECM are separate processors which do not share programming, they work together to "share" the logical requirements for a particular function. The Active Fast Idle Output from the MPX Module alone does not cause the actual occurance of High Idle; it serves as but one of the ECM's requirements.