CHAPTER 2

THEORY OF OPERATION

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (continued)

LIST OF TABLES

2-1 GENERAL

The ATC system description in this chapter is divided into the following sections:

- o redundancies,
- o system level inputs and outputs, and
- o interdependent subsystems and functions.

See section 2 of the engineering documentation on vehicle automatic train control system for detailed circuit descriptions.

2-1-1 REDUNDANCIES

For safe and reliable train operation, the ATC system includes redundant channels for most signals. For discussion purposes, the three channels are called:

- o operational and safety leader (ATP1 or ATP2),
- o operational and safety backup (ATP1 or ATP2), and
- o safety backup (ATP3 only).

A. The leader and backup are exact duplicates of one another. Both can perform operational and safety functions. These channels reside in ATP1 and ATP2 modules. Select two of the three ATP (ATP1, ATP2, and ATP3) modules by turning them on at the power panel. Then use the leader select (mode) switch on the power panel (see Figure 1-2-5) to select ATP1 or ATP2 as the leader module. Only the leader LRU can perform the operational functions. Safety functions are performed by the leader and the second chosen ATP (redundance and cross-checking for safety).

B. The safety backup processes only safety related functions, such as door and brake operation. This channel resides in ATP3 module. It cannot be selected as the leader, since it has no operational capabilities.

C. The train can operate as long as a leader and at least one backup ATP module is powered up and functioning properly. If a fault is detected in the leader channel, the following events occur.

1. The ATC system stops the train.
2. The operator turns off the failed electronic module (ATP1 or ATP2).
3. The operator reports the SET information displayed on the LCD display (see subsection 2-1-4).

4. The operator then selects the alternate channel (ATP1 or ATP2) as the new leader.

D. If a fault is detected in either backup channel, the operator is notified (SET address reported on LCD by ATP1 and ATP2 only), and the train stops. The operator turns off the failed electronic module, then continues to operate in the automatic mode.

E. If more than one cradle channels fail, the train comes to a halt and can be moved through manual operation only.

F. In the rest of this chapter, it is assumed that only the leader (either ATP1 or ATP2) and safety backup (ATP3) electronic cradles are powered on and functioning properly.

2-1-2 SYSTEM LEVEL INPUTS AND OUTPUTS

As described in subsection 1-1, the ATC system receives information from sources outside the system, processes the information in a variety of ways, and transmits information to other systems.

A. The block diagram in Figure 2-1-1 shows all system level inputs and outputs. As shown, the ATC system receives inputs from the following sources:

1. trainlines (the cabling that connects cars in a consist), which provide information such as the number of brake cutouts and performance adjust controlling car signals;

2. wayside/track antennas, which provide signals such as door commands, program stop, speed data, and performance level;

3. car body and various components outside the ATC frame, which provide car motion, tachometer signals, battery power, keyswitch and master control selector switch (MCSS) signals, manual door commands, door status, and flipper door status (C-car).

   NOTE: *On the A-car, flipper door status is hardwired closed, since this car has no flipper door.*

   NOTE: *On the C-car, power to the ATC is routed through the flipper door contact. If the flipper door is opened, ATC power is cut and the car comes to a halt.*

4. train operator, which provides information in the form of console keypad entries (including data logging control), train ID, and train length selection and verification; and

5. maintenance technician or test equipment, which provides test signals and wheel wear data entered by tech at DIP on XA5 board.

B. The ATC system processes the information and makes decisions based on the processed signals. (Subsections 2-2 through 2-6 explain how the signals are processed.) The system then sends outputs to the following destinations.

1. External components and systems -- These outputs are commands to operate doors, sound chimes, turn on/off the public address system, and display speed command data.

2. The trainlines (and from there, to systems) -- These outputs are propulsion, brake and performance adjust (noncontrolling car) signals.

3. The wayside antenna tape -- These outputs are status signals, such as train identification and door open.

4. The train operator or technician -- These outputs are status and diagnostic information in the form of liquid crystal displays, LED indicators, and an audible buzzer.

5. External test equipment (and from there, to the technician) -- These outputs are test and diagnostic data.

C. External Control Switch Positions

Although the master control selector switch (MCSS) and the keyswitch are not part of the ATC system, the positions of these switches are crucial to ATC system operation.

1. The keyswitch establishes which car in a consist controls the train. In the lead car, the keyswitch must be ON. In all other cars of the consist, the keyswitch must be OFF. In the rest of this chapter, unless otherwise noted, the discussion relates to a lead car with the keyswitch ON.

2. The MCSS has four possible positions.

   a. AUTO -- With the MCSS in the AUTO position, the ATC system is fully operational, controlling both train movement and door opening/closing.

   b. ROAD MANUAL -- If the MCSS is set to ROAD MANUAL, ATC system enables door operation and transmits ID and door open, but not train movement. All ATC subsystems remain active, but they are not used to control train motion. In ROAD MANUAL position, the operator must push the door open pushbutton to open the doors, if the door open command is present from wayside.

   c. YARD MANUAL -- When the MCSS is in the YARD MANUAL position, the ATC system is disconnected from the trainlines, so there is no ATC control. Door open signal is transmitted but door operation, train movement and ID transmit are inactive.

   d. OFF -- When the MCSS is in the OFF position, there is no transmission and no control.

3. Throughout this chapter, unless otherwise noted, the discussion assumes that the MCSS is set to AUTO.

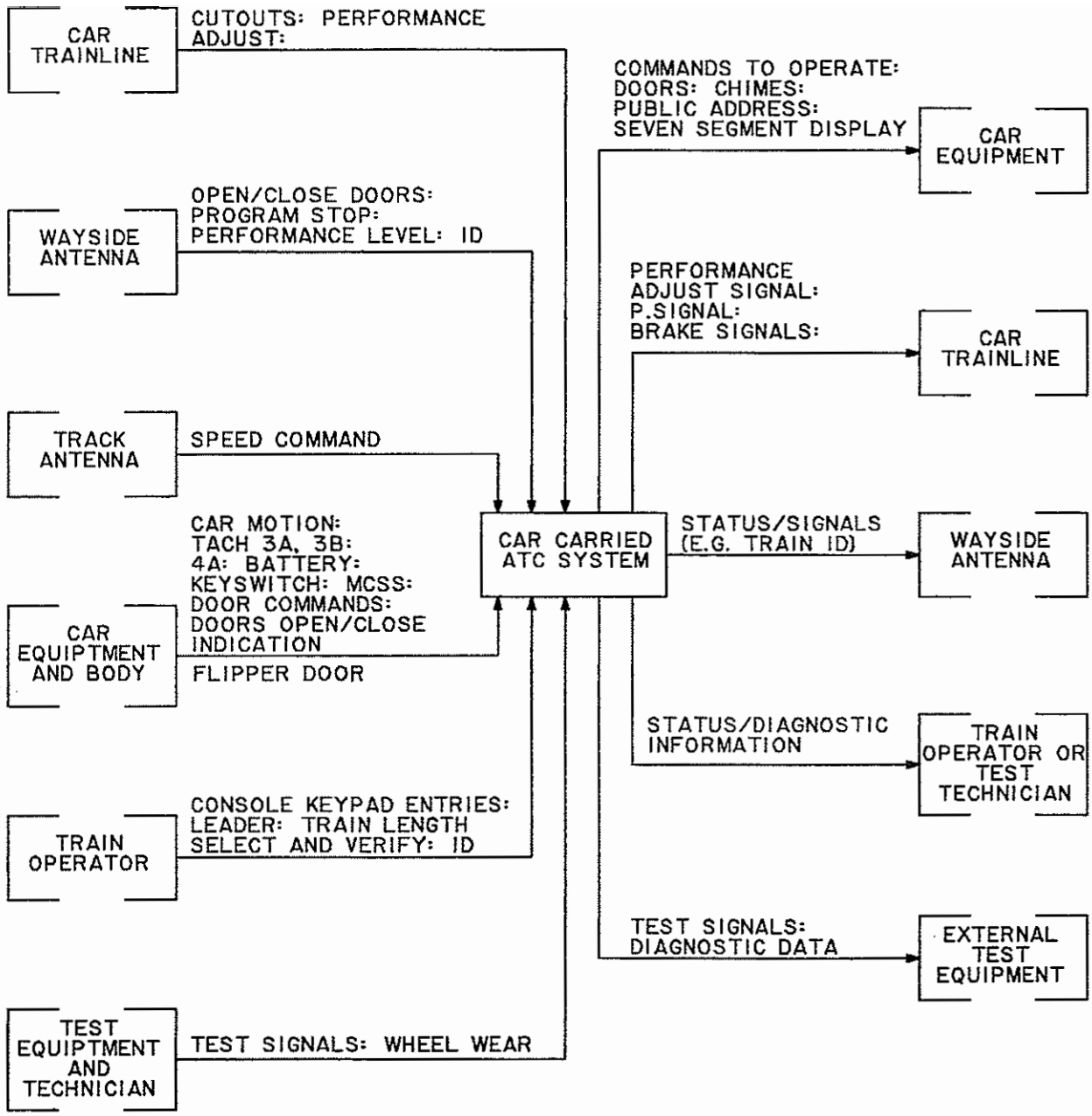

FIGURE 2-1-1. SYSTEM-LEVEL INPUTS AND OUTPUTS

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2-1-3 INTERDEPENDENT SUBSYSTEMS AND FUNCTIONS

A. As noted in subsection 1-3, the ATC system has five subsystems. These subsystems are described in detail in the following subsections:

1. motion control, subsection 2-2.

2. wayside communications, subsection 2-3.

3. door control, subsection 2-4.

4. console communications, subsection 2-5.

5. system monitoring, subsection 2-6.

B. For each subsystem, functional diagrams trace the flow of signals between the LRUs identified in subsection 1-2. The signal processing within LRUs is covered in the secondary maintenance manual.

C. Although the five subsystems are functionally discrete, they are not independent. The five subsystems use the same hardware and exchange signals back and forth. For example, the system monitoring subsystem uses signals produced by each of the other subsystems.

D. The block diagram in Figure 2-1-2 shows the exchange of signals between subsystems. Because this signal exchange takes place within the electronic cradles, the exchange does not appear on the functional diagrams for each subsystem. The text accompanying each diagram explains how the exchange takes place.

E. Table 2-1-1 lists the functions each subsystem performs.

F. Each subsystem is explained in terms of the functions that it performs. The signal traces for each function are discussed under the following headings:

- o external inputs,
- o internal inputs,
- o signal processing, and
- o internal outputs.
- o External Outputs

1. External inputs traces all signals required by a function supplied by systems, components, or individuals outside the ATC system. Under this

heading, the signals are described from the point at which they enter the ATC system until they enter one or more of the electronic modules.

2. Internal inputs refers to signals that are supplied by other ATC subsystems or functions.

3. Signal processing describes, in very general terms, how the signal is used, analyzed, or modified by the electronic modules.

4. Internal outputs refers to signals generated by a function used by another ATC function or subsystem.

5. External outputs traces signals leaving the electronic modules to the point at which they exit the ATC system.

TABLE 2-1-1. ATC SUBSYSTEMS AND FUNCTIONS

SUBSYSTEM	FUNCTIONS
Motion Control	Motion Control Integrity Checking Speed Reference Generation Speed Control
Wayside Communications	Reception from Wayside Transmission to Wayside
Door Control	Command Reception Door Decoding Door Platform Relay Driving Advanced Door Opening
Console Communications	Console End Functions ATC End Functions
System Monitoring	Data Logging Diagnostics

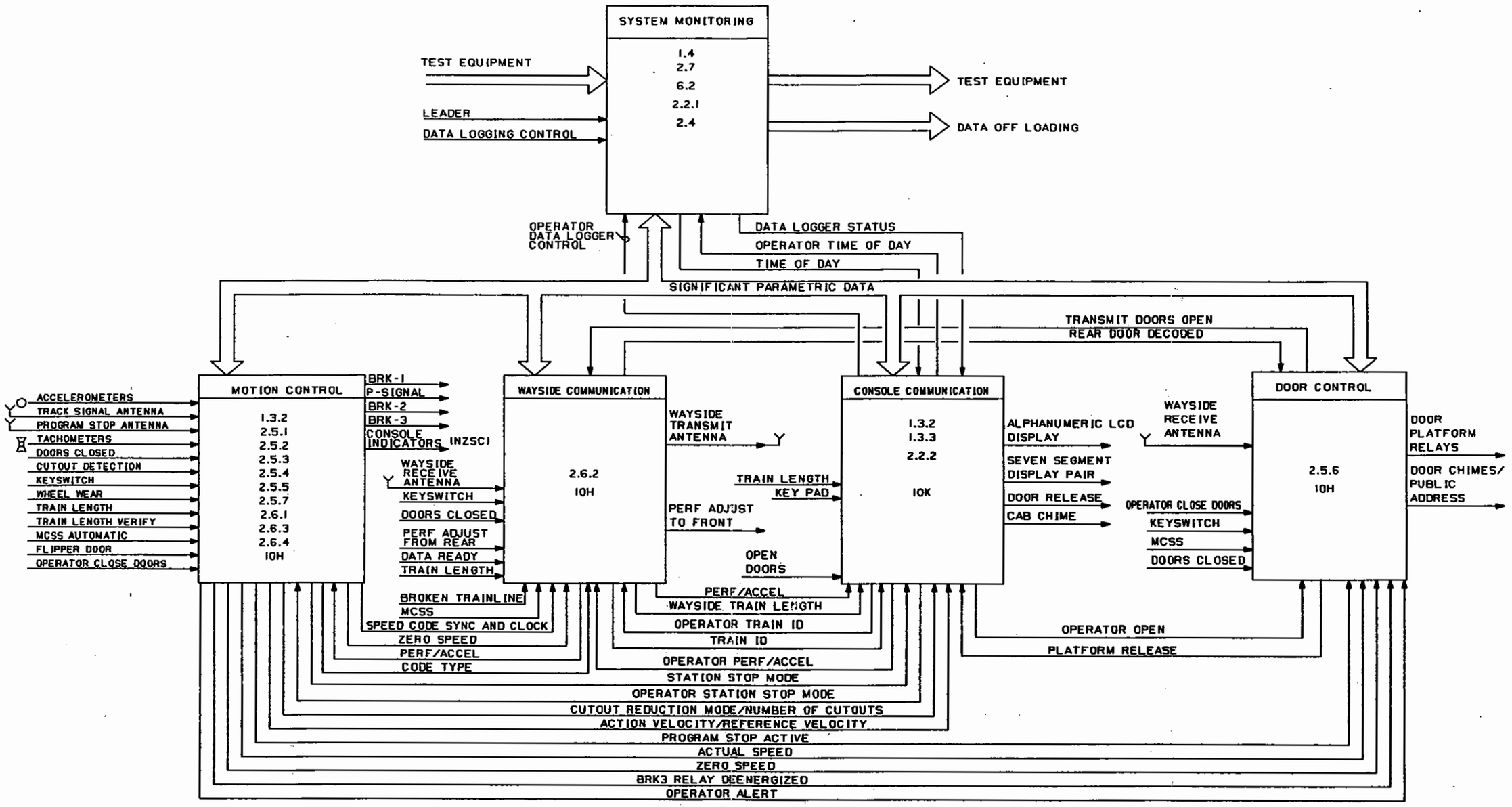

FIGURE 2-1-2. SIGNAL EXCHANGE BETWEEN SUBSYSTEMS

2-1-4 SET (SAFETY ERROR TERMINATION)

This is a set of program routines resident in the ATC ROMs which check for safety related problems in the ATC.

The routines are performed sequentially by the ATP microprocessors. When an error is detected, the ATC shuts down the car and sends a SET number to the operator's LCD module. The SET appears on screen I of the LCD (see Figure 2-1-3).

The underlined areas in Figure 2-1-3 indicate location of the SET numbers. The first underlined area is reserved for an alphanumeric display (such as D200) when ATP1 is selected as either leader or backup. The second underlined area is reserved for a similar alphanumeric display when ATP2 is selected as either leader or backup. An "---" in either display area indicates the corresponding ATP was not selected as either leader or backup. Since ATP3 is not programmed to communicate its SET information to the LCD, no space is allocated for an ATP3 SET.

An additional three part display in the lower right corner of the screen confirms the status of the three ATP modules. The first part of the display indicates the status of ATP1. The second part indicates the status of ATP2, and the third part of ATP3. LDR indicates a module is the leader. BAK indicates it is the backup. OFF indicates it was not selected.

Interpreting Figure 2-1-3 in this way reveals that ATP1 was selected as leader. Since "---" appears in the second underlined area, this indicates ATP2 was not selected, so ATP3 was backup. The display in the lower right corner confirms this, reading LDR, OFF, and BAK.

Figure 2-1-4 illustrates the display if ATP2 is selected as leader and ATP1 is not selected as backup. Again, ATP3 serves as backup. This is confirmed by the display in the lower right corner (OFF, LDR, BAK).

If you select ATP1 as leader and ATP2 as backup, or vice versa, an alphanumeric display appears in both underlined areas. In this case, the display in the lower right corner reveals which module is leader and which is backup. Figure 2-1-5 shows the LCD display if you select ATP2 as leader and ATP1 as backup. The alphanumeric display D200 appears in both underlined areas, and the display in the lower right corner reads BAK, LDR, OFF.

The SET number displayed on the LCD is useful troubleshooting information for the technician. It can either pinpoint a failed LRU or direct the technician to a specific test.

The SET number for a specific fault is stored in battery backed up memory only so long as there is not a subsequent SET. If the cradle with the SET is powered up again, the first SET, which originally shut down the ATC, is overwritten by the second SET.

This is because there is only a single memory space for a SET number per CPU configuration, and memory space cannot be commanded not to accept the next SET

number. To make sure the SET and the diagnostic information it represents is maintained for the technicians, the operator must record the SET number from the LCD display.

Therefore, the operator must report the SET number to dispatch when the operator reports a system shutdown. The SET of ATP3 is maintained in memory. It can be read by the MBL in the repair area as long as ATP3, or the ATP module used as the backup, does not have its data logger cycled off, then on again, to accept another SET number.

The SET number is recorded at dispatch for the technician to recover when the car is repaired. Each SET number has a corresponding SET Diagnostic Report (Table 3-3-1). Each SET diagnostic consists of a description of the failure and a suggested action.

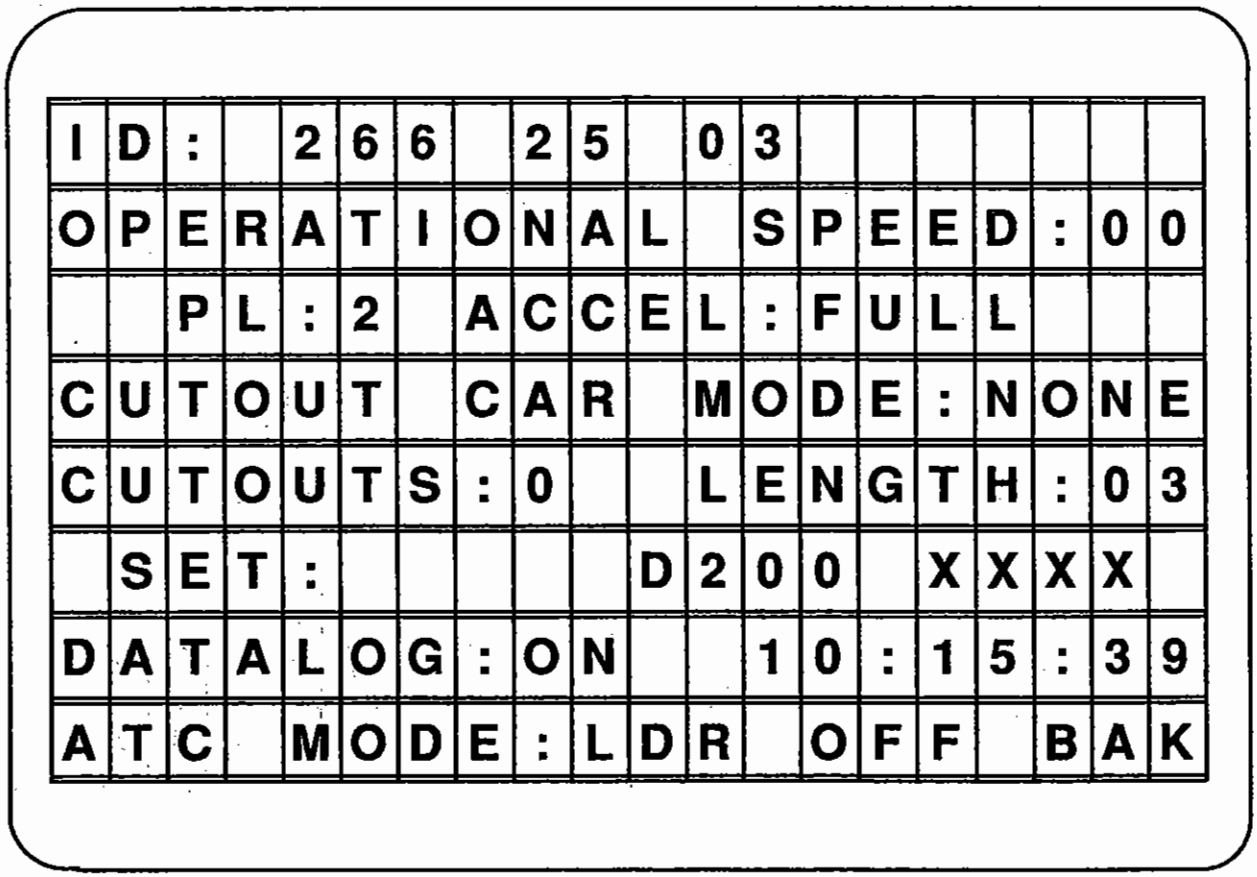

FIGURE 2–1–3. SET REPORT, ATP1 AS LEADER

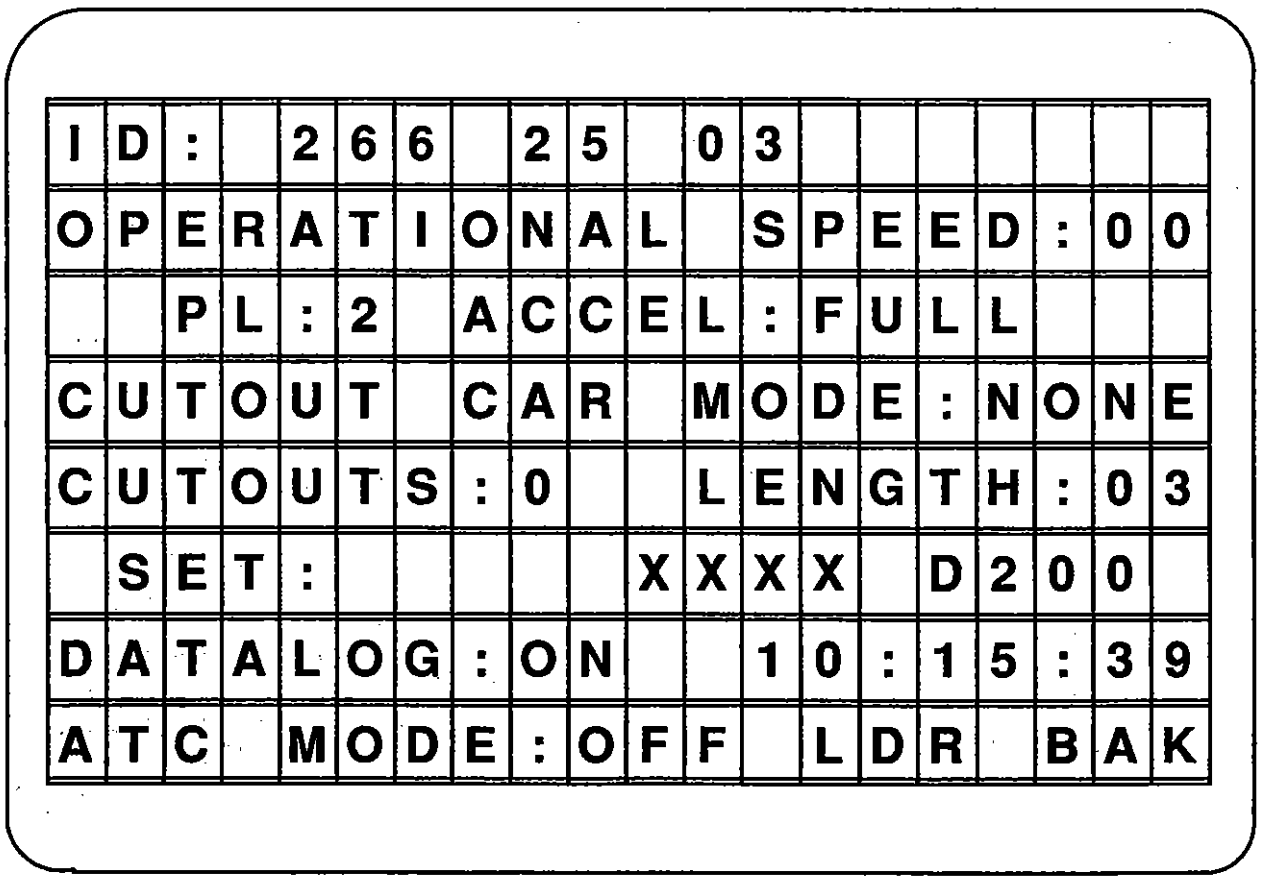

FIGURE 2–1–4. SET REPORT, ATP2 AS LEADER

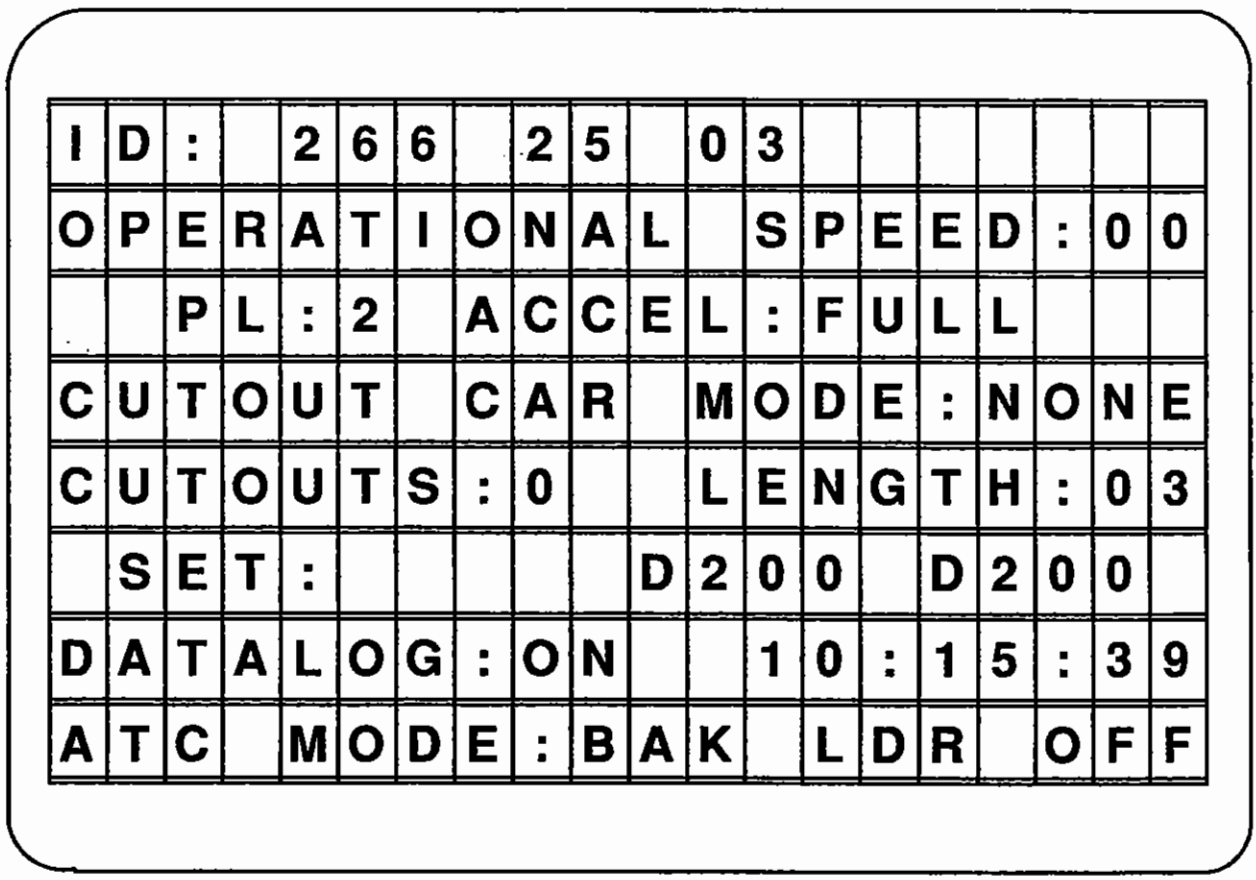

FIGURE 2–1–5. SET REPORT, ATP1 AND ATP2 ONLINE

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2-2 MOTION CONTROL SUBSYSTEM

The motion control subsystem controls train movement and stopping. The subsystem receives and processes speed commands and location information for station stopping from the wayside. The subsystem also compares actual vehicle performance with desired performance and considers any differences as errors. These errors are reduced to bring performance within acceptable limits. The motion control subsystem performs the following functions:

- o motion control integrity checking, and
- o speed reference generation.

2-2-1 MOTION CONTROL INTEGRITY CHECKING FUNCTION

The primary purpose of the motion control integrity checking function is to provide safe control of vehicle braking. This function controls what might be called the train's emergency brake. It stops the train in an emergency, prevents the train from moving after it has stopped at a station, and prevents rollback. The speed control function (see subsection 2-2-3) controls braking to slow the train and bring it to a planned stop at a station.

As Figure 2-2-1 shows, the motion control integrity checking function receives information from tachometers and trainlines. Information is processed to determine the condition of doors, tachometers, and train motion. When the conditions indicate the need, a braking signal is sent to the trainlines, then to the vehicle braking system.

A. External Inputs

1. The DOORS CLOSED RELAY (DCR) signal from the trainlines enters the ATC system at the interface module (A12), where noise is filtered from the signal. From there, the signal travels directly to all three electronic modules. (See Figure 2-2-1.)

2. Keyswitch, flipper door, and closed door status from the operator's console enter the ATC through ATC J1, then through the interface module (A12). There they are directed to the ATP modules.

3. There are three tachometer signals – TACH 3A, TACH 3B, and TACH 4A. TACH 3A and TACH 3B determine proper direction and zero speed (motion control integrity checking). TACH 4A is for speed reference (refer to subsection 2-2-2). The tach signals enter the ATC system through the track signal junction box. There they are routed to all three electronic modules via the interface module.

B. Internal Inputs

In addition to external inputs from the trainlines and the tachometers, this function also receives UNDERSPEED ENABLE, START-UP ENABLE, BPM, and BRK 30 ENABLE signals from the speed reference generation function. (See subsection 2-2-2.)

C. Signal Processing

1. In the electronic modules, the incoming signals are analyzed and compared. Both ATP1 and ATP2 generate a vital brake request (a low BRK 30 TRAINLINE DRIVE signal) under any of these conditions:

   a. if an ALL DOORS CLOSED signal is not received from the trainlines, indicating that any door is open;

   b. if flipper doors are open;

   c. if keyswitch is off;

   d. if both tachometer signals (3A and 3B) are not dynamic, indicating that the train is not moving or that a tachometer is defective;

   e. if the phase relationship of the tachometer signals is reversed, indicating that the train is rolling backward; and

      NOTE *Tachs 3A and 3B are oriented 90° out of phase and determine direction.*

   f. if UNDERSPEED ENABLE signals are false, indicating the train speed is greater than the SPEED COMMAND and is not in BPM.

      NOTE: *All the tachs (3A, 3B, and 4A) are compared to each other and must be within the larger of 5% or 1 mph. If this test passes, the highest tach determines speed.*

2. Under the conditions described above, each electronic module sends a BRK 3 ENABLE signal to the other module(s). If all active modules agree, ATP1 and ATP2 generate a BRK 3 RELAY DRIVER signal. However, only one output signal physically connects to the trainline, depending on the position of the leader select switch.

3. If the UNDERSPEED ENABLE and START-UP ENABLE signals from the speed reference generation function are present, tachometer signals are bypassed. The brakes are removed and the train can be started, despite the absence of dynamic tachometer signals.

D. Internal Outputs

In addition to external outputs to the trainlines, this function generates signals used by other subsystems or functions. Table 2-2-1 lists these internal output signals.

E. External Outputs

1. Both ATP1 and ATP2 send BRK 3 RELAY DRIVER, BRAKE 20, and BRAKE 30 TRAINLINE DRIVER signals through the vital relay panel.

   NOTE: The trainline driver signals are known internally as BRK 20 and BRK 30. After the vital relay, however, these signals are identified as BRK 2 and BRK 3.

   When ATP1 has been selected as the leader, the signals from ATP2 dead-end at the relay panel. Using only the signals from ATP1, the relays output a braking signal to the trainlines.

2. If the BRK 3 relay driver signal is low, the relay panel removes a BRK 2 and BRK 3 TL signal. This causes application of full brakes, and train movement stops. BRK 1 TL is always connected to B(-) at the ATC.

3. If the BRK 3 relay driver signal is high, the BRK 2 and BRK 3 TL signal is applied. In this case, the brakes are not applied, and the train is allowed to move. When this signal is high (brakes are not requested), the circuits provide 2 amps at 21.5 to 42 Vdc to the BRK 2 and BRK 3 trainline.

TABLE 2-2-1. INTERNAL OUTPUTS GENERATED BY MOTION CONTROL INTEGRITY CHECKING FUNCTION

SIGNAL	USED BY	REFERENCE
BRK 3 RELAY ENERGIZED	Door Control Subsystem	2-4
TACH COUNTS	Speed Reference Generation Function	2-2-2
FORWARD & REVERSE	Speed Reference Generation Function	2-2-2
BRK 3 RELAY	Speed Control Function	2-2-3
BRK 30 ENABLE	Speed Control Function	2-2-3
BRK 30	Speed Control Function	2-2-3

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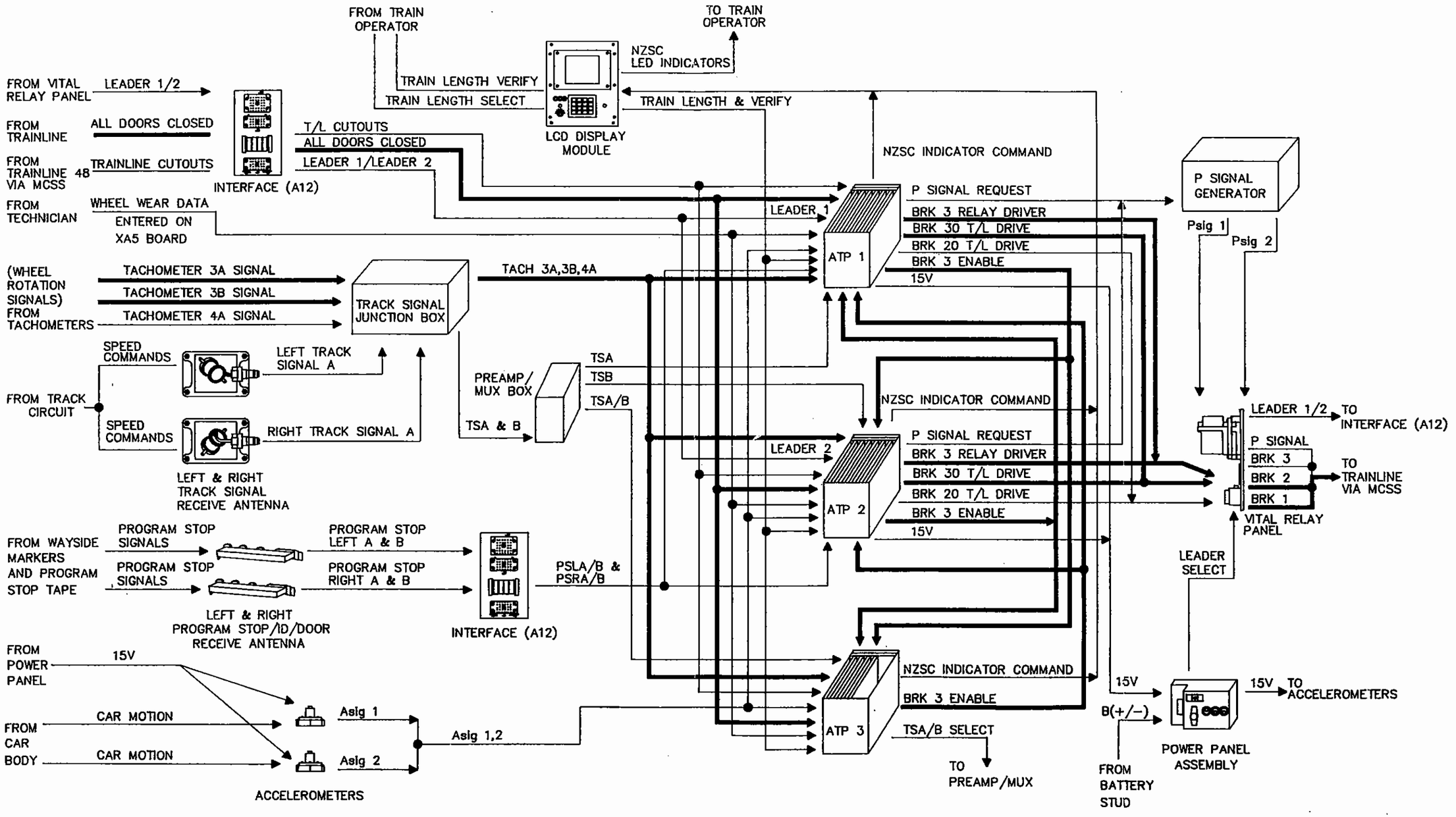

FIGURE 2-2-1. SIGNAL TRACE FOR THE MOTION CONTROL INTEGRITY CHECKING FUNCTION

2-2-2 SPEED REFERENCE GENERATION FUNCTION

The primary purpose of the speed reference generation function is to receive and process information for later use by other subsystems or functions. For example, the speed reference generation function issues modified speed commands used by the speed control function to control train movement. (See subsection 2-2-3.) Specifically, the speed reference generation function handles the following safety related operations of the motion control subsystem:

- o enabling vehicle start-up from a full stop;
- o receiving track signals;
- o decoding speed data from the tracks;
- o monitoring brake system cutouts and modifying (reducing) speed commands based on the number of cutouts;
- o modifying tach counting based on wheel wear to determine the correct train speed;
- o monitoring acceleration/deceleration during speed reduction to permit braking without dropping BRK 3 (without applying the emergency brakes);
- o detecting speed errors the difference between safe and actual speed);
- o providing a non-zero speed command indication to the train operator; and
- o providing cutout and speed data to other subsystem display.

As Figure 2-2-2 shows function receives information from various external hardware. This information generates signals required by other subsystems and functions. The only external output of this function is an LED indication to the train operator.

A. External Inputs

This function requires inputs from the train operator, the trainlines, the technician, tachometers, the track signal antenna, and the accelerometers.

1. Use the TRAIN LENGTH SELECT switch on the LCD module to indicate the number of cars (from 2 to 10) in the consist. (The consequence of selecting TL-2 is shutting down ATC, or a no-go condition). Press the TRAIN LENGTH VERIFY pushbutton to enter this information into the ATC system. The TRAIN LENGTH signal is sent from the LCD module to ATP1, ATP2, and ATP3.

2. The trainlines provide two discrete signals:

   a. ALL DOORS CLOSED signal, and

   b. BRAKE CUTOUTS signal, indicating the number of friction brake failures.

   Both signals enter the ATC system at the A12 interface card and are sent to all three electronic modules.

3. The technician indicates wheel size (wheel wear) by setting a DIP switch on the XA5 board in ATP1, ATP2, and ATP3.

4. The tachometers (3A, 3B and 4A) provide a signal which indicates wheel rotation. The signals are routed by the interface module to all three electronic modules.

5. The track provides speed command signals to the track signal receive antennas. (Incoming frequency is based on 64.2 Hz = 1 mph for a 30 inch wheel.) The track is subdivided into sections or blocks. When a speed command is selected for a specific block, the track circuit transmits the associated code to the ATC system via the track signal receive antennas, using one of these frequency pairs:

Frequency Pair	Logic Level 1s	Logic Level 0s
A	5184 Hz	7776 Hz
B	5842 Hz	8763 Hz
C	6624 Hz	9936 Hz
F	5600 Hz	8400 Hz

   a. Independent output is provided for 1s and 0s data. The 0s data is inverted and compared on a bit-by-bit basis with 1's path.

   b. Speed commands are digitally encoded using two frequencies. The code is frequency-shift-keyed, comma-free and is six bits long. Three speed code words are sent per second. Frequencies are phase reversed at the end of each bit. Four frequency pairs minimize interference between track circuits. The higher frequency is the binary 0. The lower frequency is the binary 1. This transmission scheme provides redundant data recovery, since the data represented by the logical 1 should be the complement of the data represented by the logical 0.

   c. Each antenna has one coil which generates a signal that is sent to the track signal junction box, where it is filtered. The signal is then amplified by the preamp/mux box. Based on a signal from ATP3, this box also determines which track signal is sent to ATP3. Because

ATP1 has been selected as leader, track signal TS A is sent to both ATP1 and ATP3. Track signal TS B is sent to ATP2.

6. The motion of the car body allows the accelerometers to generate a signal indicating the rate of acceleration or deceleration. These signals are sent directly to all three electronic cradles. The accelerometers do not operate without a ± 15 volt supply from the power panel assembly.

B. Internal Inputs

The speed reference generation function receives TACH COUNTS and FORWARD & REVERSE signals from the motion control integrity checking function.

C. Signal Processing

1. The non-zero speed code (NZSC) activates when a valid non-zero speed code is received from the track.

2. The TRACK SIGNAL speed commands received are encoded into a six bit, comma free code. This code is transmitted to the vehicle using a frequency shift key/phase key (FSK/PSK) modulation at an 18 Hz data rate.

3. The codes are decoded into their corresponding speed commands according to the following chart.

	BITS						SPEED COMMAND	
	A	B	C	D	E	F	(mph)	(kph)
	1	0	1	1	1	1	80	128.7
	1	0	0	1	1	1	70	112.7
SPEED	1	0	1	0	1	1	50	80.5
CODES	1	0	0	0	1	1	36	57.9
	1	0	0	1	0	1	27	43.5
	1	0	1	0	0	1	18	29.0
	1	0	0	0	0	1	6	9.7
	1	0	0	0	0	0	0	0.0

4. Twelve bits must be received before the code is considered valid. The 1s and 0s codes must agree for the last six bits.

5. The CUTOUTS signal from the trainline determines the CUTOUT REDUCTION MODE, in accordance with these rules.

   a. If there is any change in the number of cutouts, the CUTOUT REDUCTION MODE indicates that speed be reduced to 50% of the decoded speed command or that the vehicle be placed out of service, as required by Table 2-2-2.

b. To remove the 50% speed penalty, first insure that the train length switch is set to the correct number of cars in the train. Then press the train length verify push button. The ATC accepts the entry of verification only if the keyswitch is on and the train is stopped. Train length can vary between two and ten cars. (Two results in no-go.)

c. Once the system accepts the train length verification, one of three speed modes is selected from a built-in table of cutouts versus train length. The speed control function immediately begins enforcement of the selected speed mode. Table 2-2-2 shows the speed modes to be provided initially. The letter F indicates full speed, while R indicates speed reduced between full and half speed. The commanded speed from the track is reduced based on the cutout reduction mode. The resulting signal is the modified speed command.

6. MCSS automatic allows the ATC to fully operate the train.

7. Operator closed door signal requires operator action once the car is in MCSS automatic. Otherwise, the car does not run.

8. Keyswitch signal goes through A(12) to the three ATP cradles.

D. Internal Outputs

Depending on the value of the input signals, this function produces a variety of signals used by other subsystems and functions (see Table 2-2-3).

E. External Outputs

The only external outputs of the speed reference generation function are the three non-zero speed LED indicators on the LCD module. These indicators inform the operator that the train is receiving a valid non-zero speed command (NZSC). Each LED lights when the corresponding electronic module issues a NZSC INDICATOR COMMAND.

TABLE 2–2–2. CUTOUT REDUCTION MODES

F = full speed
R = reduced speed
H = half speed
▨ = zero speed

Cutouts \ Train Length	3	4	5	6	7	8	9	10
0	F	F	F	F	F	F	F	F
1	R	R	F	F	F	F	F	F
2	▨	H	R	R	F	F	F	F
3	▨	▨	▨	H	H	R	F	F
More than 3	▨	▨	▨	▨	▨	▨	▨	▨

TABLE 2-2-3. INTERNAL OUTPUTS SUPPLIED BY SPEED REFERENCE GENERATION FUNCTION

SIGNAL	USED BY	REFERENCE
SPEED CODE SYNC & CLOCK	Wayside Communication Subsystem	2-3
ZERO SPEED	Wayside Communication Subsystem	2-3
NUMBER OF CUTOUTS	Console Communications Subsystem	2-5
CUTOUT REDUCTION MODE	Console Communications Subsystem and Speed Control Function	2-5 2-2-3
ACTION VELOCITY	Console Communications Subsystem and Speed Control Function	2-5 2-2-3
ACTUAL SPEED	Door Control Sub and Speed Control Function	2-2-3
UNDERSPEED ENABLE	Motion Control Integrity Checking Function	2-2-1
START-UP ENABLE	Motion Control Integrity Checking Function	2-2-1
BPM BRK 3 ENABLE	Motion Control Integrity Checking Function	2-2-1

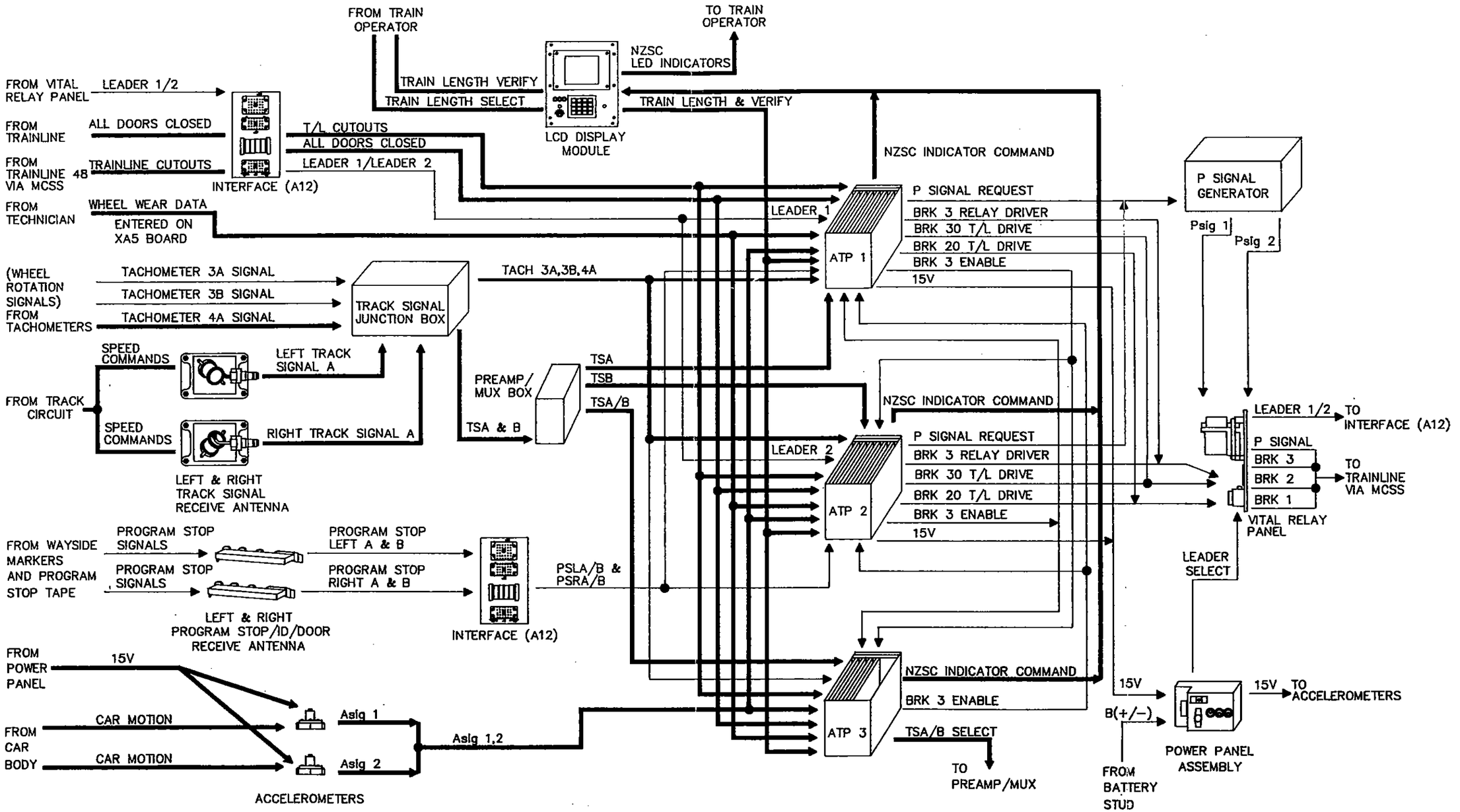

FIGURE 2-2-2. SIGNAL TRACE FOR THE SPEED REFERENCE GENERATION FUNCTION

2-2-3 SPEED CONTROL FUNCTION

The speed control function has two purposes:

- o to bring the train to a smooth stop within the station platform boundary, and
- o to provide propulsion and brake signals that maintain train speed in safe, efficient limits.

The first task is accomplished by processing information from the program stop tape and wayside markers to determine the distance to the station. Both tasks require information from the speed reference generation function.

As Figure 2-2-3 shows, this function receives external inputs from the train operator and wayside markers (future development) and the program stop tape. It provides outputs to the trainlines.

A. External Inputs

1. As described in subsection 2-2-2, the operator must select and verify the train length via the controls on the LCD module. The resulting TRAIN LENGTH signal travels from the LCD module to ATP1, ATP2, and ATP3.

2. The PS/ID/door receive antennas on either side of the train receive program stop data from the wayside. These signals determine distance traveled. The PROGRAM STOP (PS) signals consist of a phase reversal for every six inches of train travel. They are conditioned by the A12 interface module. For more detail, see subsection 2.4.1.3.1 of reference engineering documentation on Vehicle Automatic Train Control System, Final Design Review. The PS LEFT A and PS RIGHT A signals are sent to both ATP1 and ATP2.

   This antenna also receives door control and performance level signals. These signals are active only on the opposite side of the train from which the passengers disembark.

B. Internal Inputs

Table 2-2-4 shows signals required by the speed control function but generated by other subsystems and functions.

C. Signal Processing

1. At station entry, the system counts the phase reversals of the PROGRAM STOP signal to determine the distance traveled. The system then determines desired vehicle speed (REFERENCE VELOCITY) based on the position of the vehicle relative to the program stop tape and the required stopping point (given the TRAIN LENGTH).

2. The OPERATOR STATION STOP MODE signal from the console communications subsystem indicates whether the train is to make a long or short station stop or is to run-through the station

3. The TRACK SPEED COMMAND, ACTUAL SPEED, CUTOUT REDUCTION MODE, and ACTION VELOCITY signals from the speed reference generation function indicate current and maximum vehicle performance, regardless of whether the train is approaching a station.

4. The performance level code (PERF/ACCEL) comes from the wayside communications subsystem. This code indicates speed modification requests from the wayside. Such requests are usually based on scheduling considerations.

5. In the electronic modules, the speed control function uses these signals to determine whether to increase or decrease train speed. The difference between ACTUAL SPEED and REFERENCE SPEED determines the SPEED ERROR.

   If the SPEED ERROR indicates that the ACTUAL SPEED is below REFERENCE VELOCITY, the system determines that train speed is to be increased. See paragraph E., below.

   If the SPEED ERROR indicates that the ACTUAL SPEED is above the REFERENCE VELOCITY (or less than 1.33 mph below), the system determines that train speed should be decreased. See paragraph E., below.

D. Internal Outputs

Table 2-2-5 shows signals generated by the speed control function for use by other functions.

E. External Outputs

1. Electronic modules ATP1 and ATP2 constantly issue a P-SIGNAL REQUEST signal to the P-signal generator. The output from the P-signal generator ranges from 20 to 100 mA, depending on whether the speed should be decreased or increased, and if so, by how much:

20 mA or less	=	full braking
60 mA	=	coast
100 mA	=	full power

The P-signal generator issues two redundant propulsion signals (PSIG1 and PSIG2) which are sent to the vital relay panel. Depending on which channel is selected as leader, one of these propulsion signals is output to the trainlines.

2. If the system determines that train speed should be decreased in a closed loop (compare and adjust) manner, electronic modules ATP1 and ATP2 drop BRK 20 TRAINLINE DRIVE signals to the vital relay panel. Depending on which ATP is the leader, one of the two signals is output to the trainlines as a BRK 2 signal. This causes the application of brakes, and train motion is slowed. The percent of brake depends on P-signal.

TABLE 2-2-4. INTERNAL INPUTS REQUIRED BY SPEED CONTROL FUNCTION

SIGNAL	GENERATED BY	REFERENCE
BRK 3 RELAY	Motion Control Integrity Checking Function	2-2-1
BRK 30 ENABLE	Motion Control Integrity Checking Function	2-2-1
BRK 30	Motion Control Integrity Checking Function	2-2-1
TRACK SPEED COMMAND	Speed Reference Generation Function	2-2-2
ACTUAL SPEED	Speed Reference Generation Function	2-2-2
CUTOUT REDUCTION MODE	Speed Reference Generation Function	2-2-2
ACTION VELOCITY	Speed Reference Generation Function	2-2-2
OPERATOR STATION STOP MODE	Console Communications Subsystem	2-5
PERF/ACCEL	Wayside Communications Subsystem	2-3

TABLE 2-2-5. INTERNAL OUTPUTS GENERATED OR TRANSMITTED BY SPEED CONTROL FUNCTION

SIGNAL	USED BY	REFERENCE
PROGRAM STOP HALT	Speed Reference Generation Function	2-2-2
STATION STOP MODE	Console Communications Subsystem	2-5
REFERENCE VELOCITY	Console Communications Subsystem	2-5
PROGRAM STOP ACTIVE	Door Control Subsystem	2-4

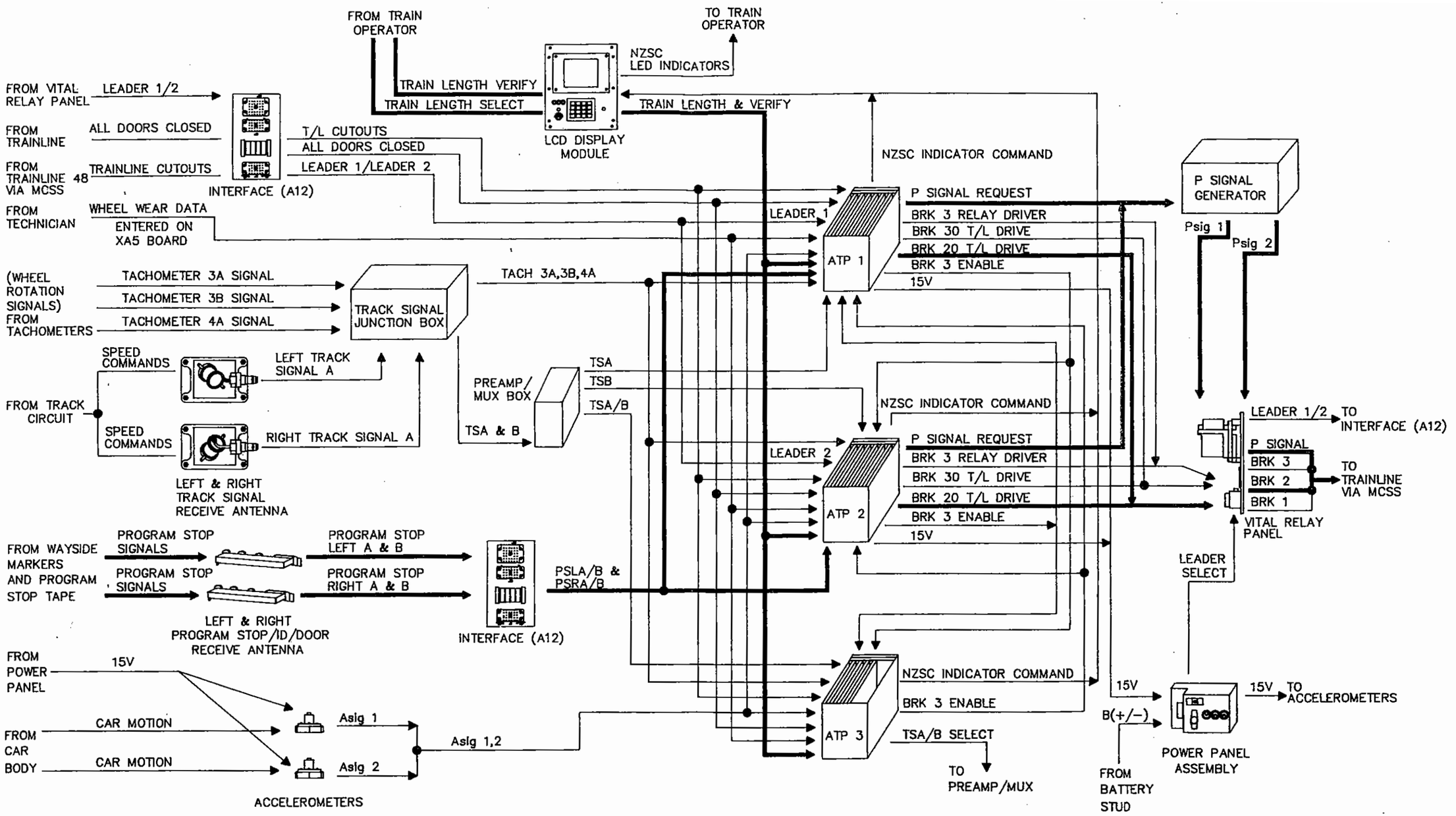

FIGURE 2-2-3. SIGNAL TRACE FOR THE SPEED CONTROL FUNCTION

2-3 WAYSIDE COMMUNICATIONS SUBSYSTEM

The wayside communications subsystem performs two basic functions:

- o reception from wayside, and
- o transmission to wayside.

2-3-1 RECEPTION FROM WAYSIDE FUNCTION

The reception from wayside function receives, decodes, and disseminates data from the wayside. Data is also transmitted from the rear car to the front car of the consist. Figure 2-3-1 shows the signal trace for head-end cars. Figure 2-3-2 shows the trace for tail-end cars.

A. External Inputs

1. Both head-end and tail-end cars receive information from the wayside antenna tape. This information, called DATA FROM STATION, may include any of the following:

   a. complete train identification (serial number, destination, and length);

   b. destination portion (only) of the train ID;

   c. performance level code; and

   d. door open command. (Reception of this information is covered in subsection 2-4).

2. The DATA FROM STATION (DFS) enters the ATC system at the left and right program stop/ID/door receive. The signal is frequency-shift-keyed at an 18 Hz rate, with phase reversals for end-of-bit identification. The frequencies received are:

   a. 5328 Hz, which indicates a logical 1, and

   b. 7992 Hz, which indicates a logical 0.

3. Both end cars also receive an ALL DOORS CLOSED signal from the trainlines. This signal enters the system at the A12 interface card. There is conditioned, then sent directly to all three electronic cradles.

4. Head-end cars also receive performance adjust DATA FROM REAR via the performance adjust trainline. This signal enters the lead car's ATC system at the preamp/mux box, which amplifies the signal and sends it to all three electronic cradles. Thus, the reception from wayside function on head-end car receives three external inputs:

a. DATA FROM STATION,

b. DATA FROM REAR, and

c. ALL DOORS CLOSED. (This trainline signal is summarized by DCR before it is input to the ATC.)

5. The rear car receives the DATA FROM STATION signal. It also receives a FLIPPER DOOR STATUS signal and a KEYSWITCH OFF signal.

a. On A-cars, the FLIPPER DOOR STATUS signal (open) is generated when the TRAIN LENGTH is set to 2. From the LCD module the signal is routed to the A12 interface card. On C-cars, the trainlines supply this signal. It enters the ATC system at the A12 interface card. On both cars, the signal is conditioned by the A12 interface card and sent directly to the preamp/mux box. An open flipper door indication isolates the preamp/mux from the trainlines.

b. On both A-cars and C-cars, the KEYSWITCH OFF signal enters the system at the A12 interface card. There it is conditioned, then sent to the preamp/mux box and all three electronic cradles. If the keyswitch is in the OFF position, the preamp/mux is in the track signal self-test mode.

B. Internal Inputs

Table 2-3-1 lists internal inputs required by software supplied by other ATC subsystems or functions.

C. Signal Processing

1. On head-end cars, the incoming signals from the wayside are analyzed and processed for use by other subsystems and functions.

a. The ATC system decodes the TRAIN ID data (serial number, destination, and train length). If the ZERO SPEED signal is not present (indicating that the train is moving), the system decodes the PERFORMANCE LEVEL code. If the incoming data is not valid, the performance level code defaults to PL2. If the doors are open and keyswitch is off, the performance level defaults to 2.

b. The absence of an ALL DOORS CLOSED signal (indicating that the train is stopped in a station) causes the system to clear any stored performance level code. Stored performance level codes are also cleared if the operator turns off the keyswitch.

c. The lead car processes the signals decoded by the rear car (945 Hz, representing a 1) and superimposed on 18 to 24 Vdc. The data is

sent to the preamp/mux box as two signals -- DFS READY and DFS LEFT or DFS RIGHT.

2. On tail-end cars, the KEYSWITCH OFF signal indicates that this is not the lead car. This causes ATP1 and ATP2 to generate a MUX TRANSMIT (TX) ENABLE signal. If the preamp/mux also receives a FLIPPER DOOR STATUS CLOSED signal, indicating that this is an end car, the DFS signal (data from station) is output to the trainlines.

3. On head-end cars, the DATA FROM REAR is demodulated and provides BROKEN TRAINLINE detection, using the superimposed dc level.

D. Internal Outputs

Table 2-3-2 lists all signals generated by this function for use by other AT subsystems or functions.

E. External Outputs

On head-end cars, the reception from wayside function has no external outputs. On tail-end cars, the only external output is the DATA TO FRONT signal to the trainlines. This signal is then received by the head-end car as a DATA FROM REAR signal.

TABLE 2-3-1. INTERNAL INPUTS REQUIRED BY SOFTWARE

SIGNAL	GENERATED BY	REFERENCE
OPERATOR TRAIN ID	Console Communications Subsystem	2-5
OPERATOR PERF/ACCEL	Console Communications Subsystem	2-5
ZERO SPEED	Motion Control Subsystem	2-2
BROKEN TRAINLINE	Transmission to Wayside Function	2-3-2
PROGRAM STOP	Motion Control Subsystem	2-3-2

TABLE 2-3-2. INTERNAL OUTPUTS GENERATED BY RECEPTION FROM WAYSIDE FUNCTION

SIGNAL	USED BY	REFERENCE
WAYSIDE TRAIN LENGTH	Console Communications Subsystem	2-5
PERF/ACCEL	Motion Control Subsystem	2-2
REAR DOOR DECODED	Door Control Subsystem	2-4
TRAIN ID	Transmission to Wayside Function and Console Communications Subsystem	2-3-2
PERFORMANCE ADJUST DATA	Motion Control Subsystem	2-3-2

TABLE 2-3-3. EXTERNAL INPUTS TO RECEPTION FROM WAYSIDE FUNCTION

SIGNAL	GENERATED BY	REFERENCE
PERFORMANCE ADJUST FROM REAR	Performance Adjust Trainline	2-3-1
WAYSIDE RECEIVE	PSID Antenna	2-3-1
KEYSWITCH	Console Keyswitch	2-3-1
FLIPPER DOOR	Flipper Door	2-3-1
TRAIN LENGTH	LCD	2-3-1

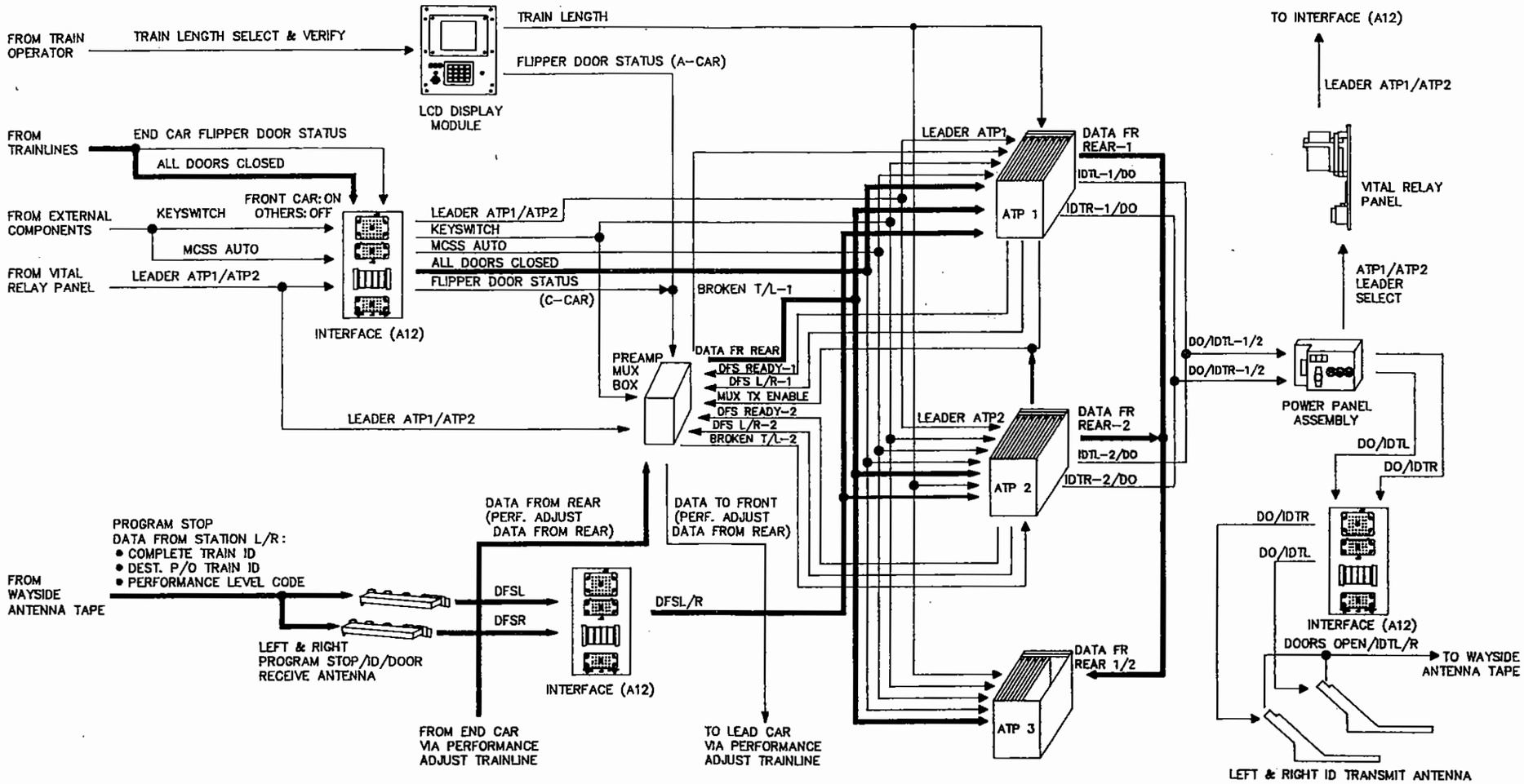

FIGURE 2-3-1. SIGNAL TRACE FOR THE RECEPTION FROM WAYSIDE FUNCTION ON HEAD-END CARS

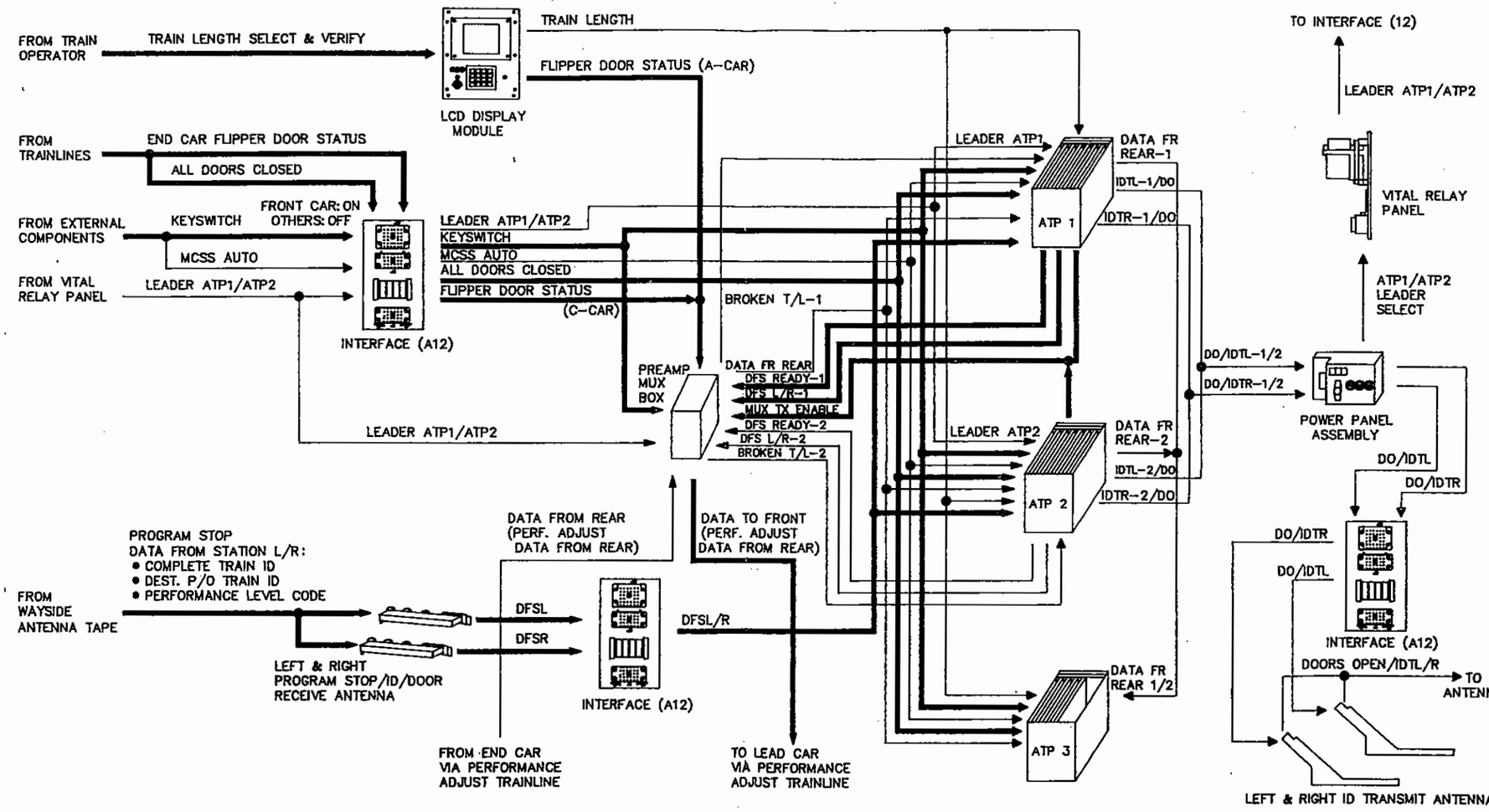

FIGURE 2-3-2. SIGNAL TRACE FOR THE RECEPTION FROM WAYSIDE FUNCTION ON TAIL-END CARS

2-3-2 TRANSMISSION TO WAYSIDE FUNCTION

The transmission to wayside function encodes and transmits data generated by the reception from wayside function and other ATC subsystems. Figure 2-3-3 shows the signal trace for this function. Because transmission occurs only when the keyswitch is set to ON and MCSS is not at OFF position (AUTO, YARD or ROAD OK), the signal trace applies to head-end cars only.

A. External Inputs

The only external inputs to this function are the KEYSWITCH ON & MCSS SWITCH signals, and the TRAIN LENGTH SELECT signal from the train operator. The A12 interface card conditions the KEYSWITCH ON & MCSS signals, which are then sent to all three electronic cradles. The TRAIN LENGTH SELECT signal enters the system at the LCD module. From there, it travels directly to all three electronic cradles.

B. Internal Inputs

Table 2-3-4 lists all signals required by the transmission to wayside function that other ATC subsystems or functions generate.

C. Signal Processing

1. If the door control subsystem receives a TRANSMIT DOORS OPEN signal, the leader cradle (ATP1) generates a DOORS OPEN (DO) signal for transmission to wayside. This occurs only if MCSS is in AUTO, ROAD, or YARD.) This signal is a sequence of logical 1s.

2. If the doors are closed, keyswitch is ON, and MCSS is either in AUTO or ROAD and not YARD, ATP1 (lead car) generates a TRAIN IDENTIFICATION (ID) signal for transmission to the wayside.

3. Only the train ID signal is synchronized with the recovered wayside 18 Hz clock. Thus, bit 1 is always transmitted in the same time frame as bit A of the speed code. This synchronization is needed because the wayside function uses the 18 Hz clock from the track signal generator to decode the data. The signals have the following frequencies:

   a. 5920 Hz, indicating a logical 1, and

   b. 8880 Hz, indicating a logical 0.

D. External Outputs

The DOORS OPEN and TRAIN ID signals are the only external outputs of the transmission to wayside function. The leader electronic cradle sends these signals to the power panel assembly. This assembly sends the signals on to the A12

interface card, where they are conditioned. From the A12 interface card, the signals travel to the left and right ID transmit antennas. These antennas transmit the signals to the wayside antenna tape. The transmitted signals have a transmitting current of minimum 1.98 peak-to-peak and nominal 2.5 peak-to-peak amps. The frequencies are phase-reversed (180°) at the end of each bit to allow wayside ATO equipment to recover the 18 Hz clock pulse.

TABLE 2-3-4. INTERNAL INPUTS REQUIRED BY TRANSMISSION TO WAYSIDE FUNCTION

SIGNAL	GENERATED BY	REFERENCE
SPEED CODE SYNC & CLOCK	Motion Control Subsystem	2-2
TRANSMIT DOORS OPEN	Door Control Subsystem	2-4
TRAIN ID	Reception from Wayside Function	2-3-1
BROKEN TRAINLINE	Performance Adjust Trainline Continuity	2-3-1

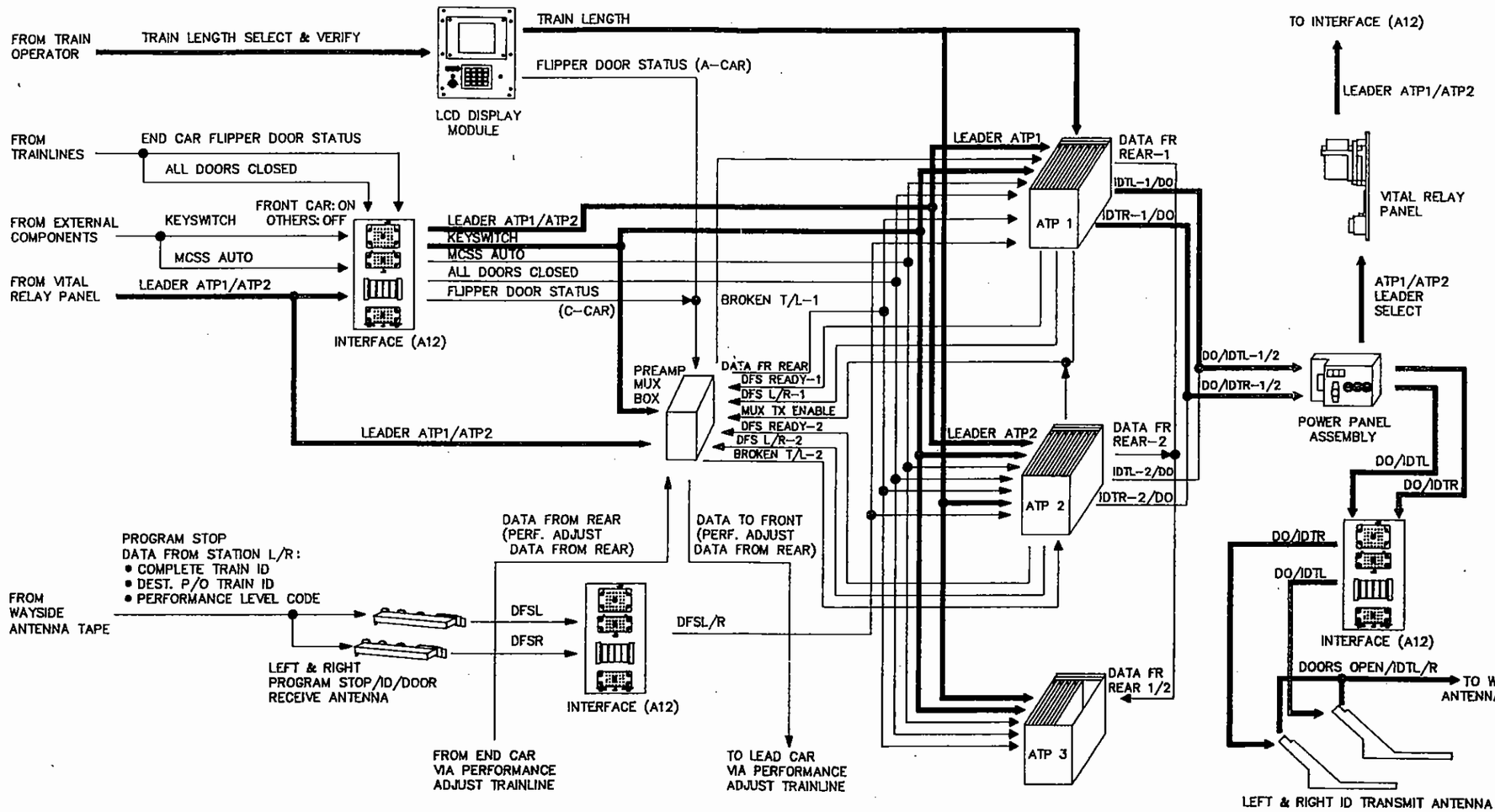

FIGURE 2-3-3. SIGNAL TRACE FOR THE TRANSMISSION TO WAYSIDE FUNCTION ON HEAD-END CARS

2-4 DOOR CONTROL SUBSYSTEM

The door control subsystem provides signals that open and close the vehicle doors in a safe manner, and operate the door chimes and public address system. The subsystem is described under the following headings:

- o command reception and door decoding functions, and
- o door platform relay driving and advanced door opening functions .

2-4-1 COMMAND RECEPTION AND DOOR DECODING FUNCTIONS

The command reception and door decoding functions receive and decode door commands from the wayside. Figure 2-4-1 shows the signal trace for these functions.

A. External Inputs

The only external inputs to the command reception and door decoding functions are 5328 Hz (ones) LEFT and RIGHT DOOR COMMAND signals from the wayside antenna tape. The signals are frequency-shift-keyed at a rate of 18 Hz, synchronized to the track signals. The signals enter the ATC system at the program stop/ID/Door receive antennas, are conditioned by A12 interface card, and sent to both ATP1 and ATP2.

B. Internal Inputs

The only internal input is program stop active from the PS stop tape subfunction processing.

C. Signal Processing

Incoming signals are amplified and filtered within the electronic cradles. The threshold is compared to recover both the serial data stream and the 18 Hz clock. The cradles generate either a LEFT DOOR DECODED signal or a RIGHT DOOR DECODED signal, depending on the signals received.

a. A LEFT DOOR DECODED signal is generated only if the left antenna is inactive, and if phase reversals and continuous ones data are received from the right antenna.

b. A RIGHT DOOR DECODED signal is generated only if the right antenna is inactive, and if phase reversals and continuous ones data are received from the left antenna.

D. Internal Outputs

The only internal output of the command reception and door decoding functions is the RIGHT or LEFT DOOR DECODED signal described above. The door

platform relay driving and advanced door opening functions use this signal. (See Section 2-4-2.)

E. External Outputs

The command reception and door decoding functions do not generate signals used outside the ATC system.

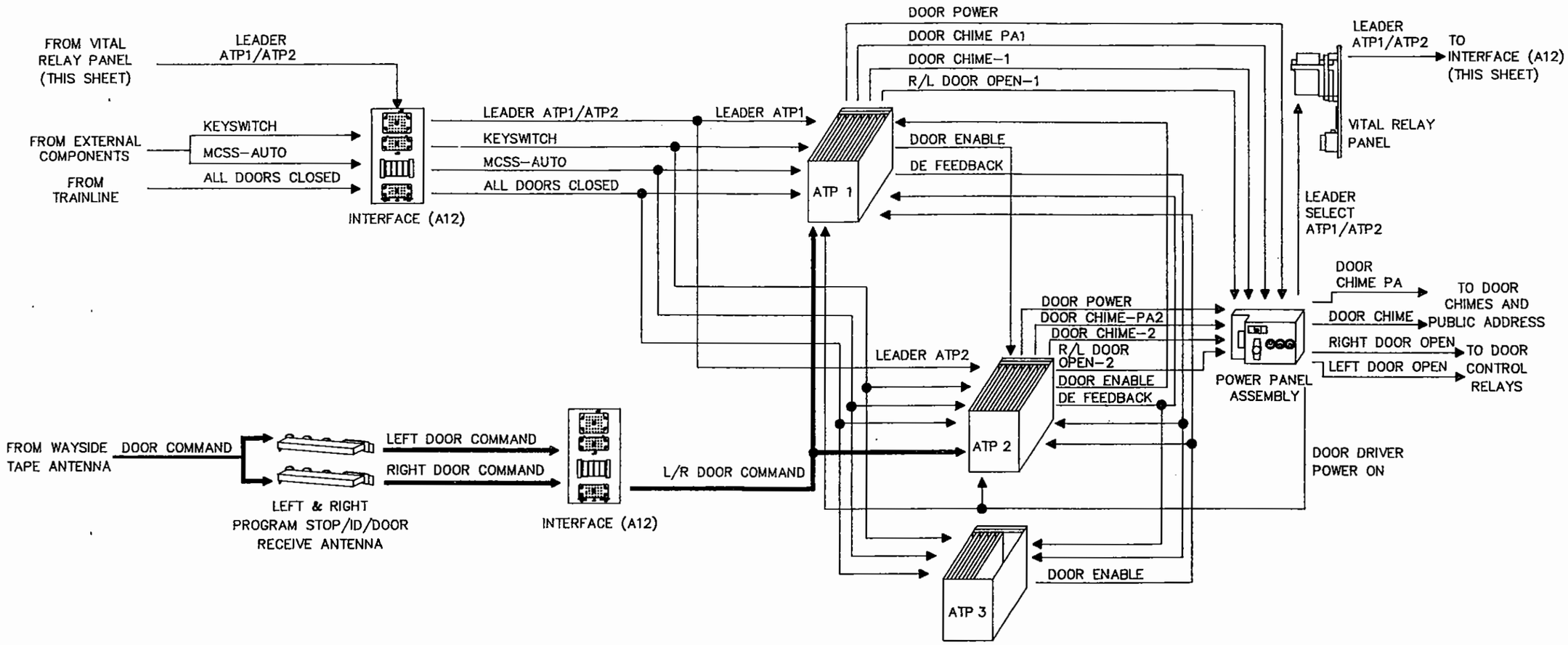

FIGURE 2–4–1. SIGNAL TRACE FOR THE COMMAND RECEPTION AND DOOR DECODING FUNCTIONS

2-4-2 DOOR PLATFORM RELAY DRIVING AND ADVANCED DOOR OPENING FUNCTIONS

The door platform relay driving function provides the signals required to operate the vehicle doors and the door chimes/PA. Figure 2-4-2 illustrates the signal trace for these functions.

A. External Inputs

1. In addition to KEYSWITCH and MCSS signals, door platform relay driving and advanced door opening functions require an ALL DOORS CLOSED and OPERATION CLOSED DOORS signals. These signals enter the ATC system at the A12 interface card. There they are conditioned and sent to all three electronic cradles.

2. The cradles also require a signal indicating that the train operator has set the ID/DOOR TOGGLE switch on the power panel assembly to ON.

B. Internal Inputs

Table 2-4-1 lists all signals required by the door platform relay driving and advanced door opening functions supplied by other ATC subsystems or functions.

C. Signal Processing

1. Incoming signals are analyzed in the electronic modules. DOOR ENABLE and DOOR ENABLE (DE) FEEDBACK signals are exchanged between the modules to check the validity of the signals. The leader (ATP1) generates DOOR POWER and RIGHT or LEFT DOOR OPEN signals if the following signals are present:

   a. LEFT or RIGHT DOOR DECODED,

   b. PROGRAM STOP ACTIVE,

   c. ZERO SPEED, and

   d. REAR DOOR DECODED.

2. If these signals do not persist for at least one second, the door commands are withdrawn. If these signals are present, the operator may open the doors manually. He may also override the automatic door open command by pressing the DOORS CLOSE button, if the lead car of the train is not at zero speed along the program stop or platform tape.

3. A DOOR PLATFORM RELEASE signal is generated when door decoded signal is lost. It is also generated when the OPERATOR ALERT SIGNAL is true, indicating MCSS switch is being moved to the AUTO position. The

console communications subsystem uses this signal to generate a CAB CHIME to alert the operator.

4. The modules generate DOOR CHIME and DOOR CHIME PA signals when the OPERATOR CLOSE DOORS signal is present. This indicates that the train operator has pressed the close door push button, usually in response to the CAB CHIME alert.

D. Internal Outputs

The door platform relay driving function has two internal outputs. It supplies a DOOR PLATFORM RELEASE signal to the console communications subsystem (see subsection 2-5) and a TRANSMIT DOORS OPEN signal to the wayside communications subsystem (see subsection 2-3).

E. External Outputs

The leader electronic module (ATP1) sends DOOR POWER, DOOR OPEN (RIGHT or LEFT), DOOR CHIME, and DOOR CHIME PA signals to the power panel assembly. The DOOR OPEN signal is then output to the door control relays. The DOOR CHIME and DOOR CHIME PA signals are sent to the door chimes and public address system.

TABLE 2-4-1. INTERNAL INPUTS REQUIRED BY DOOR PLATFORM RELAY DRIVING AND ADVANCED DOOR OPENING FUNCTIONS

SIGNAL	GENERATED BY	REFERENCE
LEFT or RIGHT DOOR DECODED	Door Decoding Function	2-4-1
ACTUAL SPEED	Motion Control Subsystem	2-2
PROGRAM STOP ACTIVE	Motion Control Subsystem	2-2
ZERO SPEED	Motion Control Subsystem	2-2
BRK 3 RELAY DEENERGIZED	Motion Control Subsystem	2-2
REAR DOOR DECODED	Wayside Communications Subsystem	2-3
OPERATOR CLOSE DOORS	Console Communications Subsystem	2-5
OPERATOR OPEN DOORS	R/L Console Communications Subsystem	2-5
OPERATOR ALERT	Motion Control Subsystem	2-2

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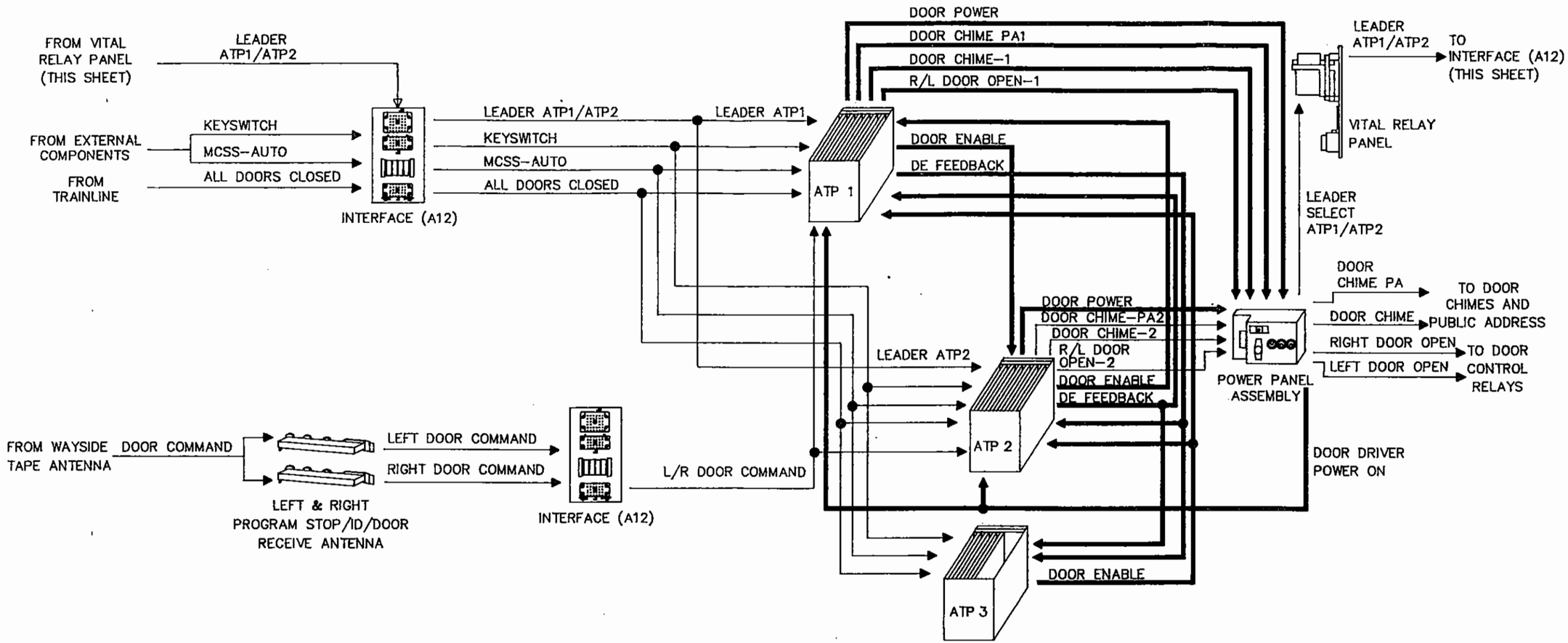

FIGURE 2–4–2. SIGNAL TRACE FOR THE DOOR PLATFORM RELAY DRIVING AND ADVANCED DOOR OPENING FUNCTIONS

2-5 CONSOLE COMMUNICATIONS SUBSYSTEM

The console communications subsystem allows two way information transfer between the train operator and the ATC system. The operator uses the controls on the LCD module to send information to and request information from the ATC system. The operator receives information from the ATC system through various indicators, both on the LCD module and on the operator's console.

The operations performed by the console communications subsystem are discussed under the following headings:

- o console end functions,
- o ATC end functions .

2-5-1 CONSOLE END FUNCTION

The console end functions have two basic purposes:

- o To receive information from the train operator (via both ATC and non-ATC controls) and route it to the ATC end functions; and
- o To receive data from the ATC end functions and route it to the train operator and various controls/indicators outside the ATC system.

Figure 2-5-1 shows the signal trace for the console end functions. Because the LCD module has its own internal processor and the electronic cradles are not involved in the console end functions, the heading "Signal Processing" refers to the processing that takes place within the LCD module.

A. External Inputs

The only external inputs to the console end functions are manual door commands and operator keypad entries.

1. The MANUAL DOOR COMMANDS (from door control panels outside the ATC system) enter the LCD module through interface hardware. However, the operator closed door pushbuttons are not processed by the LCD module. They are routed directly to the ATC through A(12).

2. The operator keypad entries are made via a 16-key keypad on the LCD module.

   a. The keys are used to:

      (1) enter numerical data, both decimal and hexadecimal,

      (2) select alternatives from the displayed menu, and

(3) control the display and respond to prompts/queries.

b. The operator controls the display and responds to prompts, using the keys labeled A, 0, B, C, D, E, and F. Additional labels below or to the right of these keys indicate their function. Use the ON/YES key (A) and the OFF/NO key (0) to respond to displayed queries. Press the SKIP key (B) to move the cursor to the next data entry position on the screen. Use the ENT key (C) to enter changes into the ATC system. Use the NEXT key (D) to turn to the next display page. Use the BACK key (E) to turn to the previous display page. Use the CLEAR key (F) to clear the display without entering any changes into the system. See subsection 4-3 for a detailed explanation of how to use the display.

c. Information that can be entered includes:

(1) train ID code,

(2) station stop mode,

(3) performance level code,

(4) ATC operating mode,

(5) requests for data logging,

(6) requests for LCD diagnostics, and

(7) entry of time and date.

Because this information is entered in conjunction with the LCD displays, keypad entries are further explained in paragraph E., below.

B. Internal Inputs

Data from the ATC end functions is the only internal input to the console end functions. (See subsection 2-5-2.) The information is transferred through an asynchronous, full-duplex, serial data link receiving at 9600 baud.

C. Signal Processing

1. The LCD module houses various electronic components, including an 8 bit parallel microprocessor. These components translate incoming electronic data from the ATC end functions and format the data for display or for transmission to external components. Similarly, these components encode the keypad entries for use by the ATC end functions.

2. With one exception, incoming MANUAL DOOR COMMANDS are processed and sent on to the ATC end functions, which make the signals available to the door control subsystem. The exception is operator closed doors pushbutton signals, which the LCD processes.

D. Internal Outputs

Console data transmitted to the ATC end functions is the only internal output of the console end functions. (See subsection 2-5-2.) The information is transferred through an asynchronous, full-duplex, serial data link transmitting at 9600 baud.

E. External Outputs

The console end functions transmit the following signals to components/ individuals outside the ATC system: DOOR RELEASE signal, DOOR STATUS (OPEN/CLOSED) signals, COMMANDED SPEED indicator signal, CAB CHIME signal, and LIQUID CRYSTAL DISPLAYS.

1. The DOOR RELEASE and DOOR STATUS signals are sent to the door control panels via interface hardware. At the door control panels, these signals drive door status indicators.

2. The COMMANDED SPEED indicator signal is sent to two seven segment displays, where it drives a numerical indication of the vehicle's speed.

3. The CAB CHIME signal informs the operator that the DOOR DECODED signal has been withdrawn or MCSS switch has been moved to AUTO. It is implemented by piezo-electric buzzer in the LCD display.

4. The LIQUID CRYSTAL DISPLAY conveys various types of information. These displays form a series of easily accessible menu pages. The pages are accessed by either selecting NEXT or BACK on the LCD entry pad. Figures 2-5-2 through 2-5-15 show the fourteen display pages.

   a. Figure 2-5-2 shows the first display or main page. After the operator enters changes on any page, this main page is automatically displayed. It remains until you press the NEXT or BACK key. This is a status page, indicating basic operating parameters. To change any of these parameters, you must access the appropriate page. Additional information is displayed automatically by changing the status display lines alternately from one message to another. Line 2 (OPERATIONAL SPEED:) alternately displays the message BPM SYSTEM DISABLED when that condition occurs. Line 6 (PROG STOP:) alternately displays the message PERF ADJ TL BROKEN when that condition occurs.

   b. Figure 2-5-3 illustrates the page used to change the TRAIN IDENTIFICATION code, which consists of the serial number,

destination, and length (number of cars). Select YES to indicate the previous destination.

c. Figure 2-5-4 shows the next page, used to change the performance level code (PERF/ACCEL).

d. Use the page in Figure 2-5-5 to select the STATION STOP MODE -- normal, short, long, or run-through.

e. The page in Figure 2-5-6 displays NUMBER OF CUTOUTS, TRAIN LENGTH, and SPEED MODE. Lines 5, 6, and 7 flash, indicating operator attention.

f. Figure 2-5-7 shows the contents of the cutout car modes screen. To select this screen, press YES at the screen displayed in Figure 2-5-6.

g. Figure 2-5-8 shows the contents of the speed mode page. To select this screen, press YES at the screen displayed in Figure 2-5-6, then press NEXT at the screen displayed in Figure 2-5-7.

h. Figure 2-5-9 shows the current status of the three electronic cradles. To change the leader, select a backup or turn a cradle on/off, then use the leader switch and cradle power switches on the power panel. This change cannot be made with the keypad. The display is updated when the you turn the keyswitch back on.

i. Use the page shown in Figure 2-5-10 to turn the ATP data loggers (one in each ATP cradle) ON and to access the clock reset and LCD memory display. When the system has been shut down, you must turn on the ATP data loggers and reset the system clock.

   NOTE: *Do not turn the ATP data loggers back on if the system has been shut down due to a fault. If this occurs, the data concerning the fault is overwritten by new data.*

j. Figure 2-5-11 shows the clock reset screen. To select this screen, press 1 at the screen displayed in Figure 2-5-10.

k. Figure 2-5-12 shows the contents of selected memory locations in the LCD. To select this screen, press 2 at the previous screen. You must press the zero on the LCD entry pad simultaneously with a function key. Otherwise the letter is entered as a hex entry, not a function.

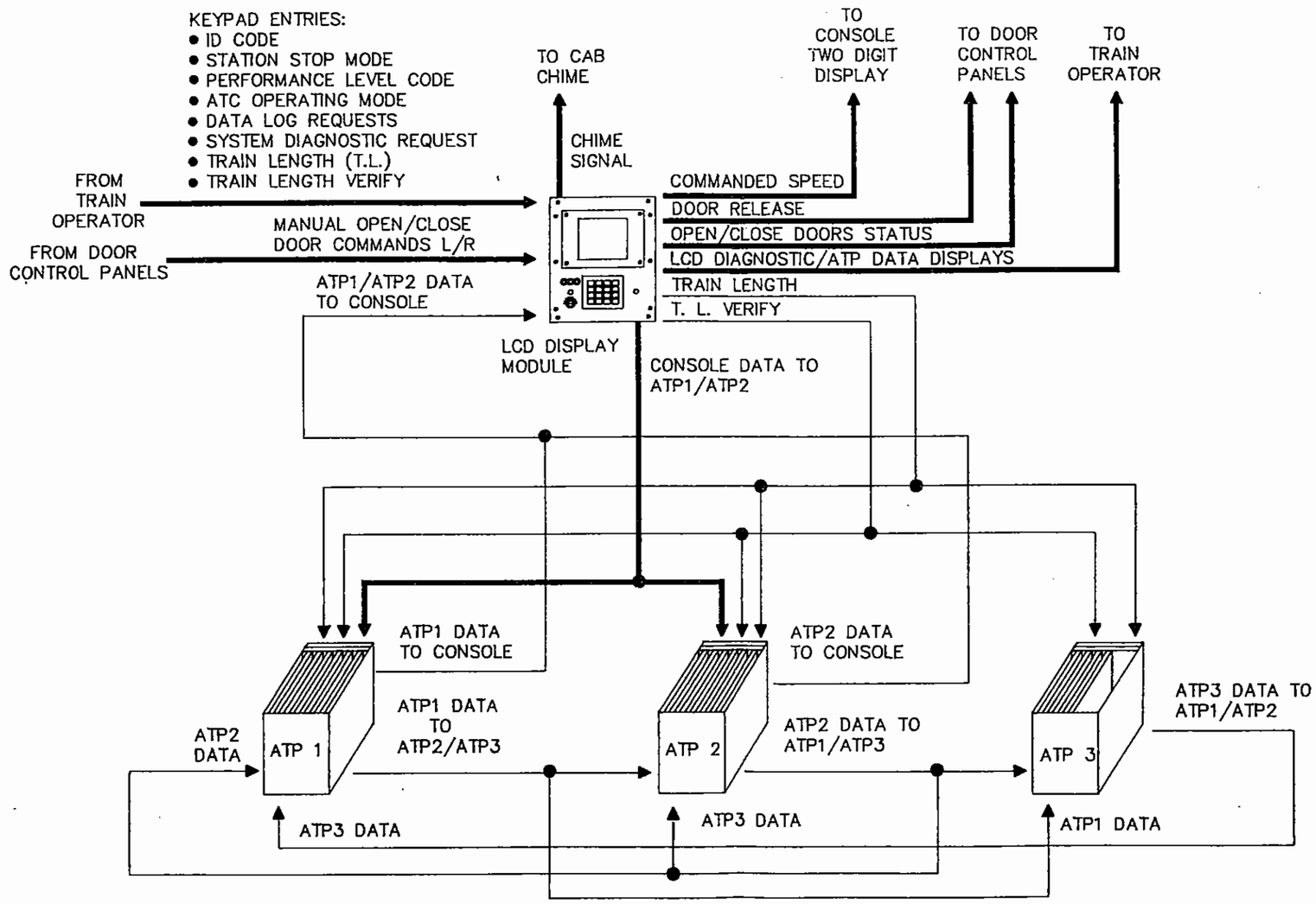

FIGURE 2–5–1. SIGNAL TRACE FOR THE CONSOLE END FUNCTIONS

2-5-2 ATC END FUNCTIONS

The ATC end functions process operator requests received by the console end functions and collect information from other subsystems to be displayed by the console end functions to the train operator.

Figure 2-5-13 shows the signal trace for the ATC end functions.

A. External Inputs

The only external inputs to this function are the TRAIN LENGTH SELECT and TRAIN LENGTH verify signals, which the train operator issues via controls on the LCD module.

B. Internal Inputs

The ATC end functions receive various signals from the console end functions and the other subsystems. Table 2-5-1 shows these signals.

C. Signal Processing

The only signal processing performed by the ATC end functions is to properly route the data supplied by other subsystems and the console end functions. The TRAIN LENGTH SELECT and TRAIN LENGTH VERIFY signals are processed, transmitted via serial link to the console, and displayed by the console end functions. These signals are also direct inputs to other subsystems.

D. Internal Outputs

The ATC end functions supply ATP data to the console end functions. They also supply a variety of operator initiated signals (the CONSOLE DATA received from the console end functions) to the other ATC subsystems. Table 2-5-2 lists these internal output signals.

E. External Outputs

The ATC end functions do not supply any signals directly to components or individuals outside the ATC system.

TABLE 2-5-1. INTERNAL INPUTS REQUIRED BY ATC END FUNCTIONS

SIGNAL	GENERATED BY	REFERENCE
CONSOLE DATA	Console End Functions	2-5-1
ACTION VELOCITY/ REFERENCE VELOCITY	Motion Control Subsystem	2-2
NUMBER OF CUTOUTS	Motion Control Subsystem	2-2
STATION STOP MODE	Motion Control Subsystem	2-2
CUTOUT REDUCTION MODE	Motion Control Subsystem	2-2
PERF/ACCEL	Wayside Communications Subsystem	2-3
WAYSIDE TRAIN LENGTH/ID	Wayside Communications Subsystem	2-3
PLATFORM RELEASE	Door Control Subsystem	2-4
TIME OF DAY	System Monitoring Subsystem	2-6
DATA LOGGER STATUS	System Monitoring Subsystem	2-6

TABLE 2-5-2. INTERNAL OUTPUTS SUPPLIED BY ATC END FUNCTIONS

SIGNAL	USED BY	REFERENCE
ATP DATA (including signals from other subsystems; see Table 2-5-1)	Console End Functions	2-5-1
OPERATOR STATION STOP MODE	Motion Control Subsystem	2-2
OPERATOR PERF/ACCEL	Wayside Communications Subsystem	2-3
OPERATOR TRAIN ID	Wayside Communications Subsystem	2-3
OPERATOR OPEN DOORS	Door Control Subsystem	2-4
OPERATOR DATA LOGGER ON/OFF TOGGLE	System Monitoring Subsystem	2-6
OPERATOR TIME OF DAY	System Monitoring Subsystem	2-6

2-6 SYSTEM MONITORING SUBSYSTEM

The system monitoring subsystem:

- o maintains a log of current parametric data from all subsystems and allows the data to be recorded permanently when necessary;
- o provides a means of designating which of the redundant channels acts as leader; and
- o performs routine diagnostics of the entire ATC system and allows special testing.

The subsystem accomplishes these purposes through:

- o data logging,
- o leader select, and
- o diagnostics.

2-6-1 DATA LOGGING FUNCTION

The data logging function constantly maintains two logs. The first log contains data that seldom changes. The second log contains significant parametric data from the previous 2.5 minutes. The data logger is programmed to be off when the ATC is first turned on. To store data, turn the data logger on. Incoming data is written over previous data while the data logger is on. If the ATC shuts down the car because of a detected safety related fault, do not turn the data recorder on again after the ATC has been powered up. Otherwise the data which was recorded immediately before the fault occurred is overwritten and lost. Data logger information may be off-loaded through the A11-J1 serial communications lines with appropriate software and recorder, neither of which are part of the ATC system contract. Figure 2-6-1 shows the signal trace for the data logging function.

A. External Inputs

A DATA LOGGING CONTROL signal from the data recorder is the only external input to the data logging function. This signal enters the ATC system via the A11-J1 serial communications port and travels directly to ATP1, ATP2, and ATP3 cradles.

B. Internal Inputs

The data logging function collects significant parametric data from all subsystems and functions. In addition, it receives OPERATOR TIME OF DAY and OPERATOR DATA LOGGER CONTROL signals from the console communications subsystem (see subsection 2-5) and DIAGNOSTIC DATA TO BE LOGGED from the diagnostics function (see subsection 2-6-3).

C. Signal Processing

Data collected from other subsystems and functions is maintained in two separate logs.

1. The first log contains data that changes infrequently, such as the following. (An * indicates data stored only on leader.)

Train Serial Number	Train Serial Number
Train Destination	Train Destination
Train Length-Operator	*Train Length-Wayside
Number of Cutouts	*Station Stop Mode
Cutout Reduction Mode	MCSS Auto
ATP1,2,3 On Status	ATP Leader Status
Wheel Wear	*Performance Level
Flipper Door Status	*Operator Acceleration Limit
*Operator Time of Day	Power On
Keyswitch	

2. The second log contains significant parametric data from the previous two minutes, including the following. (An * indicates data stored only on leader.)

BPM Profile Exceeded Enable	BRK 20 Status
BRK 30 Status	BRK3 Relay Deenergized
Actual Speed (Tach) 3A	Actual Speed (Tach) 4A
Door Closed	BRK3 Enable
Proper Direction	Start-up Enable
Program Stop Active	Rear Door Decoded
Rear Door Static Enable	Speed Check
Tester	T/L Verify
Underspeed Enable	Zero Speed
*BRK 20 Enable	*Left Door Decoded
*Left Door Static Enable	*Performance Level
Track Speed Command	Train Acceleration
*Left Platform Release	*Right Door Decoded
*Right Door Static Enable	*Right Platform Release
*Operator Close Doors	*Operator Open Door Left
*Operator Open Door Right	Program Stop Halt
CO_Bias	SP_U9_54374_PORT_0(zero)
*P-Signal Level	Time of Day

3. The data logger buffers in each electronic cradle contain 5007 bytes of random access memory (RAM). A battery backup allows the data to remain in the buffer up to 5 years, even when the cradle or the entire ATC system is shut down.

D. Internal Outputs

The only internal outputs of the data logging function are TIME OF DAY and DATA LOGGER STATUS signals. These signals are used by the console communications functions (see Section 2-5).

E. External Outputs

The only external output of the data logging function is DATA TO BE RECORDED, which requires software and recorder not supplied with this contract.

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