DELCO ELECTRONICS CORPORATION
HUGHES ELECTRONICS CORPORATION
GENERAL MOTORS CORPORATION
PRODUCT DEFINITION DOCUMENT 3615

TYPE III J-BUS TRANSPONDER

CALENDAR YEAR 1997

PART NUMBER: 16230729

-Model

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1 INTRODUCTION

1.1 Scope of Document

This specification defines the performance, functional, reliability, and validation requirements for the ETOL Type III J-1708 Transponder. This transponder is a general purpose Type III transponder with a JBus interface in the place of the current RS232 interface. This transponder shall be henceforth referred to as "JBus Transponder."

1.2 Mission/Theme

The purpose of the Vehicle to Roadside Communications (VRC) System is to respond effectively and cost efficiently to a variety of existing and projected Intelligent Transportation Systems (ITS) requirements. The VRC System consists of a roadside communications infrastructure and vehicle transponders or Radio Frequency Identification (RFID) products supplied by Delco Electronics.

With a variety of applications and customer needs, it is desirable to develop a flexible and expandable family architecture for the VRC transponder. Such a design provides maximum responsiveness to customer needs with minimum costs.

1.3 Classifications

The JBus Transponder is for applications requiring two way JBus monitoring capabilities via an JBus port. The JBus designation represents the presence of a host processor within the transponder

The JBus Transponder designation signifies a read/write transponder with an external host interface. The JBus Transponder uses active Slotted Aloha Time Division Multiple Access [TDMA] technology with the ETOL IC as the data link controller and interface.

1.4 Delco Part Number

The Delco Part Number assigned to the JBus Transponder is **16230729**.

2 APPLICABLE DOCUMENTS

2.1 Order of Precedence

In the event of a conflict between the text of this specification and the documents cited herein, the text of this specification takes precedence unless otherwise noted. Nothing in this specification, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.2 Government Documents

2.2.1 United States

DOT49 CFR ¶ 173.206 (f) (0.5.)
ICAO (International) Safety Standards for Unrestricted Shipment).
Title 47 C.F.R Part 90, 239
Federal Motor Carrier Safety Regulations 49 CFR 393.60 (c)

2.3 General Motors Documents

GM9109P (Ref. GM9100P), Conducted Susceptibility - Electrostatic Discharge Component Test
GM9112P (Ref. GM9100P), Radiated Susceptibility - Electric Field Component Test
GM9114P (Ref. GM9100P), Radiated Emissions - Maximum Radiated Emissions Component Test.
Delco Electronics Product Reliability Test Plan TP-1620749
ASC PDD 3604 VALIDATION
ASC PDD 3605 VRC LINK PROTOCOL
ASC PDD 3609 Transponder Control Messages

2.4 Industry Documents

SAE J1455 Recommended Environmental Practices for Electric Equipment Design (Heavy-Duty Trucks)
SAE J1708 Serial Data Communications Between Microcomputer Systems in Heavy Duty Vehicle Applications

SAE J1587 Joint SAE/TMC Recommended Practice for Data Interchange Between Microcomputer Systems in Heavy Duty Vehicle Applications
SAE 1992 Powertrain Control Interface for Electronic Controls Used in Medium and Heavy Duty Diesel on Highway Vehicle Applications

3 GENERAL REQUIREMENTS

3.1 System Definition

The Vehicle to Roadside Communications System provides the means by which a roadside communications infrastructure can monitor JBus activity with transponders via a two-way communication link when transponders come into communication range. Once the site and the tag are linked, the site can request either internal data from the transponder or passively monitor the bus for specific PIDs and MIDs, store data in transponder's internal memory for use by the next VRC site and transmit messages on bus. The transponder also provides the driver of the vehicle with appropriate status indicators and exchange data status between JBus and transponder.

3.2 Packaging

3.2.1 Dimensions/Size

The sides (length and width) of the JBus Transponder shall not exceed a combined length of 6.55". The maximum thickness of the JBus Transponder shall be no more than 1.75".

3.2.2 Color/Finish

The color(s) of the JBus Transponder shall minimize heat loading on the windshield side and provide sufficient contrast with the LEDs on the operator side. The surface of the transponder shall have a finish that minimizes scratch susceptibility.

3.2.3 Mounting Requirements

The JBus Transponder shall meet all performance requirements when mounted with the top of the transponder 0 to 1 inches from a non-metalized 3/16 inch sheet of glass framed by grounded steel and placed within 2.0 inches of any corner of the metal frame/glass boundary. In addition, all mounting fixtures (if used) shall be UV stable, shall successfully complete Vibration Testing (TP 16202749 PAR 3.04).

3.2.4 Labeling/Serialization

The Transponder shall have the following identified:

(1) Part number
(2) Manufacturer
(3) Unique Public ID (barcode 128 and human readable)
(4) FCC Statement
(5) Date of Manufacture

3.2.5 Programming Requirements

Units delivered to the customer shall be pre-programmed in the factory with a 32-bit Public ID and a 32-bit Private ID. The 32-bit Public ID shall match the standard GM "Code 128" bar-code labeling found on the package (see Section 3.2.4 Labeling/Serialization). The first most significant bits must be **0011**.

3.2.6 Case Material

The case material shall be a high temp, UV stable plastic.

3.3 Power Requirements

3.3.1 Power Source

The JBus Transponder shall be powered by the vehicle battery (12V system) and operate with the ignition "**on**". The current drain with vehicle ignition "**off**" will be 3 mA or less unless the LEDs or beepers are on or the unit is transmitting. The transponder will use the switched ignition signal to control power usage and radio link functions.

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3.3.2 RAM Backup

The JBus Transponder shall utilize a three volt internal battery for ETOL IC RAM backup. The battery shall not require special disposal or handling when discharged. Also, it shall not vent or exhibit decomposition at operating or storage temperatures and load extremes (DOT49 CFR ¶ 173.206 (f) (0.5) and ICAO International Safety Standards for Unrestricted Shipment). The internal RAM backup battery shall have a minimum one year shelf life.

4. FUNCTIONAL & ARCHITECTURAL DESIGN REQUIREMENTS

4.1 Architectural Overview

The architecture of the JBus Transponder shall include four basic functional elements; the ETOL IC Function, the RF Function, Power Management Function and the Host Function. (See Figure 1 ATTACHMENT)

The following sections define the design and performance requirements for each of the four function blocks, as well as the requirements for the Host, RF and, Driver Interfaces. The internal interfaces are beyond the scope of this specification.

4.2 Power

4.2.1 Power Function

The Power Function shall supply power to the remaining functional blocks (i.e. the ETOL IC Function, RF Function, and the Host Function) during operation and battery backup for the RAM. The Power Function shall also regulate the power and protect the other functions from reverse voltage, load dumps, and jump start voltages (see 5.5 Voltage Protection Requirements).

4.2.1.2 Power Source

The Power Function shall utilize the vehicle battery (12v) as the power source for the operation of the transponder (see also 3.3 Power Requirements) with an ignition sense for proper power moding.

4.2.1.3 Power Output

The Power Function shall supply power to all elements of the transponder and backup the RAM memory while the supply ~~output~~ input is at a level sufficient for normal tag operation.

4.3 Host Function

4.3.1 Host Interface

The ETOL IC Function shall provide a Serial Peripheral Interface (SPI) for data I/O with the host. The SPI shall facilitate the bi-directional transfer of data at a speed high enough to support the maximum throughput allowed by the protocol.

4.3.2 Host Driver Interface

The purpose of the Host Driver Interface shall be to communicate transponder and transaction status to the driver. In the JBus Transponder the host processor shall have control of the audio and visual indicators.

The Host Driver Interface shall provide the capability for visual and audible indicators when required by the customer application. The visual and audio signal shall be controlled by a field in the slot data messages or a user defined message. The Host Driver Interface shall be controlled independently of the sleep function.

4.3.2.1 Visual Indicators

The J-Bus Transponder shall have three visual indicators: a green LED for positive confirmation, a red LED for negative confirmation and a yellow LED for multiple purposes. The Host Driver Interface shall control activation of all LEDs.

4.3.2.2 Beeper Tone Format

The Host Driver Interface shall include an audible beeper. The activation, duration, and format of the beeper tone shall be controllable by the host. Activation for the beeper shall be controlled independently of the activation of the visual signals.

4.3.2.2.1 Beeper Loudness

The minimum Sound Pressure Level for the beeper shall be 75 dBA at 10 cm in the temperature operating range of 0°C to +70°C with a 50% duty cycle 5v p-p input signal.

4.3.2.3 User Definable Signals

4.3.2.3.1 Driver Interface Control Message

The Driver Interface Control Message protocol allows for a multitude of signaling. Each 64 bytes of a host interface (one slot) can have four LED states and four beeper states. Each state will be treated sequentially so no state numbers are used and this applies to only ONE slot data message.

The LED control is independent from the beeper control and the driver interface pattern can be created and translated into a hexadecimal representation.

4.4 ETOL IC Function

The purpose of the ETOL IC Function shall be to perform message processing functions for the data link layer and media access layer protocols, to provide central control for the transponder, and to manage the host.

4.4.1 Link Communication Protocol

All control/data message processing protocols related to media-access (VRC network) function, data link functions and basic application functions (memory read/write, etc.) shall be controlled by the ETOL Function. These message processing functions are described in Delco document ASC PDD 3605.

4.4.2 Search Cycle Management

The VRC network entry process requires the transponder to search for a Reader Control Message (RCM) in order to obtain network synchronization and, ultimately, network entry. The ETOL Function shall implement on/off receiver duty-cycling functions as defined below in order to minimize energy expenditure, and to maximize battery life. The transponder shall search for RF energy only during the "on" state. Furthermore, only the necessary circuitry shall be powered-up during this "on" period. Upon detection of RF energy, the ETOL Function shall power the entire transponder, and begin an active search for a valid RCM. In case of a false detection, the ETOL Function shall implement a search time-out. The three elements of this "search cycle" are described in more detail below.

4.4.2.1 Sleep Mode

The J-Bus Transponder shall enter a Sleep Mode for 1063 µS when the ETOL Function (ETOL IC) does not detect a possible RF signal from a reader. During this mode the ETOL Function shall disable the data detection circuitry, the 4 MHz oscillator, and all RF circuits to minimize energy consumption and, thus, maximize battery life. After sleeping for 1063 µS, the ETOL Function shall transition the tag to a Wake-Up Mode.

4.4.2.2 Wake-up Mode

During the Wake-up Mode, the ETOL Function shall enable only the signal present detection circuitry. If a possible RF signal from the reader is detected during this mode, the ETOL Function shall transition the transponder to the Reader Control Acquisition Mode. If no signal is detected the ETOL Function shall transition back to the Sleep Mode. The ETOL Function shall remain in the Wake-up mode for 57µs - the first 28.5µs is dedicated to circuit power-up and stabilization while the second 28.5µs is used to search for a possible reader RF signal (see Attachment Fig. 2) signal detection diagram).

4.4.2.3 Reader Control Acquisition Mode & Active Modes

Once a valid reader signal is detected, the ETOL Function shall enter a Reader Control Acquisition Mode. In this mode the ETOL shall activate the 4 MHz oscillator and the data reception circuitry in order to receive and decode a valid (RCM). The first time the ETOL Function detects an RCM, the tag shall transition to the Activation Mode. After the first RCM containing the ETOL's public ID then the ETOL shall switch to the Message Slot Mode and begin the transaction during the proper time frame (the ETOL shall also switch to RX and TX Modes during transactions- but this is beyond the scope of this document). For additional information on the ETOL Function's various states of operation consult Delco Document PDM 16203734 Specification.

4.4.2.4 Time-Out Mode

After the transponder has successfully processed all of the data slots and activation commands, the ETOL shall transition to a Time-Out Mode. During this mode the ETOL shall disable the 4 MHz oscillator, all data detection circuits, and any other unnecessary circuits. The length of the time-out shall be controlled by the reader (included in the RCM) and shall range from 0 to 30 seconds. After the reader specified time-out has elapsed, the transponder shall return to the Sleep Mode.

4.4.3 Host Interface

The ETOL IC shall implement a Host Interface Function which includes a set of communication and command functions. These communication functions shall support external high-level communication and application protocols for interface with the host processor . The ETOL IC shall be capable of differentiating external and internal Slot Data Messages. External messages received from the reader shall be transferred across the Host Interface (ETOL IC to Micro).

4.4.4 JBUS Interface

The JBus Transponder shall have the ability of transmitting and receiving messages on the bus utilizing a 3 pin minfit connector attached to the data bus. The minifit connector shall have the following pinout scheme:

S DAT+ pin 1 **S DAT-** pin 2 **N/C** pin 3

4.4.4.1 Protocols

4.4.4.1.1 Bit Time

A bit time shall be 104.17 µs ± 0.5% (± 500 ns). This is equivalent to a baud rate of 9600 bits per second.

4.4.4.1.2 Bus Access

The JBUS Transponder is designed as a pass thru modem to receive JBUS messages and pass them on to the roadside reader. To pass messages on to the roadside reader the transponder can be configured to filter specific PIDs and MIDs. Idle time plus the priority time delay for transmitting on the bus will be implemented by the JBUS transponder and bus contention is implemented on a byte boundary. Message priority will not be embedded in the transponder, but a priority field is passed on to the transponder from the reader with the message to transmit. This priority field is used to determine priority on the bus.

4.4.4.2 Serial Data Bus

The JBus transponder shall implement a circular buffer for receiving messages to facilitate 100% bus utilization. After the JBUS transponder enters the reader zone the roadside reader will began receiving messages contained in the circular buffer that has appeared on the JBUS. During the time the JBUS transponder is in the zone more messages will be placed in the circular buffer.

4.4.4.3 Bus Reacess

The JBus transponder does not support SAE J1587 Appendix B at the present time.

4.4.5 Transponder Memory

Memory for the JBus Transponder shall consist of 64 bits of One-Time-Programmable for factory data and 512 bits of RAM for other storage usage. The 64 bits of factory data shall be divided into a 32-bit Private ID and a 32-bit Public ID. The Private ID shall be kept internal to the tag and should be used only by the Linear Sequence Generator (LSG) when performing agency programming. The Public ID shall also be the ID for the transponder. The first four bits of the Public ID shall designate the type of tag. The factory data shall be programmed when the tag is manufactured at the factory. The factory data shall be protected such that the Private ID can never be read again and the factory data can not be overwritten. RAM shall be backed up with a battery.

RAM shall be allocated as follows:

(1) Storage	256 bits
(2) Agency Data (192 bits) & 64 Bits unused	256 bits

4.5 RF Function

The RF Function of the J-Bus Transponder shall perform all operations necessary to implement the physical layer of the VRC Link Protocol (Refer to Delco Document ASC PDD 3605 for details on the common link protocol requirements between the transponder and reader).

4.5.1 Effective Radiated Power

The transmit amplifier and antenna shall operate at a field strength between 170 mV/m to 350 mV/m when measured at a one (1) meter distance along the antenna boresight over the entire operational supply voltage range and operational temperature range.

4.5.2 RF Carrier Detector & Data Demodulator

The sensitivity of the transponder shall be such that the bit-error rate (BER) does not exceed 10-5 when placed in a horizontally polarized electric field with a signal strength from 210 mV/meter to 6850 mV/meter over the entire operational supply voltage range and operational temperature range.

4.5.3 Frequency Accuracy

The 915 MHz carrier frequency of the J-Bus Transponder shall not vary more than ± 300 kHz over the operational supply voltage range and operational temperature range.

4.5.4 Out of band Susceptibility to Interference

The transponder shall operate properly and suffer no degradation due to the local RF environment. [see TABLE 1]

4.5.5 Transmit Spectrum: Spurious Harmonics

The transmit power outside the 10 MHz band centered at 914.75 MHz shall be attenuated at least [55+10logP] dB below the transmitted power inside the band (P is the transmitter output power in Watts within the band). Emitted power outside the band shall be measured in a 100 kHz bandwidth. All measurements should be made at the output of the transmitter (place a connector at the antenna port on the board) rather than in free space when radiating through the antenna.

4.5.6 RF Damage Protection

The J-Bus Transponder shall not sustain permanent damage when placed in an electromagnetic field with a signal strength of 16.5 V/m continuous or 50 V/m for 30 seconds (per SAE J1455).

4.5.7 RF Interface

4.5.7.1 Antenna

The RF Interface shall provide for connection to an internal antenna.

4.5.7.2 Polarization

The RF transmissions from the transponder shall be omnidirectional. All radiated emissions and sensitivity requirements shall be met when transmitting in an anechoic environment using an omnidirectional test antenna.

4.5.7.3 Beamwidth

The 3 dB beamwidth shall be 100° minimum in elevation and 70° minimum in azimuth.

4.5.8 On/Off Ratio

The ratio of power output in the "on-burst" to the power output in the "off-burst" shall be more than 20 dB.

4.5.9 Carrier to Interference Ratio (C/I)

The JBus Transponder shall operate normally when interfering signals are a minimum of 15 dB below the true reader signal.

4.5.10 Dynamic Range

The JBus Transponder shall a 30 dB minimum dynamic range (up to 0 dBm).

5 VALIDATION AND ENVIRONMENTAL REQUIREMENTS

The following section describes the minimum set of validation and environmental requirements for the JBus Transponder.

5.1 Temperature

The JBus Transponder shall be capable of normal operation over a temperature range of - 40°C to +85°C. In addition, the transponder shall not suffer any permanent damage if exposed to temperatures from -54°C to +113°C (Product Reliability Test Plan TP-16202749 PAR 3.01).

5.1.1 Tri-Temperature

Functionality testing -40°C, 25°C, 85°C
Parametrically -30°C, 25°C, 70°C

5.1.2 Cold Soak

-55°C @96 HRS

5.1.3 Heat Soak

+115°C @96 HRS

5.1.4 Electrical Stress

Reverse voltage -13V, jump start 24V.
Conductive Transients : (1) -100V (2) 100V (3) -150V Train (4) 100V Train (5) -300V (6) 84 AMP Pulse.
Sinusoidal Burst 0.5MHZ to 50MHZ @ 150V.
ESD Handling 25kV

5.2 Thermal Shock

The JBus Transponder shall operate normally during Power Temperature Cycling. For more information see Product Reliability's Test Plan Document TP 16202749 PAR 3.02.

5.2.1 Power Temperature Cycling

-40°C to +85°C for 500 cycles

5.3 Humidity

The tag shall successfully pass Constant Biased Humidity testing. Relative humidity shall be 95% + 3% - 5% as stated in the Product Reliability Test Plan TP 16202749 PAR 3.03.

5.3.1 Bias Humidity

45°C @95% R.H

5.4 Vibration

The JBus Transponder shall successfully complete the following Delco Electronics' vibration tests:
Random Vibration Test - Product Reliability Test Plan TP 16202749 PAR 3.04.
Rattle Test - Product Reliability Test Plan TP 16202749 PAR 3.05.

5.4.1 Mechanical Stress

Vibration-Shock 2 G's
Random-Shock 3.2 G's each plane 2 hours
Drop Test 4 Feet

5.5 ESD Voltage Protection

The JBus Transponder must not sustain any permanent damage as a result of the following tests listed below. All electrical stress tests shall be conducted in accordance with GM EMC - Component Specifications and Overview of Test Requirements (GM9100) for a Class B device and Product Reliability Test Plan TP 16202749 PAR 3.06.

GM9116P - Immunity to Conducted Sinusoidal Bursts

GM9117P - Jump Start/Reverse Voltage:

GM9119P ESD During Handling

5.6 Radiated Susceptibility

The JBus Transponder must successfully complete GM9112P and GM9113P testing (see GM9100P) - Radiated Susceptibility to Electric Fields and Magnetic Fields (Power Lines) and Product Reliability Test Plan TP 16202749 PAR 4.0.

5.7 Radiated Emissions

While not transmitting the JBus Transponder must successfully pass GM9114 Radiated Emissions testing. During transmission the transponder must meet all FCC requirements as stated in 47 C.F.R Part 90.209,239 for operation in the United States and Canadian Department of Communications General Regulations, GRR II Section 6, Part I, Item a, or current DOC regulation for operation in Canada. and Product Reliability Test Plan TP 16202749 PAR 4.0.

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REVISION LOG

DATE	SECTION	REQUESTER	ITEM
6/10/96			START OF REVISION LOG
6/27/96	1.2	N. Burkholder	delete "At the core of this family of RFID products is the Type II Basic Transponder."
6/27/96	1.3	N. Burkholder	delete "The core of the Jbus Transponder is the ETOL Type II Basic building block.."
6/27/96	3.1	A. Strader	insert "transmit messages on bus"
6/27/96	3.1	A. Strader	insert "MIDs"
6/27/96	3.3.1	N. Burkholder	delete " both , and, off"
6/27/96	3.2	N. Burkholder	**Color/Finish** [to be defined by Mack]
6/27/96	3.2.1	N.Burkholder	**Dimensions/Size** to be defined by Mack
6/27/96	3.3.2	N.Burkholder	**Mounting Requirements** [to be defined by Mack]
6/27/96	3.3.1	A.Strader	First sentence should read "The Jbus Transponder shall be powered by the vehicle battery (12V system) and operate with the ignition "**on**". Change 10mA to "3mA or less"
6/27/96	4.1	A.Strader	Add "Host Function"
6/27/96	4.2	A.Strader	delete "**Functional Overview**" add "**Power**"
6/27/96	4.3.3.1.1 thru 4.3.3.2.1.2	N.Burkholder	delete these sections
6/27/96	4.3.3.2	E.Faison	insert **Beeper Tone Format**
6/27/96	4.3.4	Faison/Strader	insert **Signaling Requirements for Jbus Applications**
6/27/96	4.3.4.1	Faison/Strader	insert **Toll Payment Bypass** [to be defined by Mack]
6/27/96	4.3.4.2	Faison/Strader	insert **Weigh Station Bypass** [requirements to be defined by Mack]
6/27/96	4.3.4.3	Faison/Strader	insert **Diagnostics HW/SW** [to be defined by Mack]
6/27/96	4.3.4.4	Faison/Strader	insert **Exchange Data Download/Upload Status** [to be defined by Mack]
6/27/96	4.3..4.4.1	Faison/Strader	insert **Visual Status Feedback to Driver** [to be defined by Mack]
6/27/96	4.3.4.5	Faison/Strader	insert In Zone Signaling [to be defined by Mack]
6/27/96	4.3.3.3.2 thru 4.3.3.3.16	N.Burkholder	delete these sections
6/27/96	Attachment "A"	N.Burkholder	delete drawing from PDD
6/27/96	4.4.4	E.Faison	insert **Jbus Interface**
6/27/96	4.4.4.1	E.Faison	insert **Protocols**
6/27/96	4.4.4.1.1	E.Faison	insert **Bit Time**
6/27/96	4.44.1.2	E.Faison	insert **Bus Access**
6/27/96	4.4.4.2	E.Faison	insert **Serial Data Messages**
6/27/96	4.4.4.3	E.Faison	insert **Bus Reaccess**
6/28/96	4.3.4 thru 4.3.4.5	Product Team	Delete sections **4.3.4 Signaling Requirements for JBUS Applications** **4.3.4.1 Toll Payments Bypass (TBD)** **4.3.4.2 Weigh Station Bypass (TBD)**

			4.3.4.3 Diagnostics HW/SW (TBD) **4.3.4.4 Exchange Data Download/Upload Status (TBD)** **4.3.4.4.1 Visual Status Feedback To Driver (TBD)** **4.3.4.5 In Zone Signaling (TBD)**
7/12/96	3.1	Product Team	insert "Once the site and the tag are linked, the site can request either internal data from the transponder or passively monitor the bus for specific PIDs and MIDs, store data in transponder's internal memory for use by the next VRC site and transmit messages on bus. The transponder also provides the driver of the vehicle with appropriate status indicators and exchange data status between JBus and transponder."
7/12/96	3.2.1	Product Team	insert "The sides (length and width) of the JBus Transponder shall not exceed a combined length of 6.55". The maximum thickness of the JBus Transponder shall be no more than 1.75".
7/12/96	3.2.3	Product Team	insert "when mounted with the top of the transponder 0 to 1 inches from a non-metalized 3/16 inch sheet of glass framed by grounded steel and placed within 2.0 inches of any corner of the metal frame/glass boundary"
7/12/96	3.3.1	Product Team	insert "or beepers"
7/12/96	4.5.7.2	Elliott Faison	insert "The RF transmissions from the transponder shall be horizontally polarized. All radiated emissions and sensitivity requirements shall be met when transmitting in an anecohic environment using a horizontally polarized antenna."