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TIRIS Technology by Texas Instruments™

Hardware Specification
for
LUHF Vehicle Transponder (U.S.)

RI-TRP-VUSA

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1. INTRODUCTION

1.1 SCOPE

This document describes the implementation of the FCC compliant Vehicle Transponder for the ARC customer identification system. The scope of this document includes the performance requirements for the U.S. vehicle transponder and the interface definition between the transponder and other major assemblies in the ARC system.

If anything in this document is ambiguous or incorrect, it should be immediately reported to the Project Managers for the ARC Team, and corrected. The document should then be approved by all the concerned individuals on the cover page and redistributed to all parties involved.

1.2 APPLICABLE DOCUMENTS

The hierarchy of documentation pertaining to the ARC system is depicted below. As this table appears in each of the documents, it is important that revisions to any document in the family be reflected in this table.

Document Number	Document Title
TIRIS2001	Mobil Speedpass System Customer Requirements Product Specification
06-01-02-700	ARC System Specification for Retail Fueling Applications
11-09-05-702	ARC Digital Control Board Hardware Specification - RI-CTL-DCUA
11-09-05-703	ARC UHF Receiver Daughter-Board Specification (US) - RI-RFM-HRUA
11-09-05-700	Hardware Specification for LUHF Vehicle Transponder (U.S.)
11-09-05-701	Software Specification for LUHF Vehicle Transponder (U.S.)
11-09-05-704	ARC LUHF Vehicle Transponder Programmer Specification

ARC System Qualification Test Procedure & Manufacturing / QA/QC Procedures per TQM Standards.

FCC Part 15, Class B

1.3 DEFINITIONS, ACRONYMS, AND ABBREVIATIONS

ARC	Automatic Recognition of Consumers
ASK	Amplitude Shift Keying
DCB	Digital Control Board
DST	Digital Signature Transponder
ES	Electrostatic
ETSI	European Telecommunication Standards Institute
FCC	Federal Communications Commission
FSK	Frequency Shift Keying
IPC	Interconnecting and Packaging Electronic Circuits
LF	Low Frequency
MTBF	Mean Time Between Failure
PLL	Phase Locked Loop
POS	Point of Sale
UHF	Ultra High Frequency
Uplink	RF Data Transmission from the Transponder to the Reader
Downlink	RF Data Transmission from the Reader to the Transponder

2. FUNCTIONAL AND OPERATIONAL REQUIREMENTS

The ARC system, when installed in a fuel dispenser which offers pay-at-the-pump functionality, provides hands-free identification of a customer and/or the customer's vehicle. The system offers pay-at-the-pump convenience, without requiring the insertion of a credit card or any keypad entries.

The U.S. Vehicle Transponder is the component of the system placed in the customer's vehicle. When activated by a ARC dispenser, the transponder provides identification and authentication data via a radio frequency link to the dispenser. An overview of the complete ARC system is provided in the ARC System Specification, 06-01-02-700.

2.1 SYSTEM OVERVIEW

An overview of the U.S. vehicle transponder is depicted in Figure 2-1 below. The major functional blocks of the transponder are the downlink network, the processor, and the uplink network.

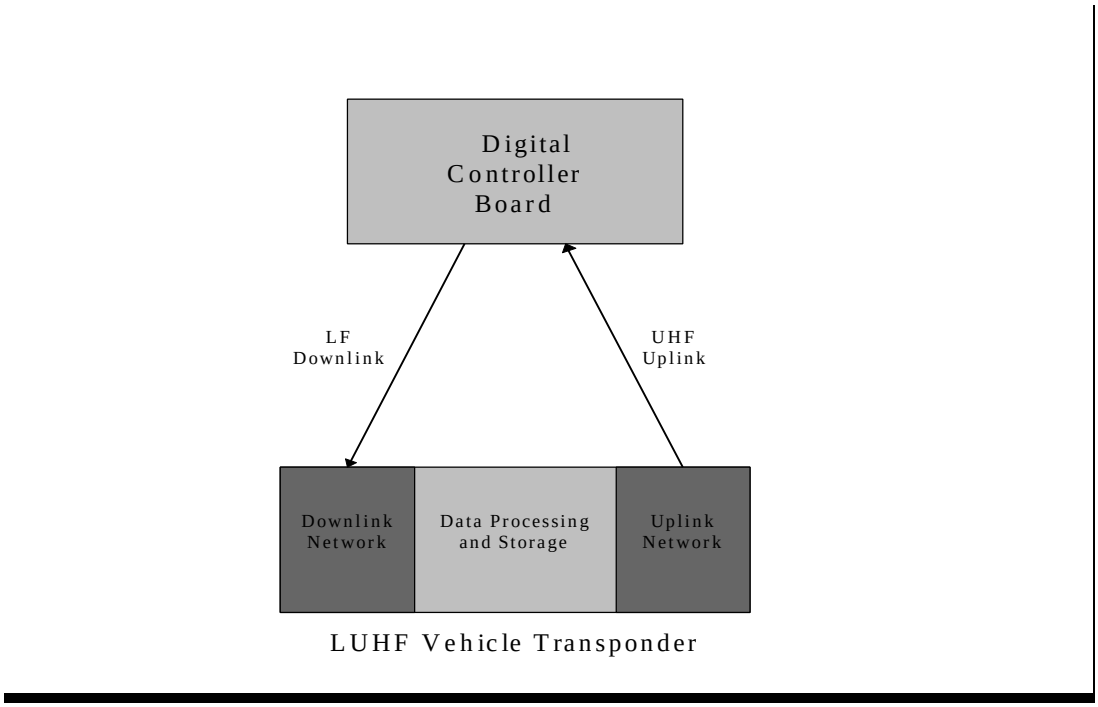

Figure 2-1. U.S. Vehicle Transponder Block Diagram.

3. PERFORMANCE REQUIREMENTS

Top-level customer specific system performance requirements are defined in the applicable Customer Requirements Product Specifications detailed in Section 1.2. This section augments and clarifies those requirements pertaining to the vehicle transponder, as appropriate.

3.1 PHYSICAL CHARACTERISTICS

3.1.1 Dimensions

The transponder shall be fully contained within a 58.mm x 44.5mm x 24.mm space. The maximum dimensions of the transponder shall not exceed this space in any direction.

3.1.2 Weight

The transponder shall weigh no more than 0.5 lbs.

3.1.3 Housing

The transponder shall be enclosed in a plastic housing, type PC/ASA.

3.1.4 Battery

The transponder housing shall provide access to the replaceable battery. The battery is a coin cell, type 2032. The chemistry of the battery will be Li-MnO_2 or equivalent approved by Texas Instruments to ensure compliance with this specification.

3.1.5 Transponder Mounting

The transponder shall be mounted in the lower middle of the rear window using "hook and loop" or "ball and cup" fasteners with adhesive attachment to the window and to the transponder.

3.2 ELECTRICAL CHARACTERISTICS

3.2.1 Radio Frequency Characteristics - Downlink

The transponder shall detect and process signals, which consist of the following properties:

Property	*Requirement*
Carrier Frequency	134.2 kHz +/- 100 ppm
Activation Field Strength Level (at the transponder surface)	34 mA/m +/- 7 mA/m, at the optimum transponder orientation At a 45° rotation from optimum, an additional 3dB of field strength is required. The transponder must be separated from any metallic material by a minimum of 3 cm.
Max. Operating Field Strength (at the transponder surface)	500 mA/m
Modulation	ASK
Modulation Depth	> 95 %
Data Encoding	FM0
Data Rate	1 kbps +/- 100 ppm
Duty Cycle of received FM0 signal	50 +/- 5%

The transponder shall successfully process signals with these properties while in the operating temperature range specified in section 7.5.

3.2.2 Radio Frequency Characteristics - Uplink

The output signals from the transponder shall conform to the following properties:

Property	***Requirement***
Virtual Carrier Frequency	902.8 MHz
Carrier Frequency Accuracy	+/- 100 ppm
Total Radiated Power	-20 dBm +/- 3dB
Spurious Emissions	-36 dBm maximum (250 nW)
Modulation	FSK
Virtual Carrier Frequency Drift within one Transmission	10 kHz maximum
Frequency Deviation	40 kHz maximum
Digital high level encoding	Positive frequency deviation
Digital low level encoding	Negative frequency deviation
Data Encoding	Manchester
Data Rate	20 kbps +/- 100 ppm
Duty Cycle of transmitted signal	50 +/- 10%

The transponder shall transmit signals with these properties while in the operating temperature range specified in section 7.5.

3.2.3 Transponder data

The transponder shall have the capability of storing data in non-volatile memory. Data may be loaded into the transponder at three possible locations: the transponder manufacturing facility; the transponder distribution center; and at Third Party locations. The following table defines the data that shall be programmed into the transponder, and the facilities where it could be programmed.

Data block	*Programmable at Factory*	*Programmable at Distribution Center*	*Programmable by Third Party*
Transponder Identification Number (32 bits)	Yes	Yes	No
Account Data field, for fleet identification (5 bits)	Yes	Yes	Yes
DST data, up to 32 unique keys (40 bits each)	Yes	Yes	No
Key activation data, to indicate programmed key	Yes	Yes	Yes

Any data block may be programmed one time only. The DST keys shall be stored in such a way that they may not be read from the transponder once programmed.

3.2.4 Processor Characteristics

The transponder processor is a dedicated microcontroller capable of operating at 1 MIPS. The processor includes a crystal clock operating at 4 MHz +/- 100 ppm over the full temperature range of the transponder. This tolerance directly influences the accuracy of the output data rate of the uplink data. Refer to the ARC Vehicle Transponder Software Specification, 11-09-05-701, for detailed requirements for the transponder software.

The processor shall have two modes, Sleep and Active. The transponder shall go into its Sleep mode after exiting a RF field with the defined RF characteristics below the maximum RF level of an incoming data 0. In Sleep mode the transponder will consume a minimal amount of current to enhance battery life. The transponder will wake-up and go into an Active mode upon entering a RF field with the defined RF characteristics above the minimum RF level of an incoming Data 1. Once activated, the transponder will attempt to acquire and respond to incoming polls or else go back into Sleep mode if the RF field goes away.

The processor executes tasks sequentially, and will only perform half-duplex communication. For a poll to be recognized by the processor, sufficient time must be allowed following the previous response. The first unique DST Challenge poll will cause the processor to save the challenge data and

execute the DST algorithm. While executing the DST algorithm, the processor will not respond to any polls. The processor will response to subsequent identical DST Challenge polls using the calculated DST Challenge Response.

3.2.5 Current Consumption Characteristics

The transponder shall achieve a minimum battery life of three years. The battery life shall be defined through the functional temperature range with the defined number of fueling transactions per week. Exposure to temperatures in excess of the defined functional temperature range will reduce the battery life.

Fueling Transactions	5 per week
Battery Voltage, typical	3V (depends on battery type)
Battery Voltage, allowable operating range	2.5 V to 3.5 V
Battery Capacity	~210 mAH
Current load (Sleep)	< 4 uA average over specified temperature range
Current load (Active)	< 5 mA

3.2.6 Operation at Temperature Extremes

The transponder may not be functional outside of the defined operating temperature range. The transponder shall return to full functionality after returning to the operating temperature range from the storage temperature range, provided that there is still sufficient battery capacity available after storage. The operating and storage temperature ranges are defined in section 7.5.

4. INTERFACE REQUIREMENTS

This section defines the interfaces between vehicle transponder and relevant subsystems of the ARC system.

4.1 DIGITAL CONTROL BOARD INTERFACES

4.1.1 Downlink message format (poll)

The Dispenser Controller Board communicates with the vehicle transponder by sending poll messages in the downlink channel. The format of the downlink poll messages are defined in the ARC Vehicle Transponder Software Specification, 11-09-05-701.

4.1.2 Uplink message format (response)

The vehicle transponder communicates with the Dispenser Controller board by sending response messages in the uplink channel. The format of the downlink poll messages are defined in the ARC Vehicle Transponder Software Specification, 11-09-05-701.

4.2 PROGRAMMING STATION INTERFACES

The programming interface shall be in accordance with Vehicle Transponder Programming Specification, 11-09-05-704.

5. ELECTROMAGNETIC INTERFERENCE REQUIREMENTS

5.1 GENERAL

The design requirements for the control of the electromagnetic emission and susceptibility characteristics of the U.S. vehicle transponder shall be in accordance with MIL-STD-461D Requirements for Control of Electromagnetic Interference Emissions and Susceptibility.

5.2 RADIATED EMISSION

Requirement	*Description*
RE101	Radiated Emissions, Magnetic Field, 30 Hz to 100 kHz for a Land Mobile platform.
RE102	Radiated Emissions, Electric Field, 10 kHz to 18 GHz. Except for 903 +/- 1 MHz, where a maximum of - 10 dBm may be present for a Land Mobile platform.
RE103	Radiated Emissions, Antenna Spurious and harmonic Output, 10 kHz to 40 GHz. Except for 903 +/- 1 MHz, where a maximum of - 10 dBm may be present for a Land Mobile platform.

5.3 RADIATED SUSCEPTIBILITY

Requirement	*Description*
RS101	Radiated Susceptibility, Magnetic Field, 30 Hz to 100 kHz. A maximum field strength of 27 mA/m is allowable.
RS103	Radiated Susceptibility, Electric Field, 10 kHz to 40 GHz.. Except for 10kHz to 200 kHz, where a field strength of 2.7 mA/m is allowable.

5.4 ELECTRIC / MAGNETIC FIELD DAMAGE SUSCEPTIBILITY

The transponder shall withstand, without permanent damage, a field of 1 A/m in the band 0 - 200 kHz, excluding 133 -135 kHz, or a field of 200 V/m in any other band.

6. REGULATORY REQUIREMENTS

6.1 FCC REQUIREMENTS

The vehicle transponder shall comply with FCC Regulations, Part 15, Class B.

7. QUALITY ASSURANCE PROVISIONS

The U.S. vehicle transponder shall be designed and manufactured under a quality assurance program equivalent to ISO 9001. This does not imply that the suppliers of the design or manufacturers shall be certified to ISO 9001 but are capable of and have withstood an external audit by an independent auditor.

7.1 INSPECTION

The transponder shall be visually inspected by the supplier. The transponder shall be inspected for compliance to the Institute for Interconnecting and Packaging Electronic Circuits (IPC) or equivalent standard. This inspection shall be sufficient to assure performance to the requirements of this specification, workmanship and electrical interface.

7.2 TESTING

The transponder shall be tested for compliance to the performance requirement of paragraphs 3 through 6**.** Test procedures shall be reviewed and approved prior to the acceptance of product.

7.3 MATERIALS

Materials chosen by the supplier shall be in accordance with IPC or equivalent standards and practices, sufficient to assure performance to the requirements of this specification.

External parts, elements or coatings including marking shall be inherently non-nutrient to fungus and do not blister, crack, outgas, soften, flow or exhibit defects that adversely affect storage, operation, or assembly.

7.3.1 Toxic Products and Formulations

No products or formulations, which are known to be toxic or harmful, shall be used without approval by Texas Instruments Incorporated.

7.3.2 Workmanship

Workmanship evidenced in the construction of the vehicle transponder shall be inspected for compliance to the Institute for Interconnecting and Packaging Electronic Circuits (IPC) or equivalent,

sufficient to assure performance to the requirements of this specification to the extremes of the environments specified herein.

7.4 RELIABILITY REQUIREMENTS

7.4.1 Reliability Performance

The reliability of the transponder shall be designed to meet or exceed the design goals documented in the table below. The reliability prediction technique shall utilize MIL-HDBK-217 or Bell Core, Method 1, at 25 degrees C, as a guideline.

Module	MTBF * (hours, Repairable)	MTTF ** (hours, Non-repairable)	Survival Probability (3 years)
LUHF Vehicle Transponder (excluding Battery)		1,000,000	.974

Table 7-1. Reliability Requirements

* MTBF - Mean Time Between Failure which are repairable.

** MTTF - Mean Time to Failure which are non-repairable.

7.5 ENVIRONMENTAL REQUIREMENTS

The U.S. vehicle transponder is to meet applicable sections defined in the applicable Customer Requirements Product Specifications detailed in Section 1.2**.**

The critical operating environmental guidelines are as follows:

- ***Operating temperature***: Operating temperature tests in accordance with MIL-STD-202F, method 102A, temperature cycling or equivalent, using the following parameters: -10 to +85 degrees C, duration 500 hours. Transponder may have degraded operational performance to -20 degrees C.

- ***Storage temperature*** (battery removed): Storage temperate tests in accordance with MIL-STD-810D, method 502.2, using the following parameters: Low temperature - 40 degrees C 1000 hours, High temperature 104 degrees C, 1000 hours.

- ***Shock Environment***: Shock test performed in accordance with Mil-STD-810D, Method 516.3 or equivalent using the following parameters: 30 G's at 10 mS, half sinusoidal wave, 6 axes.

- ***Vibration Environment***: Vibration tests in accordance with MIL-STD-810E, Method 514.4 or equivalent, using the following parameters: 10 to 500 Hz, 10 g peak, 30 minutes sweep, logarithmic.

- ***Humidity Environment*** (battery removed): Humidity tests in accordance with MIL-STD-810D, Method 507.2, procedure III, aggravated screening or equivalent, using the following humidity parameters: 85 percent relative humidity, non-condensing at 85^{o} C, duration 500 hours.

- ***Thermal Shock*** (battery removed): Thermal Shock testing in accordance with MIL-STD-810D, Method 503.2 or equivalent, using the following thermal shock parameters: - 40 to 85 degrees C, 100 cycles duration.

- ***Drop:*** Drop from 1m onto a 1-inch thick maple block, 1 drop per side on all surfaces. Operational functionality and structural integrity shall not be compromised. The battery cover is allowed to fall off of the transponder as long as it is not damaged and can be replaced into the unit.

8. PREPARATION FOR DELIVERY

8.1 PACKING AND PACKAGING

Preservation, packaging, and packing of system and subsystems to be delivered shall be to the supplier's best commercial practice to prevent deterioration and mechanical damage in shipment and in storage.

8.2 ELECTROSTATIC (ES) PROTECTION

The ARC system and subsystems shall meet an ES level of 2000 volts minimum using a standard body model.

9. BATTERY LIFE CALCULATION

Battery Load Conditions

* Standby Conditions

Load Current: 2 uA

Duration: 100% of time

* Active Conditions

Duration: 5 transactions / week, assuming 5 minutes / transaction

Continuous Load: 1 mA

Pulsed Cycle Load: (* Additional to Continuous Load)

Cycle Time: 200 mS

Pulse Time: 6 mS

Pulsed Load: 4 mA

* Temperature:

Range: -10C to +85C (Operational)

Hot %: 15% (+85C)

Cold %: 15% (-10C)

* Minimum Operational Voltage: 2.5V

* Battery Self Discharge: < 5% / year

* Battery Energy: 210 mA-Hour

Energy Usage per Year

*Self Discharge Energy per Year: 10.50 mA-Hour

(210 mA-Hour * 5%)

*Standby Energy per Year: 17.52 mA-Hours

(2 uA * 24 Hours/Day * 365 Days/Year)

* Active Energy per Year:

Continuous: 21.67 mA-Hours

(1 mA * [(5 Min/Day)/ (60 Min/Hour)]* 5 Days/Week * 52 Weeks/Year)

Pulsed: 2.60 mA-Hours

(4 mA * [(6 mS/200 mS * 5 Min/Day)/(60 Min/Hour)] * 5 Days/Week * 52 Weeks/Year)

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Total 52.29 mA-Hours/Year

Calculated Life: 4.02 Years

(210 mA-Hour / 52.29 mA-Hour/Year)