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Freescale Semiconductor
User's Guide

Document Number: RDAIRBAGPSI5UG
Rev. 2.0, 10/2014

RDAIRBAGPSI5 Airbag Reference Platform

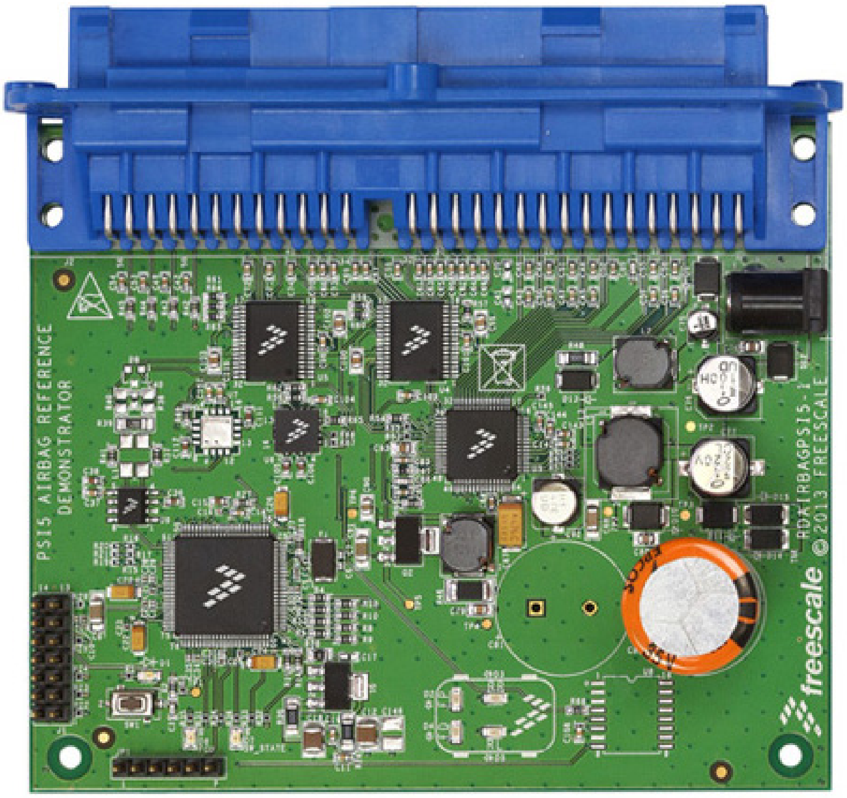

Figure 1. RDAIRBAGPSI5

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This reference design is intended for use of ENGINEERING DEVELOPMENT OR EVALUATION PURPOSES ONLY. It is provided as a sample IC pre-soldered to a printed circuit board to make it easier to access inputs, outputs, and supply terminals. This reference design may be used with any development system or other source of I/O signals by simply connecting it to the host MCU or computer board via off-the-shelf cables. Final device in an application will be heavily dependent on proper printed circuit board layout and heat sinking design as well as attention to supply filtering, transient suppression, and I/O signal quality.

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2 Getting Started

The RDAIRBAGPSI5 contents include:

- RDAIRBAGPSI5 Airbag Evaluation Platform board
- FTDI Cable
- Warranty card

The RDAIRBAGPSI5-1 contents include:

- RDAIRBAGPSI5-1 Airbag Evaluation Platform board
- PSI5 Satellites modules
- ECU Wiring Harness
- FTDI Cable
- Warranty card

2.1 Jump Start

Freescale's analog product development boards help to easily evaluate Freescale products. These tools support analog mixed signal and power solutions that include monolithic ICs using proven high-volume SMARTMOS mixed signal technology, and system-in-package devices utilizing power, SMARTMOS and MCU dies. Freescale products enable longer battery life, smaller form factor, component count reduction, ease of design, lower system cost and improved performance in powering state of the art systems.

- Go to www.freescale.com/analogtools
- Locate your kit
- Review your Tool Summary Page
- Look for

- Download documents, software, and other information

Once the files are downloaded, review the user guide in the bundle. The user guide includes setup instructions, BOM and schematics. Jump start bundles are available on each tool summary page with the most relevant and current information. The information includes everything needed for design.

2.2 Required Equipment

Minimum equipment required:

- Power supply (Power Plug or Laboratory Power Supply), with 12 V/2 Amp min current capability
- Oscilloscope (preferably 4-channel) with current probe(s)
- ECU Wiring Harness (included in the RDAIRBAGPSI5-1 kit)
- PSI5 Satellites Sensors (included in the RDAIRBAGPSI5-1 kit)
- Typical loads: 1.2 Ohm/2 Ohm for squibs, switch to ground for DC Sensors, LEDs for GPOs

Recommended equipment for ARP evaluation (GUI):

- FreeMASTER Software installed: http://www.freescale.com/arp
- Airbag Reference Platform FreeMASTER GUI Application: http://www.freescale.com/arp
- USB FTDI cable (Reference: TTL-232R-5V)

All software tools can be downloaded under Software & Tools tab of the RDAIRBAGPSI5 webpage. Registration might be required in order to get access to the relevant files.

Recommended equipment for software development:

- Freescale CodeWarrior 10.5 or greater for Qorivva MCUs (Eclipse IDE) family installed: http://www.freescale.com/arp
- Airbag System Evaluation Software (source code): http://www.freescale.com/arp
- USB A-B cable
- P&E USB Multilink Debugger for Power Architecture:
  http://www.freescale.com/webapp/sps/site/prod_summary.jsp?code=USBMLPPCNEXUS

2.3 System Requirements

- USB-enabled PC with Windows XP or greater
- FTDI Drivers installed for serial communication: http://www.ftdichip.com/Drivers/VCP.htm

3 Understanding the System

The Freescale Airbag Reference Platform (ARP) is an application demonstrator system which provides an airbag Electronic Control Unit (ECU) implementation example using complete Freescale standard products for the growing automotive safety segment. The GUI firmware does not constitute a true airbag application but is intended to demonstrate features and capabilities of Freescale's standard products aimed at the airbag market.

The ARP addresses a mid-range airbag market segment, with up to eight squib drivers (for squibs and seatbelt pre-tensioners) and four satellite sensor interfaces supporting four or more high g collision sensors positioned around the vehicle. All other vehicle infrastructure (including seat belt sensors and vehicle communications networks) and ECU functions (including full power supply architecture and a local mid g X/Y safing sensor) are also supported.

The new ARP hardware is implemented using a standard Freescale Qorivva 32-bit microcontroller (MPC560xP), Analog (MC33789 and MC33797). In the case of sensors, the families include both local ECU and PSI5 satellite sensors. The ARP implements a system safety architecture based on the features in the standard products supported by appropriate firmware.

The example ECU is implemented on a single Printed Circuit Board (PCB). Vehicle functions - in principal, satellite sensors, seat belt switches and warning lamps - can be accessed thanks to the ECU cables.

This User Manual is intended to detail the available hardware functionality and related software drivers (firmware) offered in the Freescale ARP.

The high level system block diagram here outlines the way the Freescale standard products are used to implement an example airbag ECU.

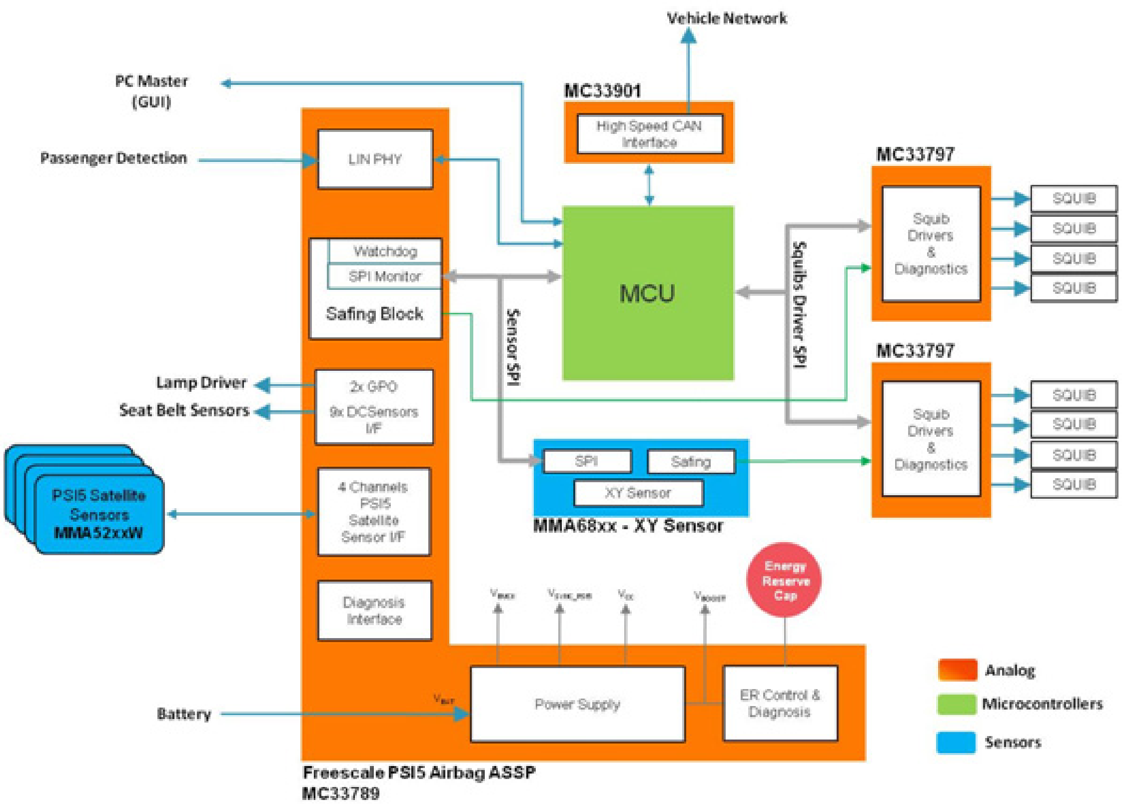

Figure 2. RDAIRBAGPSI5 Block Diagram

3.1 Device Features and Functional Description

This reference design features the following Freescale products:

Table 1. Airbag Reference Platform Device Features

Device	Description	Features
MPC560xP	Qorivva 32-bit Microcontroller	• Scalable MCU family for safety applications • e200z0 Power Architecture 32-bit core up to 64 MHz • Scalable memory, up to 512 KB flash
MC33789	Airbag System Basis Chip (PSI5)	• Power supply for complete ECU • Up to four Satellite Sensor interfaces (PSI5) • Up to nine configurable switch input monitors for simple switch, resistive and Hall-effect sensor interface • Safing block and watchdog • LIN 2.1 physical layer interface
MMA68xx	ECU Local X/Y Accelerometer	• ±20 g to ±120 g full-scale range, independently specified for each axis • SPI-compatible serial interface • 10-bit digital signed or unsigned SPI data output • Independent programmable arming functions for each axis • 12 low-pass filter options, ranging from 50 Hz to 1000 Hz
MC33797	Four Channel Squib Driver	• Four channel high-side and low-side 2.0 A FET switches • Externally adjustable FET current limiting • Adjustable current limit range: 0.8 to 2.0 A • Diagnostics for high-side safing sensor status • Resistance and voltage diagnostics for squibs • 8-bit SPI for diagnostics and FET switch activation
MC33901	High Speed CAN Physical Layer	• ISO11898-2 and -5 compatible • Standby mode with remote CAN wake-up on some versions • Very low current consumption in standby mode, typ. 8 μA • Excellent EMC performance supports CAN FD up to 2 Mbps
MMA52xx MMA51xx	High G Collision Satellite Sensor	• ±60 g to ±480 g full-scale range • PSI5 Version 1.3 Compatible (PSI5-P10P-500/3L) • Selectable 400 Hz, 3 pole, or 4 pole low-pass Filter • X-axis (MMA52xx) and Z-axis (MMA51xx) available

3.1.1 MPC5602P - Microcontroller

This microcontroller is a member of the highly successful Qorivva MPC560xP family of automotive microcontrollers.

It belongs to an expanding range of automotive-focused products designed to address chassis applications as well as airbag applications. The advanced and cost-efficient host processor core of this automotive controller family complies with the Power Architecture® embedded category. It operates at speeds of up to 64 MHz and offers high performance processing optimized for low power consumption. It capitalizes on the available development infrastructure of current Power Architecture® devices and is supported with software drivers, operating systems and configuration code to assist with users implementations.

3.1.2 MC33789 - Airbag System Basis Chip

This device implements all vehicle sensor interfaces and the airbag system support functions:

3.1.2.1 Power Supply Block

- A switched-mode power supply DC-DC converter in a boost configuration to generate the high voltage level (33 V), in which energy is stored in the autarky capacitor, and used to allow continued operation of the airbag system for a defined time following a collision, which leads to disconnection of the battery
- A switched-mode power supply DC-DC converter in a buck configuration, to efficiently step down the boost supply to a level suitable for supplying the satellite sensors interfaces (9.0 V) and further regulators, for the local ECU supplies
- A switched capacitor charge pump to double the output of the buck converter, for use in supplying the necessary voltage for the PSI5 sync pulse generation (18 V)
- A linear regulator to provide the local logic supply (5.0 V) for ECU devices i.e. microcontroller, local sensor, squib driver

3.1.2.2 Safing Block

This block includes a SPI monitor which inputs all inertial sensors (PSI5 satellites and onboard sensors) read by the microcontroller over the sensor SPI interface, and compares it to pre-defined threshold acceleration values for each local and vehicle collision sensor. Based on this comparison, where the threshold is exceeded in three consecutive acquisition cycles, the system is armed by enabling the safing outputs, which in turn enables the squib drivers, so that the application can fire the necessary squibs based on the airbag algorithm results.

3.1.2.3 DC Sensors Interface

A low speed (DC) interface which connects to resistive, simple switch and hall effect sensors which are used to check whether seat belts are being worn through seat belt switches and seat position through seat track sensors.

3.1.2.4 PSI5 Satellite Sensors Interface

Four Satellite sensors interfaces, which connect to collision sensors distributed around the vehicle. The interfaces are implemented based on the PSI5 V1.3 specification, and can operate in synchronous modes. It detects current drawn by the satellite and translates the current-modulated satellite messages into digital data, which the MCU retrieves via the SPI interface.

3.1.2.5 LIN Physical Layer

For connection to vehicle diagnostic interface (K-line) or Occupant Classification System.

3.1.2.6 Lamp Driver

A flexible high or low-side driver which can be configured in hardware which supports PWM driven LED or warning lamp driver.

3.1.2.7 Diagnostics

A number of measures which allow diagnosis of implemented functions on the system basis chip, e.g. all voltage supplies including power transistor temperature monitors, autarky capacitor ESR, etc.

3.1.2.8 Additional Communication Line

MC33789 is designed to support the Additional Communication Line (ACL) aspect of the ISO-26021 standard, which requires an independent hardwired signal (ACL) to implement the scrapping feature.

3.2 MMA6813KW - ECU Local Sensor

The ECU local sensor acceleration data is used by the airbag application to cross check the acceleration data received from the satellite collision sensors, to confirm that a collision is really happening, and that airbags need to be deployed.

The local sensor used in the ARP is dual channel, and confirms both frontal and side impacts. In addition, the MMA68xx includes its own safing block, which will compare the measured acceleration to configurable thresholds and set safing outputs accordingly. This function is used in the ARP to enable the squib drivers, and therefore be an independent part of the system safing architecture - both the safing blocks in the system basis chip and in the local sensor must enable the squib drivers before the application is able to fire the appropriate squibs.

3.3 MC33797 - Four Channel Squib Driver

Each channel consists of a high-side and a low-side switch. The ARP uses two MC33797 devices connected in cross-coupled mode, i.e. high-side switch from one device and low-side switch from the other, connected to each squib or seat belt pre-tensioner. This ensures no single point of failure in the squib output stage.

The MC33797 implements a comprehensive set of diagnostic features that allows the application to ensure that the squib driver stage is operating correctly.

3.4 MMA5xxx - High G Satellite Collision Sensor

A single channel acceleration sensor operating in the range of 60 - 480g (depending on G-cell fitted), which includes a PSI5 V1.3 interface for direct connection to the system basis chip. The device can operate in either asynchronous (point-to-point single sensor connection) or synchronous (bus mode with multiple sensors connected to each interface) mode. The device can be used either for frontal collisions or side impacts. For more information about PSI5, please refer to the PSI5 standard specification for airbag systems: http://psi5.org/

4 Getting to know the Hardware

4.1 Overview

RDAIRBAGPSI5 is an eight loops airbag system ECU. **Figure 3** shows all the main components of an airbag ECU hardware. **Table 2** lists all the functions performed by each component.

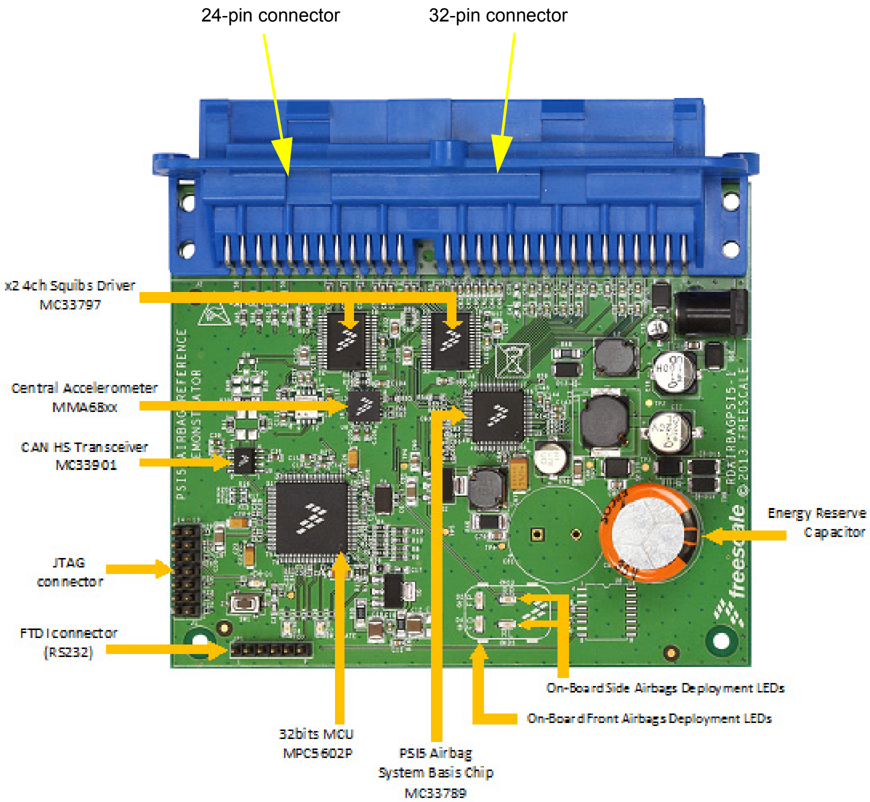

Figure 3. Board Description

Table 2. Board Description

Name	Definition
x2 4ch Squibs Driver MC33797	x2 Four channels Squibs Driver configured in cross-coupled mode to make an eight firing loops airbag system
Central Accelerometer MMA68xx	Central Accelerometer, also called Local Safing Sensor, designed for use in automotive airbag systems
CAN HS Transceiver MC33901	Physical interface between the CAN protocol controller of an MCU and the physical dual wires of the CAN bus
JTAG Connector	P&E USB Multilink Debugger
FTDI Connector (RS232)	USB to serial communication connector for GUI application
32-bit MCU MPC5602P	Qorivva Power Architecture MCU for Chassis and Safety Application
PSI5 Airbag System Basis Chip MC33789	Airbag System Basis Chip (SBC) with Power Supply and PSI5 Sensor Interface
On-Board Front Airbags Deployment LEDs	2x LEDs used to indicate a front impact Deployment event: Front Driver and/or Front Passenger

Table 2. Board Description (continued)

Name	Definition
On-Board Side Airbags Deployment LEDs	2x LEDs used to indicate a side impact Deployment event: Rear Right and/or Rear Left
Energy Reserve Capacitor	Autarky Capacitor used as Energy Reserve in case of Battery disconnection

4.2 LED Display

This section describes the LEDs on the lower portion of the RDAIRBAGPSI5 board.

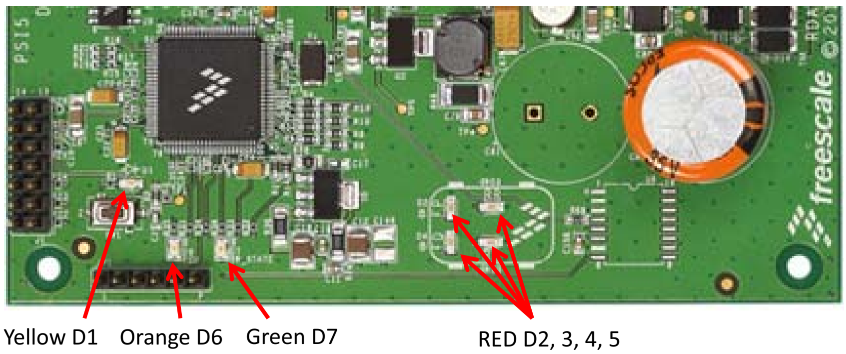

Figure 4. LED Locations

The following LEDs are provided as visual output devices for the RDAIRBAGPSI5 board:

1. LED D1 indicates when a System Reset occurred (LED color: Yellow).
2. LED D2 first indicates MC33789 is correctly initialized only during INIT phase. Then, it is used to display Front Passenger deployment during GUI Application mode (LED color: Red).
3. LED D3 first indicates MMA68xx is correctly initialized only during INIT phase. Then, it is used to display Rear Right Side deployment during GUI Application mode (LED color: Red).
4. LED D4 first indicates MC33797 are correctly initialized only during INIT phase. Then, it is used to display Front Driver deployment during GUI Application mode (LED color: Red).
5. LED D5 first indicates MCU is correctly initialized only during INIT phase. Then, it is used to display Rear Left Side deployment during GUI Application mode (LED color: Red).
6. LED D6 indicates when a FCU fault is detected by MCU (LED color: Orange).
   Note: If no FCU faults are detected, LED is turned ON.
7. LED D7 indicates MCU Software is running (LED color: Green).

4.3 Connectors

This section discusses the ARP 32-pin and 24-pin positions and their descriptions.

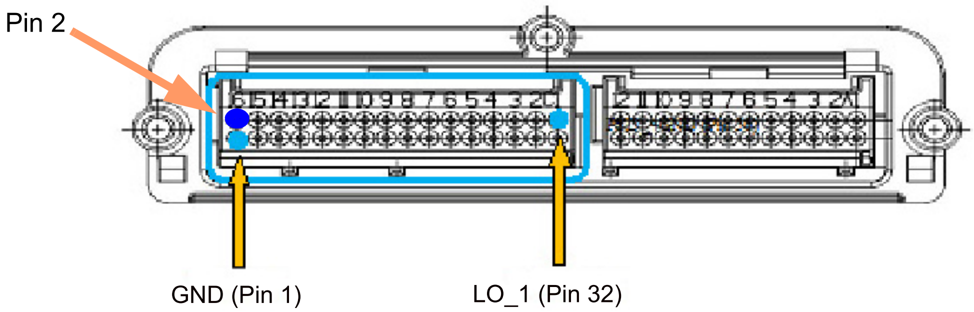

Figure 5. J1 32-pin Connector Location

Table 3: 32-pin Connector Pin List

Position	Signal name	Description	Position	Signal name	Description
1	GND	Ground Signal	17	IN6	Port 6 of input monitor for DC sensor
2	VBAT	Battery Voltage	18	IN5	Port 5 of input monitor for DC sensor
3	GND	Ground Signal	19	IN4	Port 4 of input monitor for DC sensor
4	VBAT	Battery Voltage	20	IN3	Port 3 of input monitor for DC sensor
5	NC	Not connected	21	IN2	Port 2 of input monitor for DC sensor
6	NC	Not connected	22	IN1	Port 1 of input monitor for DC sensor
7	OUT2_S	Source pin of configurable output FET 2	23	CANH	CAN Bus High Signal
8	OUT2_D	Drain pin of configurable output FET 2	24	CANL	CAN Bus Low Signal
9	OUT1_D	Drain pin of configurable output FET 1	25	HI_4	Source of the Squib Driver High-side switch 4
10	OUT1_S	Source pin of configurable output FET 1	26	LO_4	Drain of the Squib Driver Low-side switch 4
11	LIN_GND	LIN Ground	27	HI_3	Source of the Squib Driver High-side switch 3
12	LIN	LIN Signal	28	LO_3	Drain of the Squib Driver Low-side switch 3
13	NC	Not connected	29	HI_2	Source of the Squib Driver High-side switch 2
14	IN9	Port 9 of input monitor for DC sensor	30	LO_2	Drain of the Squib Driver Low-side switch 2
15	IN8	Port 8 of input monitor for DC sensor	31	HI_1	Source of the Squib Driver High-side switch 1
16	IN7	Port 7 of input monitor for DC sensor	32	LO_1	Drain of the Squib Driver Low-side switch 1

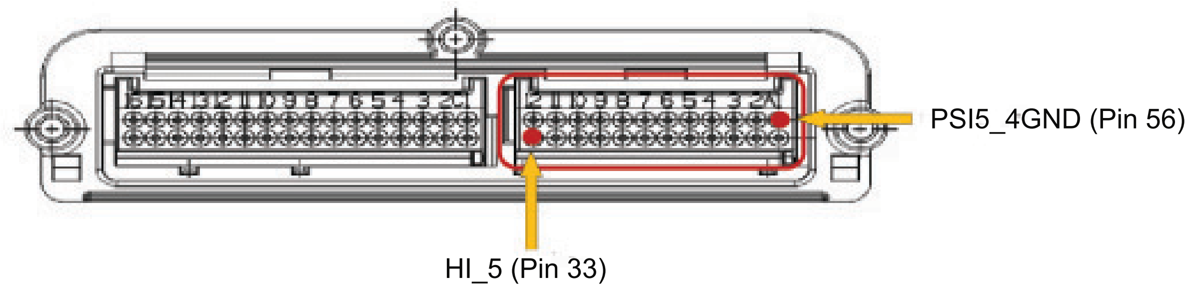

Figure 6. J2 24-pin Connector Location

Table 4: 24-pin Connector List

Position	Signal name	Description	Position	Signal name	Description
33	HI_5	Source of the Squib Driver High-side switch 5	45	NC	Not Connected
34	LO_5	Drain of the Squib Driver Low-side switch 5	46	NC	Not Connected
35	HI_6	Source of the Squib Driver High-side switch 6	47	NC	Not Connected
36	LO_6	Drain of the Squib Driver Low-side switch 6	48	NC	Not Connected
37	HI_7	Source of the Squib Driver High-side switch 7	49	PSI5_1OUT	PSI5 Channel1 Signal line
38	LO_7	Drain of the Squib Driver Low-side switch 7	50	PSI5_1GND	PSI5 Channel1 Ground line
39	HI_8	Source of the Squib Driver High-side switch 8	51	PSI5_2OUT	PSI5 Signal Channel2 line
40	LO_8	Drain of the Squib Driver Low-side switch 8	52	PSI5_2GND	PSI5 Channel2 Ground line
41	GND	Ground signal	53	PSI5_3OUT	PSI5 Channel3 Signal line
42	GND	Ground signal	54	PSI5_3GND	PSI5 Channel3 Ground line
43	NC	Not Connected	55	PSI5_4OUT	PSI5 Channel4 Signal line
44	NC	Not Connected	56	PSI5_4GND	PSI5 Channel4 Ground line

5 Describing the Device Functions

The RDAIRBAGPSI5UG Airbag Reference Platform is aimed to cover all major functions of a true airbag system application.

The following section describes individual functions and available view using the GUI:

5.1 MC33789 - Airbag System Basis Chip

5.1.1 Power Supply - Boost Converter and Energy Reserve

Table 5. Power Supply - Boost Converter and Energy Reserve

Define	Function	Config Register	Diagnosis	Comment
MC33789	Energy Reserve Supply	PS_CONTROL	AI_CONTROL	

Default setting for the boost converter is ON and will start up when VBATT exceeds a predefined limit. Initially, the boost converter will charge a small capacitor. Default setting for the energy reserve is OFF to prevent excessive inrush current at key on. The firmware must turn the energy reserve on through the PS_CONTROL register once VBOOST is stable. Firmware can monitor VBOOST through the analog output pin selected through AI_CONTROL register. After the energy reserve is turned on, the large energy reserve capacitor (min 2200 μF) will be charged.

5.1.2 Power Supply - Energy Reserve Capacitor ESR Diagnostic

Table 6. Power Supply - Energy Reserve Capacitor ESR Diagnostic

Define	Function	Config Register	Diagnosis	Comment
MC33789	Energy Reserve Capacitor Diagnostic	ESR_DIAG	ESR_DIAG	

During ESR diagnostic, the energy reserve capacitor is slightly discharged and the firmware can calculate, based on the discharge rate, the value of the capacitor's equivalent series resistance (ESR) - this is a measure of the condition of the capacitor.

5.1.3 Power Supply - Buck Converter

Table 7. Power Supply - Buck Converter

Define	Function	Config Register	Diagnosis	Comment
MC33789	Vcc5, DC Sensor and Satellite Sensor Supply	PS_CONTROL	AI_CONTROL	

Buck converter is internally enabled when the VBOOST voltage is above the under-voltage lockout threshold. The firmware cannot disable the Buck converter in the RDAIRBAGPSI5 application.

5.1.4 Power Supply - SYNC Pulse Supply

Table 8. Power Supply – SYNC Pulse Supply

Define	Function	Config Register	Diagnosis	Comment
MC33789	Satellite Sensor SYNC Pulse Supply	PS_CONTROL	AI_CONTROL	

Default setting for the SYNC supply is OFF. Firmware needs to turn the SYNC supply on through PS_CONTROL register only if the satellite sensors are operating in synchronous mode. Firmware can monitor VSYNC voltage through the analog output pin selected through the AI_CONTROL register.

5.1.5 Power Supply - ECU Logic Supply

Table 9. Power Supply - ECU Logic Supply

Define	Function	Config Register	Diagnosis	Comment
MC33789	Linear Regulator	–	–	

The internal ECU logic supply is always on and firmware has no configuration to perform.

5.1.6 Safing Block - Sensor Data Thresholds

Table 10. Safing Block - Sensor Data Thresholds

Define	Function	Config Register	Diagnosis	Comment
MC33789	Threshold	T_UNLOCK, SAFE_TH_n	–	

In order to be able to change the sensor data threshold value or values at which the ARM/DISARM pins are set to their active states (i.e. the system is armed when a sensor value exceeds the defined threshold), a secure firmware sequence must be carried out to unlock the threshold register using T_UNLOCK. Once that is done, the threshold can be changed by firmware through the SAFE_TH_n register.

Notes: There is no special firmware required to input sensor data into the safing block. The SPI protocol on the sensor SPI interface is the same to both the local sensor and the satellite sensor interfaces on the system basis chip, and whenever the microcontroller reads a sensor value, the response from the sensor or system basis chip is recognized as being sensor data, and is automatically read into the safing block. The only requirement the application has to meet is that the sensor data is read in the correct sequence, starting with the local sensor X-axis data followed by the Y-axis, and then the satellite sensor interfaces on the system basis chip.

5.1.7 Safing Block - Diagnostics

Table 11. Safing Block - Diagnostics

Define	Function	Config Register	Diagnosis	Comment
MC33789	Linear Regulator	–	SAFE_CTL	

The firmware has the capability to change the mode in which the safing block is operating, so that diagnosis of the ARM/DISARM pins can be diagnosed or the scrapping mode (i.e. the system is armed when no sensor data exceeds any threshold, used to fire all squibs when a vehicle is being scrapped) can be entered. Either of these changes is only possible at startup prior to the safing block entering normal operation.

5.1.8 DC Sensors

Table 12. DC Sensors

Define	Function	Config Register	Diagnosis	Comment
MC33789	Seat belt/Seat track sensor interface	DCS_CONTROL, AI_CONTROL	–	

The firmware must select which DC sensor is active and which supply voltage is used on that sensor through the DCS_CONTROL register. The firmware must also select the correct sensor to be read through the analog output pin using the AI_CONTROL register. Note that both registers can be returned to their default state by a correct write to the DIAG_CLR register.

5.1.9 PSI5 Satellite Sensor Interface

Table 13. PSI5 Satellite Sensor Interface

Define	Function	Config Register	Diagnosis	Comment
MC33789	Satellite Sensor	LINE_MODE, LINE_ENABLE	–	

The firmware must select the correct mode of operation of the satellite sensor interface and enable each interface individually. The interfaces should be enabled one at a time to reduce current inrush.

When the interface is enabled, the satellite sensor will automatically send its initialization data, and the firmware must handle this data to ensure the sensor is operating correctly.

5.1.9.1 LIN Physical Layer

Table 14. LIN Physical Layer

Define	Function	Config Register	Diagnosis	Comment
MC33789	LIN physical layer	LIN_CONFIG	–	

The firmware has the potential to change the configuration of the LIN physical layer, but the default setting is the most common configuration.

A special mode exists which allows the Manchester encoded data from a satellite sensor to be monitored on the LIN RXD output pin, for example in case MCU has a PSI5 peripheral module embedded.

5.1.9.2 Lamp Driver

Table 15. Lamp Driver

Define	Function	Config Register	Diagnosis	Comment
MC33789	Lamp driver	GPOn_CTL	GPOn_CTL	

The firmware must configure whether the driver is a high or low-side switch, and the PWM output duty cycle. In the response to the command, the firmware can check that high or low thresholds on the pins have been exceeded, and whether an over-temperature shutdown has occurred.

As part of the application, the warning lamp should be turned on at key on, kept illuminated until the startup diagnostic procedure has completed, and the system is ready to start operating.

5.1.9.3 Diagnostics

Table 16. Diagnostics

Define	Function	Config Register	Diagnosis	Comment
MC33789	Diagnostics	–	STATUS, AI_CONTROL	

The firmware can monitor the operation of the main ASSP through the STATUS and AI_CONTROL registers.

5.2 MMA6813KW - Local ECU Acceleration Sensor

The local ECU acceleration sensor is a dual channel device which also includes a safing block. At start up, the configuration, offset cancellation, and self test of the device, occur before the configuration is complete ('ENDINIT' set) and the device goes into normal operation.

5.2.1 Configuration - General

Table 17. Configuration - General

Define	Function	Config Register	Diagnosis	Comment
MMA6813KW	Configuration	DEVCFG	–	

The general configuration sets up the data format, whether offset monitoring is enabled, and the functionality of the ARM_X and ARM_Y output pins. When configuration is complete, the ENDINIT bit is set and this locks out access to the configuration registers.

5.2.2 Configuration - Axis Operation

Table 18. Configuration - Axis Operation

Define	Function	Config Register	Diagnosis	Comment
MMA6813KW	Configuration	DEVCFG_X, DEVCFG_Y	–	

The axis operation configuration triggers self-test and selects one of the low pass filter options for each axis.

5.2.3 Configuration - Arming Operation

Table 19. Configuration - Arming Operation

Define	Function	Config Register	Diagnosis	Comment
MMA6813KW	Configuration	ARMCFG_X, ARMCFG_Y	–	

The arming operation configuration defines the arming pulse stretch period and the arming window, which has different meanings, depending on which arming mode is configured.

5.2.4 Configuration - Arming Threshold

Table 20. Configuration - Arming Threshold

Define	Function	Config Register	Diagnosis	Comment
MMA6813KW	Configuration	ARMT_XP, ARMT_XN ARMT_YP, ARMT_YN	–	

For each axis, both the positive and negative threshold can be set above which and when the arming window requirements are met, the arm outputs will be set to active as defined in the arming operations register.

In the startup phase, the threshold can be set to such a level that when the self test deflection is triggered, the arming outputs will become active. This can be used as part of the self-test at startup. After completion of the self test, thresholds should be set back to the correct application values, and before the configuration is complete, by setting the 'ENDINIT' bit, after which no further configuration changes can be made.

The complete startup and self-test procedure is described in the ARP specification (Airbag Reference Platform).

Note that after the configuration is complete and the 'ENDINIT' bit is set, a CRC check of the configuration is carried out in the background, which will lead to an error in the status register if a configuration bit flips.

5.2.5 Status

Table 21. Status

Define	Function	Config Register	Diagnosis	Comment
MMA6813KW	Status	–	DEVSTAT	

Internal errors are flagged in the DEVSTAT register.

5.3 MC33797 - Four Channel Squib Driver (FCS)

The ARP uses two Four Channel Squib Drivers (FCS) configured in cross-coupled mode to safely implement eight squib drivers.

The four channel squib driver is addressed using an 8-bit SPI interface over which commands and data are sent.

The only configuration possible is the time the device remains enabled after the fire enable (FEN1, FEN2) pins have been activated. This is equivalent to the arming pulse stretch time applied to the safing output on both the system basis chip and the local ECU sensor. Two commands are required to change this time - first is an unlock command and second is the programmed time between 0 and 255 ms. Default is 0 ms.

Firing the squibs also requires two commands - the first arms one of the banks of drivers, the second turns on the required switches. More than one switch can be turned on by a single command.

The majority of the commands relate to diagnostics of the four channel squib driver and the connected squibs. A full list of diagnostic commands is available in the ARP specification (Airbag Reference Platform).

5.4 MMA5xxx High G Satellite Collision PSI5 Sensor

Configuration of the device is done off line prior to assembly in the system.

As soon as the device is switched on, it will begin an internal configuration and self test, and also sends initialization data, which is received in the system basis chip and checked by the application. Once the device has completed sending the initialization data, which concludes with an OK or NOK message, it enters normal operation and starts sending sensor data, either autonomously if in asynchronous mode, or in response to SYNC pulses on the satellite sensor interface if in synchronous mode.

6 Installing the Software and Setting up the Hardware

ARP software is built on basic low level MCU drivers (MCAL), which provide access to the modules ADC, GPIO, EEPROM, SPI, LINFlex, etc. in the microcontroller, thus providing all necessary MCU functions. The upper software layer contains Complex Drivers for all main ARP devices - Main Airbag ASIC MC33789 (Analog system Basis Chip (ASBC) Driver), Central Accelerometer MMA6813KW (ACC Driver), and Four Channel Squib Driver MC33797 (SQUIB Driver). These drivers have an MCU independent API, which means no modification of ASBC, SQUIB or ACC drivers is needed for all MCU derivatives (8/16/32-bit).

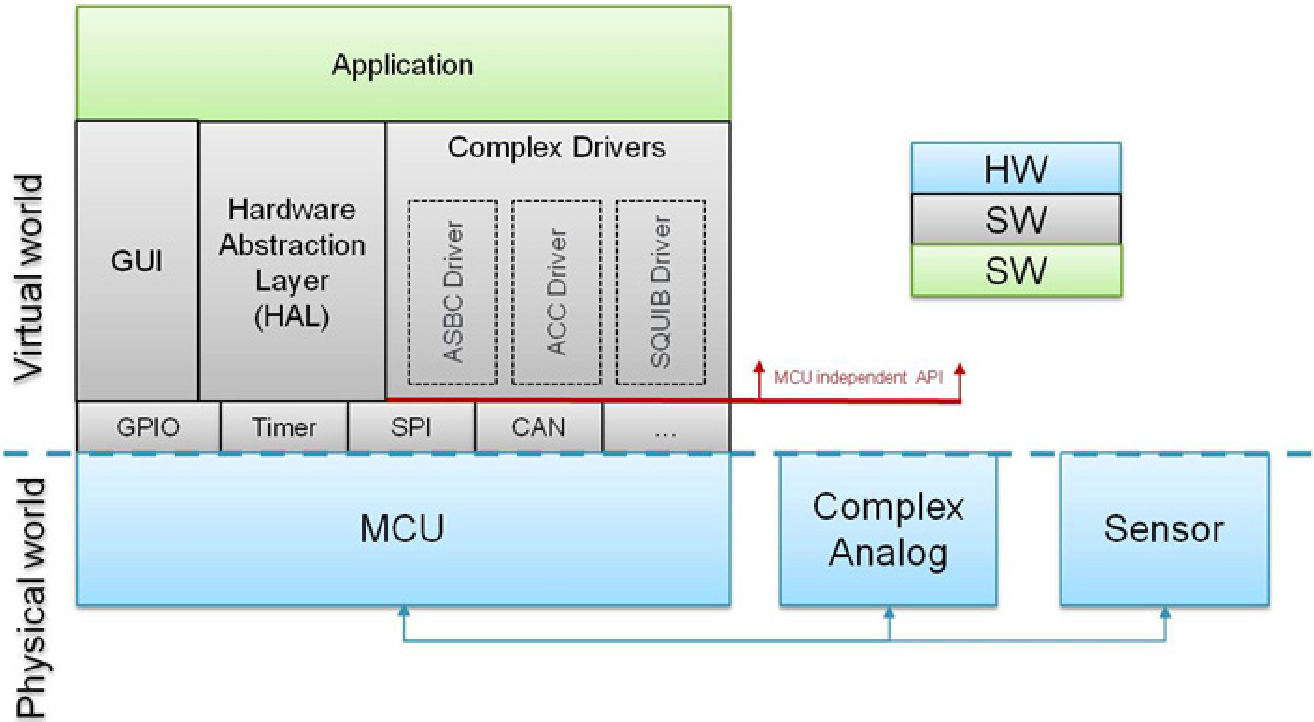

Figure 7. SW Design Concept

6.1 Hardware Abstraction Layer (HAL)

The software architecture for this Airbag Reference Platform uses a Hardware Abstraction Layer that removes details of working with a MPC560xP 32-bit microcontroller. This will allow a developer to focus attention on the application tasks instead of focusing on the very specific functionality of the MCU used. Software applications can then be created based on a higher level of understanding.

6.2 GUI - FreeMASTER Software

FreeMASTER software was designed to provide a debugging, diagnostic, and demonstration tool for the development of algorithms and applications. Moreover, it's very useful for tuning the application for different power stages and motors, because almost all the application parameters can be changed via the FreeMASTER interface. This consists of a component running on a PC and another part of the component running on the target controller, connected via an RS-232 serial port or USB. A small program is resident in the controller that communicates with the FreeMASTER software to parse commands, return status information to the PC, and process control information from the PC. FreeMASTER software, executed on the PC, uses Microsoft Internet Explorer as the user interface.

6.2.1 Installing FreeMASTER on your Computer

To set up the GUI on your PC, you have to install the FreeMASTER software if not already installed.

Notes: If FreeMASTER is already on your system, the steps in this section can be skipped.

1. Start the FMASTERSW.exe install shield wizard. The file can be downloaded from http://www.freescale.com. The License Agreement box is displayed and you are prompted for further actions.
2. Clicking the Next button starts the installation program. The Installation Wizard prompts you for further actions.
3. Follow the instructions given by the Installation Wizard.

6.2.2 FreeMASTER Serial Communication Driver

The presented application includes the FreeMASTER Serial Communication Driver.

The main advantage of this driver is a unification across all supported Freescale processor products, as well as several new features that were added. One of the key features implemented in the new driver is Target-Side Addressing (TSA), which enables an embedded application to describe the memory objects it grants the host access to. By enabling the so-called "TSA-Safety" option, the application memory can be protected from illegal or invalid memory accesses.

To include the FreeMASTER Serial Communication Driver in the application, the user has to manually include the driver files in the CodeWarrior project. For the presented application, the driver files have already been included.

The FreeMASTER driver files are located in the following folder:

- {Project_Loc}\Sources\GUI

This folder contains platform-dependent driver C-source and header files, including a master header file freemaster.h.

For instance, in the current ARP, user will find freemaster_MPC56xx.c and freemaster_MPC56xx.h for Qorivva MPC56xxP family.

This folder also contains common driver source files, shared by the driver for all supported platforms.

All C files included in the FreeMASTER folder are added to the project for compilation and linking.

The master header file freemaster.h declares the common data types, macros, and prototypes of the FreeMASTER driver API functions. This should be included in the application (using #include directive), wherever there is need to call any of the FreeMASTER driver API functions.

The FreeMASTER driver does NOT perform any initialization or configuration of the SCI module it uses to communicate. This is the user's responsibility to configure the communication module before the FreeMASTER driver is initialized by the FMSTR_Init() call. The default baud rate of the SCI communication is set to 9600 Bd.

FreeMASTER uses a poll-driven communication mode. It does not require the setting of interrupts for SCI. Both communication and protocol decoding are handled in the application background loop. The polling-mode requires a periodic call of the FMSTR_Poll() function in the application main.

The driver is configured using the freemaster_cfg.h header file. The user has to modify this file to configure the FreeMASTER driver. The FreeMASTER driver C-source files include the configuration file, and use the macros defined there for conditional and parameter compilation.

For more information, a detailed description of the FreeMASTER Serial Communication Driver is provided in the FreeMASTER Serial Communication Driver User's Manual.

6.2.3 Airbag Reference Platform - GUI

FreeMASTER GUI application can work in two modes:

- Debug mode - GUI firmware together with GUI applications allow debug of the main ARP devices - MC33789 (Airbag System Basis Chip), MC33797 (Four Channel Squib Driver), and MMA6813KW (Central Accelerometer). The device registers are readable and configurable. At all times, the registers remain visible and can be monitored. This is intended to aid engineers understand both the hardware and software routines.
- Application mode - Application mode allows ARP users to view acceleration data from central and satellite accelerometers. These numerical values are also plotted on a graph, which allows informative outlook to the acceleration levels of all sensors. Deployment of squibs is simulated in this mode on a simple car model picture, using pictures of both front and side deployments. The same simulation is performed at MCU level, indicated using the four onboard red LEDs.

Notes: The GUI firmware is already loaded into Airbag Reference Platform after delivery and immediately ready for using with the FreeMASTER GUI application.

6.2.4 FreeMASTER Debug Mode

Parameters of the devices MC33789, MC33797, or MMA6813KW, can be arbitrarily changed. Parameters are sent to the selected device after the button press "Send Parameters To Reference Board". All meaningful device registers are shown in the registry table "Command Responses Table" at the bottom of the each device page. For each cell in this table, a tool-tip help is available. View these tips, hover over the cell to see descriptions of the selected register (For an example page see **Figure 8**).

Figure 8. FreeMASTER Debug Page for the MC33789 Device

After starting the watchdog refresh (Watchdog -> Enable), parameters "Safing Thresholds" and "Dwell Extensions" in MC33789 cannot be changed.

6.2.5 FreeMASTER Application Mode

ARP Application mode permits the user to (see **Figure 9**):

- View acceleration data from central and satellite accelerometers. These numerical values are displayed in points where sensors should be placed inside the car.
- View acceleration data plotted on a graph, which allows informative outlook to the acceleration levels of all sensors and a simple car model simulation of the both front and side collisions. Plotted data is only informative, since transferred data from sensors is averaged for illustration of ARP functionality only.
- Simulate deployment of an airbag when the acceleration data reaches the threshold values. These thresholds are set to very low limits, so even a soft hit of the satellite sensor to the ARP board will cause relevant airbags' "deployment". Airbags deployment is illustrated in the GUI thanks to front and side airbags pictures. (Any "collision" at the driver or passenger location causes inflation of two front airbags. Impact from left side causes inflation of the left side airbags, and impact from right side causes deployment of the right side airbags. Anytime after deployment, simulation is possible to reset an inflated bag or bags by pressing button "Reset Deployed Airbags".

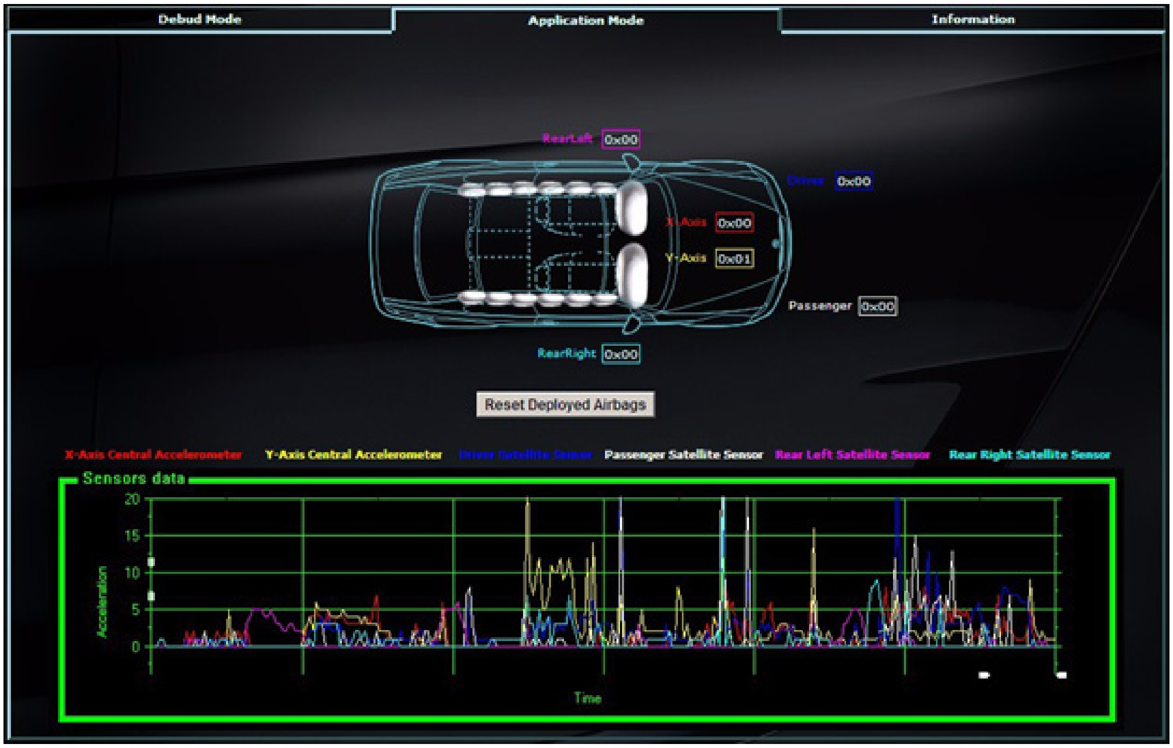

Figure 9. FreeMASTER Application Mode

Notes: In this GUI mode during simulated airbags' "deployment", the relevant squibs drivers are not activated. In order to deploy front airbags, a combination of acceleration values (Front Satellites & Central Accel) above the threshold is required to simulate front deployment.

Other deployment indicators can be found on the actual ARP Hardware. Four red color LEDs are implemented onboard in order to provide the same information as displayed on FreeMASTER GUI. User can also take advantage of this onboard LEDs in case a real application firmware is developed based on Freescale ARP to indicate which car airbags have been deployed.

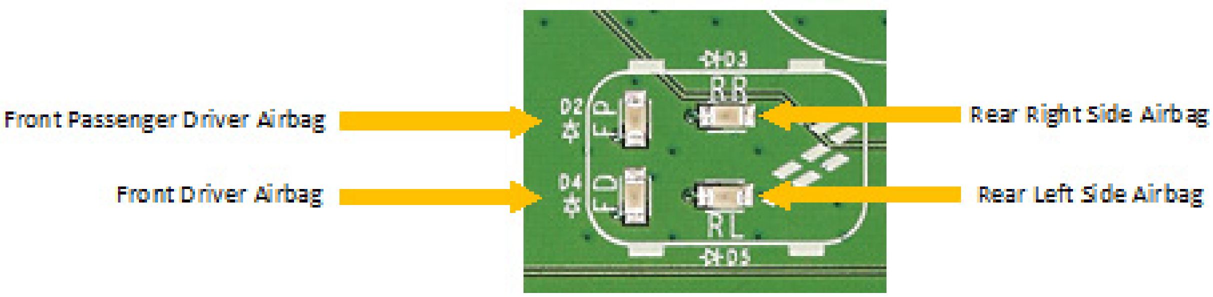

Figure 10. On-Board and Side Airbags Red Color LEDs

6.2.6 Configuring the Hardware using FreeMASTER

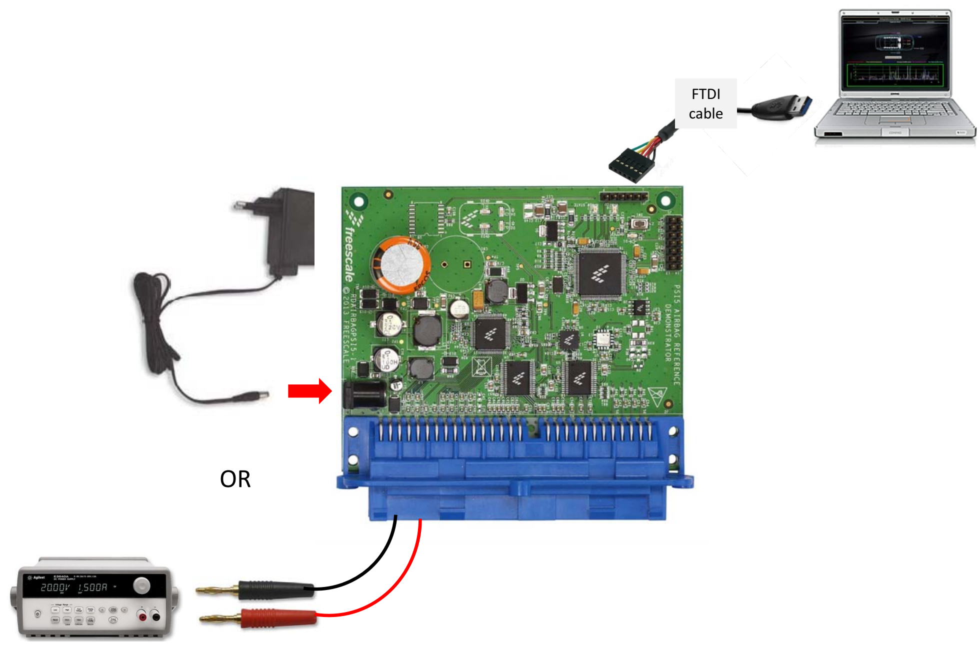

Figure 11. RDAIRBAGPSI5 Configured for ARP Evaluation Using FreeMASTER GUI

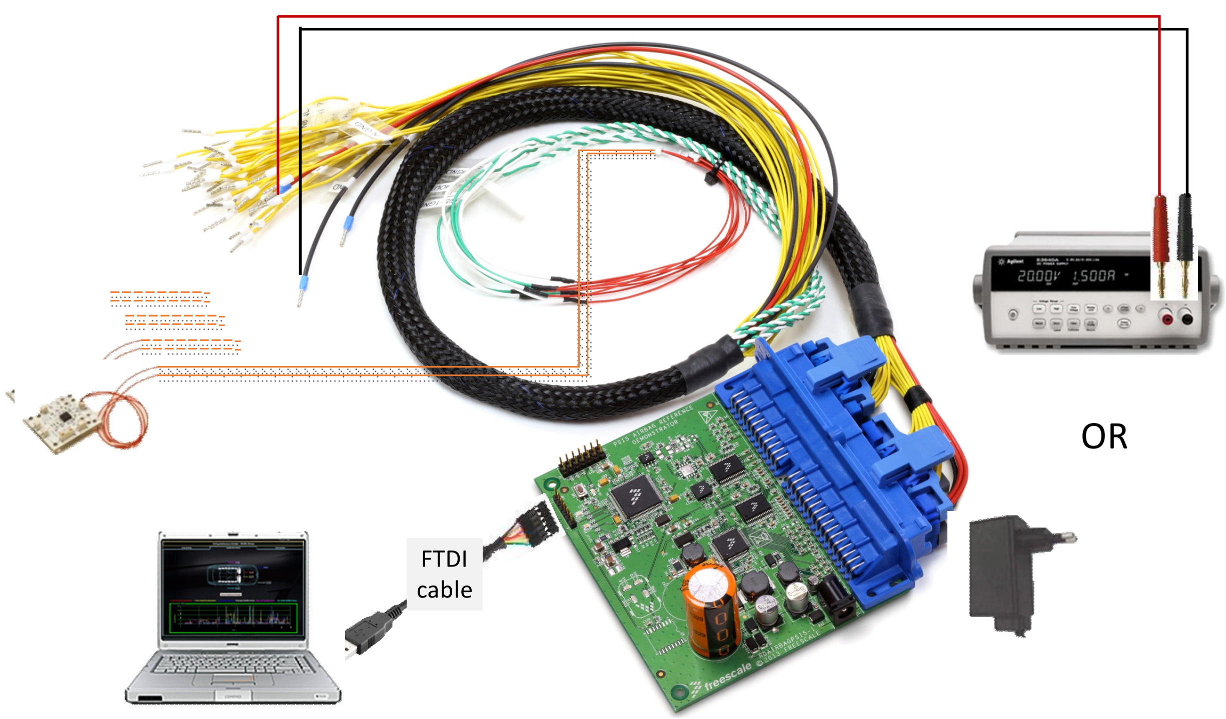

Figure 12. RDAIRBAGPSI5-1 Configured for ARP Evaluation Using FreeMASTER GUI

In order to perform the demonstration examples, set up the reference platform hardware and software as follows. All software tools can be downloaded under Software & Tools tab of the RDAIRBAGPSI5 webpage. Registration might be required in order to get access to the relevant files.

1. Install FreeMASTER Software (can be downloaded from freescale.com/freemaster).
2. Connect ECU wiring harness to the ARP blue connector.
3. Connect the power supply, either using a power plug or lab power supply.

CAUTION

Please pay attention to the power supply's polarity.
(DO NOT connect both power supply’s inputs).

4. Switch on the power supply at 5.2 - 20 V. (Nominal value: 12 V)
5. Initialization Phase:
    - On the ARP Hardware, four red LEDs should turn on one after another, then they all turn off
    - This firmware sequence is intended to provide visual information to the user that all four main devices (MC33789, MMA68xx, MC33797 and MCU) are correctly initialized
    - The Green and Orange LEDs should remain ON
6. Connect the Airbag Reference Platform to the PC using an FTDI cable. Upon connection of FTDI cable, autoinstallation begins. If not, visit http://www.ftdichip.com/Drivers/VCP.htm and select the driver compatible with the OS being used.
7. Wait until FTDI drivers installation is completed (during first connection, drivers for the device have to be installed. This can take several minutes). When finished, a status message is displayed in the Windows taskbar and confirms the appropriate drivers were installed correctly.
8. Launch the ARP Graphical User Interface by double clicking on the RDAIRBAGPSI5_FreeMASTER application file.The ARP GUI should appear as in **Figure 13**.

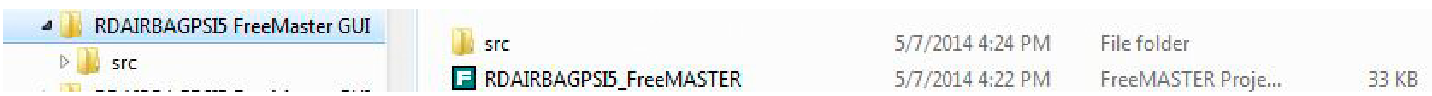

Figure 13. ARP Graphical User Interface

9. Open "File/Start communication" to establish the connection. See **Figure 14**.

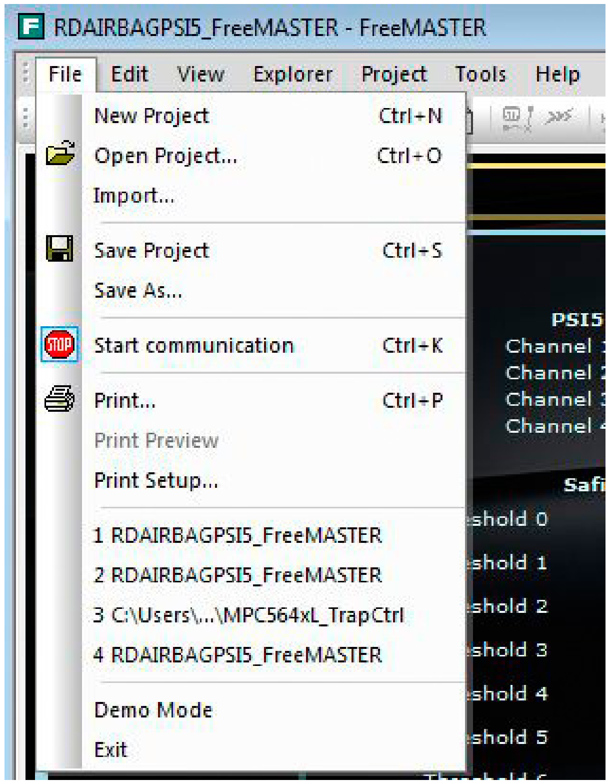

Figure 14. ARP Graphical User Interface File/Start

At the bottom of the GUI screen, a message "Communication With Reference Board Works Properly" should appear. Once the steps above are all accomplished, proceed to using the GUI for evaluation. Refer to the **Troubleshooting Section** for assistance in using the GUI.