Airbag Reference Demonstrator

Reference Manual

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Chapter 1 Introduction

The Freescale Airbag Reference Demonstrator (ARD) is an application demonstrator system which provides an airbag ECU implementation example using Freescale standard products and firmware which exercises the primary functions in those products as well as any diagnostic features. The 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 current ARD 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 ARD hardware is implemented using standard Freescale microcontroller, analog and sensor family products. In the case of sensors, the families include both local ECU and satellite sensors. The ARD 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 – are implemented on separate pcbs and mounted on a base plate.

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

1.1 Relevant Documents

[1] *Airbag Reference Demonstrator – ARD Reference Manual*

[2] *MC33789 – System Basis Chip Data Sheet*

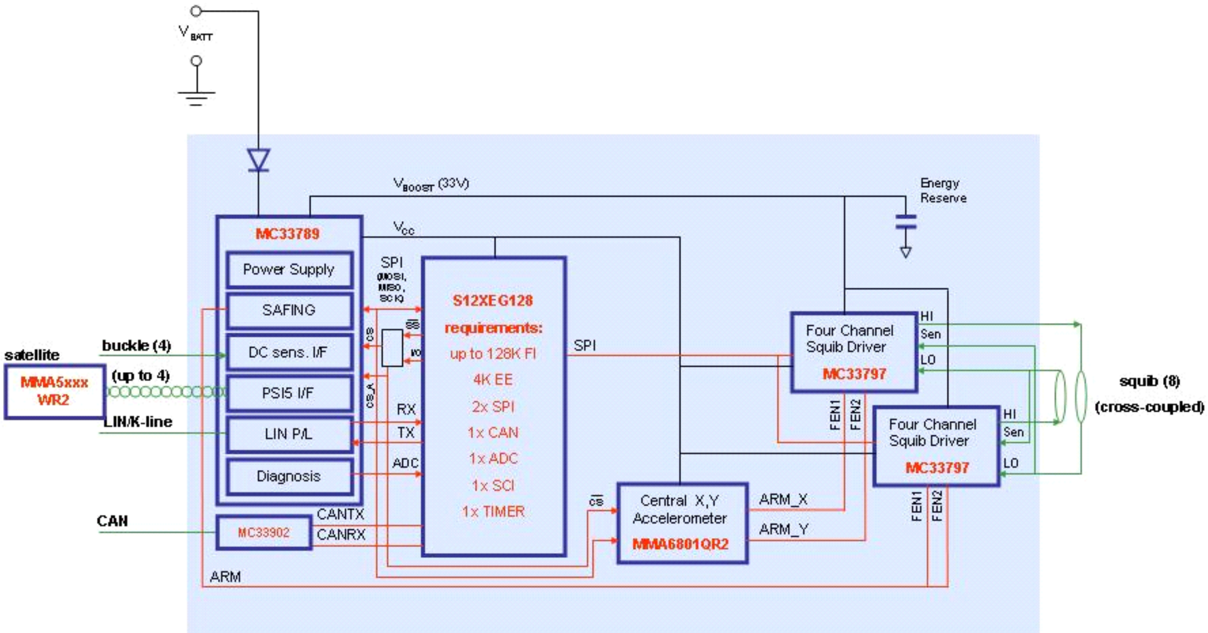
[3] *MMA68xx - SPI Medium-g Dual Channel Local ECU Sensor Data Sheet*

[4] *MC33797 – Four Channel Squib Driver IC Data Sheet*

[5] *MMA5xxxWR2 - PSI5 High-g Satellite Sensor Data Sheet*

Chapter 2 ARD System Outline

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



- MC9S12XEG128MAA – Microcontroller
- MC33789 – Airbag System Basis Chip
- MMA6801QR2 – ECU Local X/Y Accelerometer
- MM33797 – Four Channel Squib Driver
- MM33902 – High Speed CAN Physical Layer
- MMA5xxxWR2 – High G Collision Satellite Sensor

Chapter 3 Standard Products Description

All devices used in the Freescale ARD are standard products and those devices are described here.

3.1 MC9S12XEG128MAA - Microcontroller

This microcontroller is a member of the highly successful S12 family of automotive microcontrollers that includes flexible Flash memory, which allows cost efficient implementation of internal EEPROM emulation, and a rich selection of peripherals to support an efficient system connection.

3.2 MC33789 – Airbag System Basis Chip

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

3.2.1 Power Supply Block

- A switch 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 system for a defined time following a collision, which leads to disconnection of the battery
- A switch 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 charge pump to double the output of the buck converter, to supply the necessary voltage for the PSI5 sync pulse generation (18 V), to facilitate operation of the satellite sensor interfaces in synchronous mode, and therefore more than one sensor per interface. This is only enabled if more than one satellite sensor per interface is required
- A linear regulator to provide the local logic supply (5.0 V) for ECU devices i.e. microcontroller, local sensor, squib driver,...

3.2.2 Safing Block

This block includes an SPI monitor which inputs sensor data 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.

3.2.3 DC Sensors

A low speed (D.C.,) interface which connects to resistive 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.

3.2.4 PSI5 Satellite Sensors

Satellite sensors interfaces, which connect to collision sensors distributed around the vehicle. The interfaces implement the PSI5 V1.3 specification, and can operate in asynchronous and synchronous modes.

3.2.5 LIN Physical Layer

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

3.2.6 Lamp Driver

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

3.2.7 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.

3.3 MC6801QR2 - 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 ARD is dual channel, and confirms both frontal and side impacts. In addition, the MC6801QR2 includes it's own safing block, which will compare the measured acceleration to configurable thresholds and set safing outputs accordingly. This function is used in the ARD 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.

3.4 MC33797 – Four Channel Squib Driver

Each channel consists of a high side and a low side switch. The ARD 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.

3.5 MC33902 – High Speed CAN Physical Layer

3.6 MMA5xxxWR2 – 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.

Chapter 4 Function Description

The following section describes individual functions and how they relate to firmware.

4.1 MC33789 – Airbag System Basis Chip

4.1.1 Power Supply – Boost Converter and Energy Reserve

Device	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 V_{BATT} exceeds a predefined limit. Initially, the boost converter will charge a small capacitor. Default setting for the energy reserve is OFF to prevent current inrush at key on. The firmware must turn the energy reserve on through the PS_CONTROL register once V_{BOOST} is stable. Firmware can monitor V_{BOOST} 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.

4.1.2 Power Supply – Energy Reserve Capacitor ESR Diagnostic

Device	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 effective series resistance – this is a measure of the condition of the capacitor.

4.1.3 Power Supply – Buck Converter

Device	Function	Config Register	Diagnosis	Comment
MC33789	Satellite Sensor Supply	PS_CONTROL	AI_CONTROL	

Default setting for the buck converter is ON and will start up when V_{BOOST} starts up. Firmware can monitor V_{BUCK} through the analog output pin selected through AI_CONTROL register.

4.1.4 Power Supply – SYNC Pulse Supply

Device	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 V_{SYNC} through the analog output pin selected through the AI_CONTROL register.

4.1.5 Power Supply – ECU Logic Supply

Device	Function	Config Register	Diagnosis	Comment
MC33789	Linear Regulator	-	-	

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

4.1.6 Safing Block – Sensor Data Thresholds

Device	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/$\overline{\text{DISARM}}$ pin are set to active (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.

NOTE

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.

4.1.7 Safing Block – Diagnostics

Device	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/$\overline{\text{DISARM}}$ 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.

4.1.8 DC Sensors

Device	Function	Config Register	Diagnosis	Comment
MC33789	Seat belt/Seat track sensor interface	DCS_CONTROL, AI_CONTROL	-	

The firmware must select which 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.

4.1.9 Satellite Sensor Interface

Device	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 it’s initialization data, and the firmware must handle this data to ensure the sensor is operating correctly.

4.1.9.1 LIN Physical Layer

Device	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 raw Manchester encoded data from a satellite sensor to be monitored on the LIN output pin, but this is only for the debug operation.

4.1.9.2 Lamp Driver

Device	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.

4.1.9.3 Diagnostics

Device	Function	Config Register	Diagnosis	Comment
MC33789	Diagnostics	-	STATUS, AI_CONTROL	

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

4.2 MMA6801QR2 – Local ECU Acceleration Sensor

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

4.2.1 Configuration - General

Device	Function	Config Register	Diagnosis	Comment
MMA6801QR2	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

4.2.2 Configuration – Axis Operation

Device	Function	Config Register	Diagnosis	Comment
MMA6801QR2	Configuration	DEVCFG_X, DEVCFG_Y	-	

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

4.2.3 Configuration – Arming Operation

Device	Function	Config Register	Diagnosis	Comment
MMA6801QR2	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.

4.2.4 Configuration – Arming Threshold

Device	Function	Config Register	Diagnosis	Comment
MMA6801QR2	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 ARD specification (Airbag Reference Design).

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.

4.2.5 Status

Device	Function	Config Register	Diagnosis	Comment
MMA6801QR2	Status	-	DEVSTAT	

Internal errors are flagged in the DEVSTAT register.

4.3 MM33797 – Four Channel Squib Driver (FCS)

The ARD uses two FCS in cross-coupled mode to implement eight squib drivers.

The FCS 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 FCS and the connected squibs. A full list of diagnostic commands is available in the ARD specification (Airbag Reference Design).

4.4 MMA5xxxWR2 – High G Satellite Collision Sensor

No configuration of the MMA5xxxWR2 is possible. All 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.

Chapter 5 Airbag Reference Demonstrator Firmware and Setup

5.1 Airbag Reference Demonstrator Demo

The ECU is implemented on a single printed circuit board (PCB). Vehicle functions - in principal, satellite sensors, seat belt switches, and warning lamp - are implemented on separate PCBs and mounted on a base Plexiglas plate. This set is placed on rubber columns on the heavy aluminium base plate. Squibs are replaced by resistors with corresponding values to actual squibs.

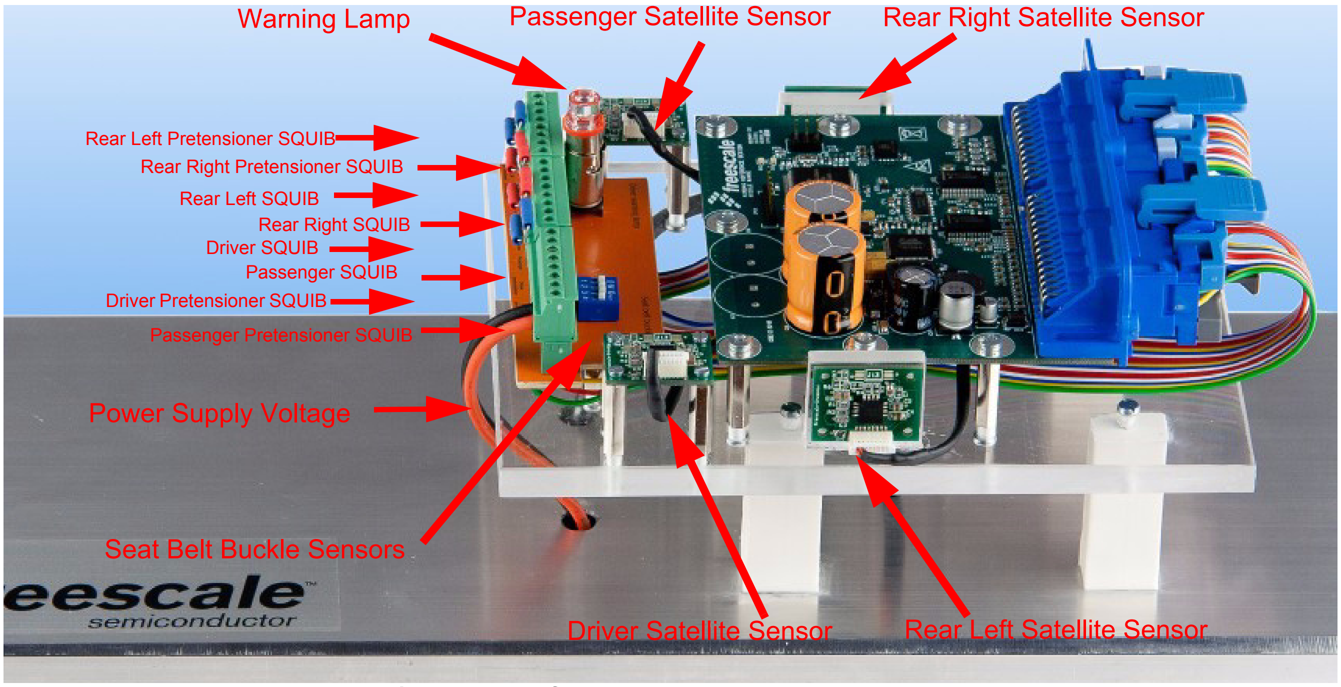


Figure 5-1. Airbag Reference Demonstrator Demo Description

5.2 Warnings

The user should be aware of:

- Operating power supply voltage from 6.0 to 20 V DC continuous
- Nominal voltage 12 V DC (automotive battery)
- Observe power supply voltage polarity. The devices have incorporated reverse battery protection, however, on-board electrolytic capacitors may be damaged.

5.3 Airbag Reference Demonstrator PCB Detail Description

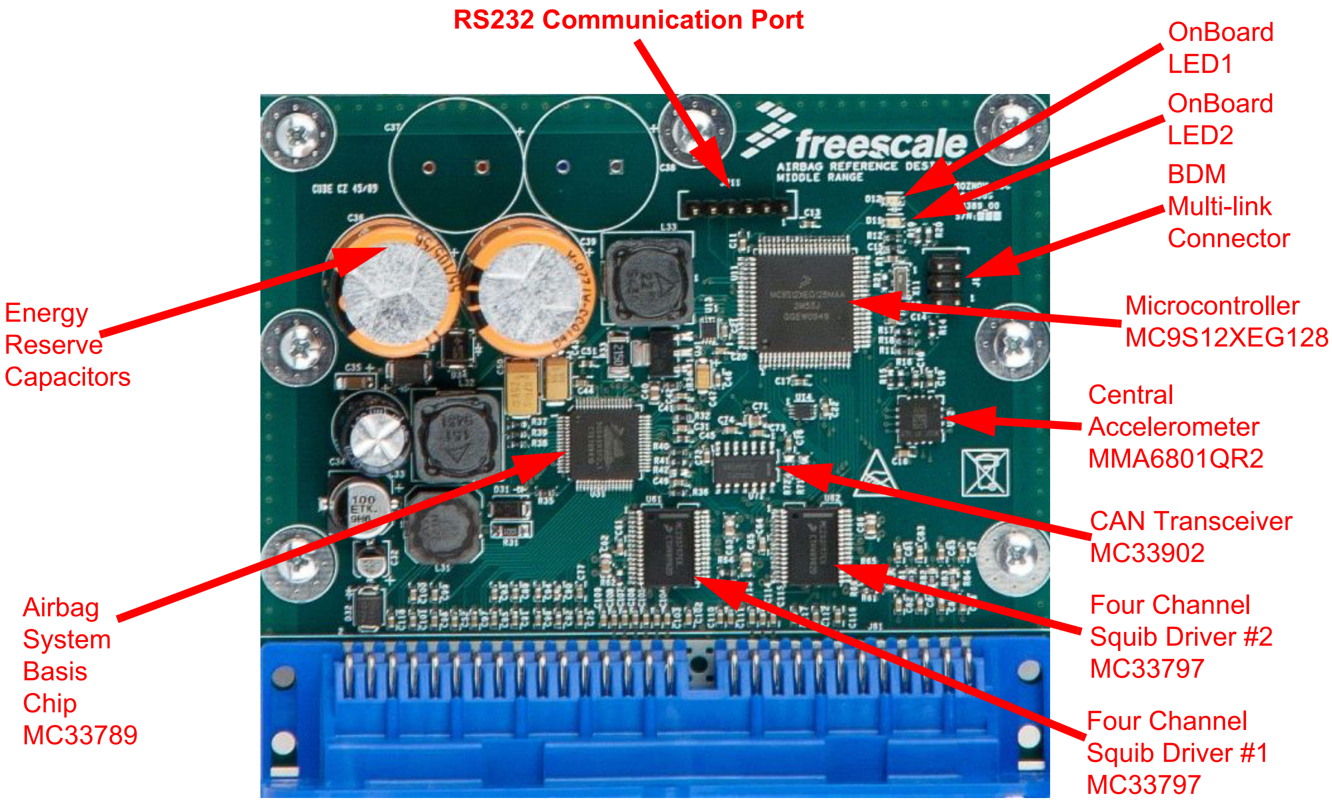


Figure 5-2. ARD PCB Detail Description

5.4 Airbag Reference Demonstrator - GUI

FreeMASTER GUI application can work in 2 modes:

- **Debug Mode** - GUI firmware together with GUI applications allow debug of the main ARD devices - MC33789 (Airbag System Basis Chip), MC33797 (Four Channel Squib Driver), and MMA6801QR2 (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 the 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.

5.4.1 Firmware downloading - GUI version

When using the Code Warrior Development Studio S12(X) first time, install the Code Warrior IDE from the Freescale web page.

1. From CD open Code Warrior project file: *"\ARD_Firmwares\AirbagReferenceDesign_GUIFirmware\ard_gui_middle\ard_gui_middle.mcp".*
2. Connect the DC power supply 12 V. Observe polarity: red is positive, blue or black is negative.
3. Connect attached P&E micro debugger to J11 connector on the ARD main board and plug the USB cable to the PC USB port.
4. Press function key F5 or go to *"Project"* and select *"Debug"*.
5. After finish of the downloading, unplug P&E micro debugger from the J11 port.

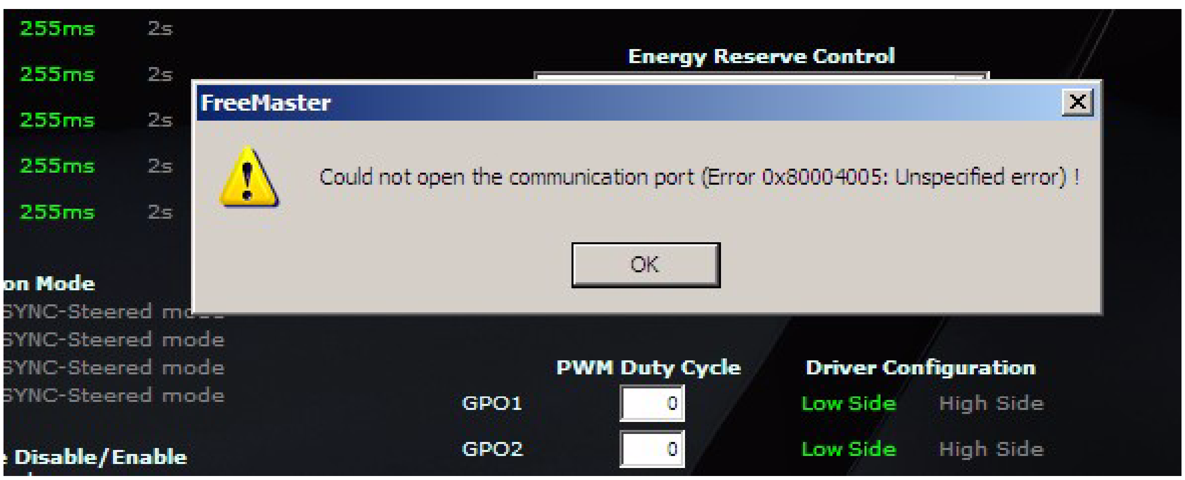
NOTE

This firmware is loaded into Airbag Reference Demonstrator Demo after delivery and immediately ready for using with the FreeMASTER GUI application without doing steps above.

5.4.2 Hardware and Software Setup

When using the FreeMASTER first time, install the FreeMASTER tool from the enclosed CD, as well as the USB drivers. If you have already done this, proceed to point 5.

1. From the CD run file: *FreeMASTER\FMASTERSW.exe and* leave all steps as the default.
2. Connect the DC power supply 12 V. Observe polarity: red is positive, blue or black is negative.
3. Plug the USB cable to the PC USB port. On the screen bottom right-hand corner will appear the message: “Found New Hardware”. Please install the USB drivers located in the enclosed CD, directory \USB_Driver. USB driver is installed twice. Once itself USB driver and second virtual RS232 COM port.
4. PC desktop, mouse right click the icon *“My computer”* and select *“Properties”*. The *“System Properties*” window will open. Select the tab *“Hardware”* and then click on the “*Device Manager”* button. In a new window, expand the *“Ports (COM & LPT)”*. If you have installed the USB drivers properly, the virtual COM ports will be listed, e.g. *“USB Serial Port (COMx)”*. The PC assignees COMx port number. Note the port number used for FreeMASTER control pages configuration.
5. Copy folder *“AirbagReferenceDesign_GUI\”* from the CD to your local hard drive. You will be able to save the FreeMASTER configuration.
6. Open the Airbag Reference Demonstrator FreeMASTER control page.
7. “\ARD_GUI\MiddleARD_FreeMASTER.pmp”.
8. Immediately after opening, a message box may appears:



Click OK and proceed steps as follows.

1. Configure the COM port number and COM port speed 38400Bd, menu *“Project\Options...”*, the tab *“Comm”*. Write proper serial communication port COMx (see bullet 4).
2. Open *“File\Start communication”* to establish the connection.
3. In case you do not execute mentioned steps properly, the message depicted in point 7 appears. The error sources could be:
4. The ARD demo has no power.
5. COM ports are not assigned correctly.
6. Press Ctrl+S to save your settings.

5.4.3 GUI Demonstration

5.4.3.1 Debug mode

Parameters of the devices MC33789, MC33797, or MMA6801QR2, 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. Just place the mouse cursor over the cell to see descriptions of the selected register (see example page Figure 5-3).

Figure 5-3. FreeMASTER Debug Page for the MC33789 Device

NOTE

After starting the watchdog refresh (Watchdog -> Enable), parameters “Safing Thresholds” and “Dwell Extensions” in MC33789 can not be changed.

5.4.3.2 Application Mode

This simple ARD application mode allows to (see Figure 5-4):

- 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 ARD functionality only.
- Simulate deployment of an airbag when the acceleration data reaches the threshold values. These thresholds are set to very low limits, so the soft hit to sensor place by fingers or by rubber hand tool cause relevant airbags “deployment”. This deployment is shown as inflated bags picture in a place where the “collision” occurred. Any “collision” at the driver or passenger place causes inflation of two front airbags. Impact from left side causes inflation of the left side airbags, and from right side causes deployment of the right sides airbags. Anytime after deployment, simulation is possible to reset an inflated bag or bags by pressing button “Reset Deployed Airbags”.

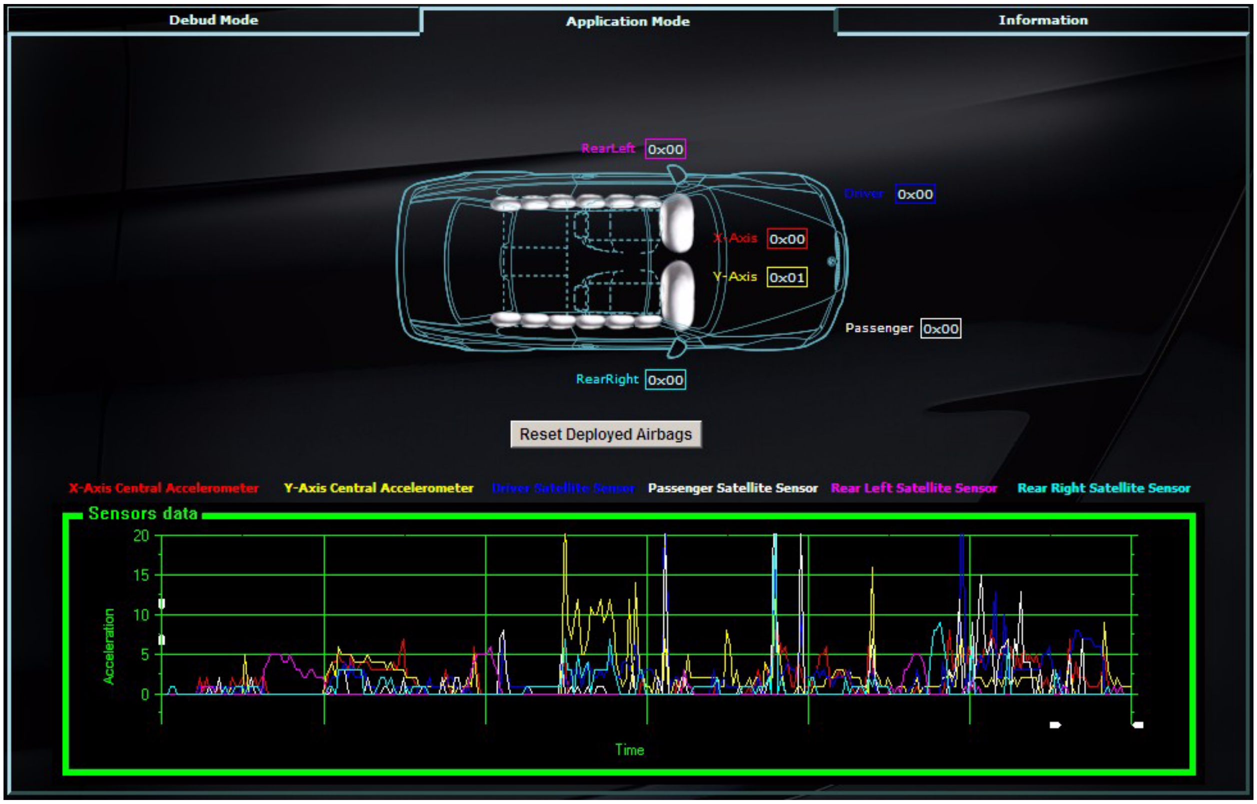


Figure 5-4. FreeMASTER Application Mode

NOTE

In this GUI mode during simulated airbags “deployment”, the relevant squibs drivers are not activated.

5.5 Airbag Reference Demonstrator - “Application”

GUI firmware was designed specifically for communication with the GUI, but firmware uses the same API and low level drivers, as the version described in this chapter, which is intended to demonstrate the functionality of the hardware in an application environment.

The ARD application demonstrator firmware goes through the phases as indicated in *Figure 5-5*.

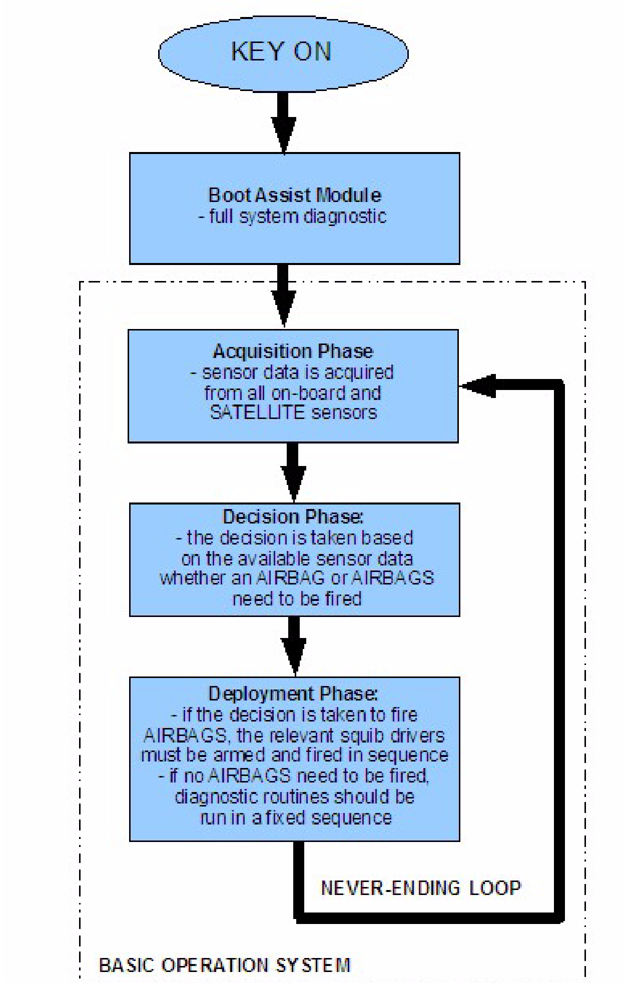


Figure 5-5. Flowchart of the "Application Demonstrator"

Firmware has been divided into GUI firmware as described in 5.4, "Airbag Reference Demonstrator - GUI, and the real firmware described in this chapter for keeping the readability of the C code, and also to allow full access to each analog device and its registers in the GUI mode.

5.5.1 Firmware Downloading - "Application Demonstrator"

When using the Code Warrior Development Studio S12(X) for the first time, install the Code Warrior IDE from the Freescale web page.

1. From the CD, open the Code Warrior project file: *"\ARD_Firmwares\AirbagReferenceDesign_Firmware\ard_application_middle\ard_application_middle.mcp".*
2. Connect the DC power supply 12 V. Observe polarity: red is positive, blue or black is negative.
3. Connect the attached P&E micro debugger to the J11 connector on the ARD main board, and plug the USB cable into the PC USB port.
4. Press function key F5, or go to *"Project"* and select *"Debug"*.
5. After finishing the download, unplug the P&Emicro debugger from the J11 port.

NOTE

This firmware is NOT loaded into Airbag Reference Demonstrator Demo after delivery, and for this ARD functionality, it is necessary to do all the above steps.

5.5.2 Airbag Reference Demonstrator - “Application”

This real ARD application demonstrator allows simple user friendly verification of the functionality. Threshold values for initiation of the airbag deployment are set at very low level limits, so simulation can take place without major car collision impact. Just a soft hit to the sensor place by a finger, or by a rubber tool cause relevant airbag “deployment”.

All ARD SW processes work in real time - reading acceleration values, evaluation and deployment of the squib drivers. This ARD application works independently without communication with the GUI. Evaluation of a collision is indicated only by RED or YELLOW on-board LEDs on the main ECU board.

Lighting up the yellow LED means that impact occurred from the left or right rear side, lighting of the red denotes the collision occurred from front side. Both LEDs switched on it means that the collision occurred from front and also from left or right rear side.

In this demonstrator mode, the relevant squibs (represented by equivalent resistors) are fired, means the firing current flows through resistors, representing the actual airbag squibs.

For a collision simulation (see Figure 5-6):

- hit the rear left sensor place => on-board YELLOW LED turns on
- hit the rear left sensor place => on-board YELLOW LED turns on
- hit the driver or passenger sensor place => on-board RED LED turns on

Simultaneously with on-board LEDs, the warning lamp is also turned on.

NOTE

Keep in mind that in case of a disconnection of the main supply voltage source (possible automotive battery), the whole system is still powered by reserve capacitors in the Autarky mode (roughly for 10 seconds), so it is possible to disconnect the power supply and still operate the demonstrator.

After the power disconnection, please wait before turning off all on-board LEDs, and then reconnecting the power supply.

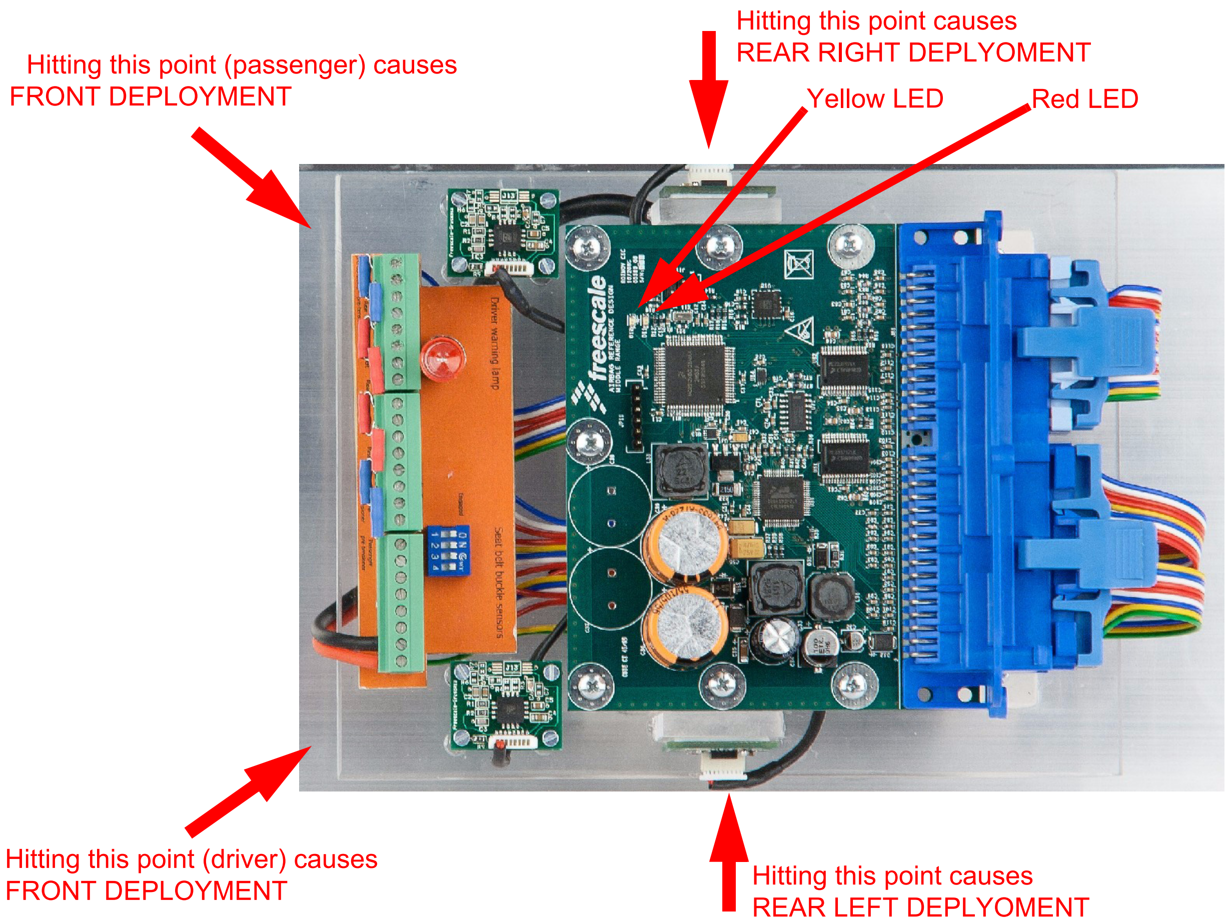


Figure 5-6. Demonstration of the Airbag Application

Chapter 6 Software - Boot Assist Module

6.1 Boot Assist Module (BAM)

The Boost Assist Module controls start up of the demonstrator. During start up of the system, the power supply chain (boost converter, buck converter, and linear regulator) starts automatically once the input to ASBC device has exceeded 5.2 V for more than 1.0 ms. Once stabilized, system RESET is released, allowing the microcontroller to start operating.

Once operating, the microcontroller can continue with the start up process. The microcontroller must turn on the charging of the main energy reserve capacitor and satellite sensors (if present), configure acceleration thresholds for the safing block in central accelerometer, and run a complete diagnostic check of the system before turning off the driver warning lamp.

Once the driver warning lamp has been switched off, the system is considered ‘ARMED’ and able to fire squibs, if no system fault is found prior to a collision, this leads to the warning lamp being switched on again.

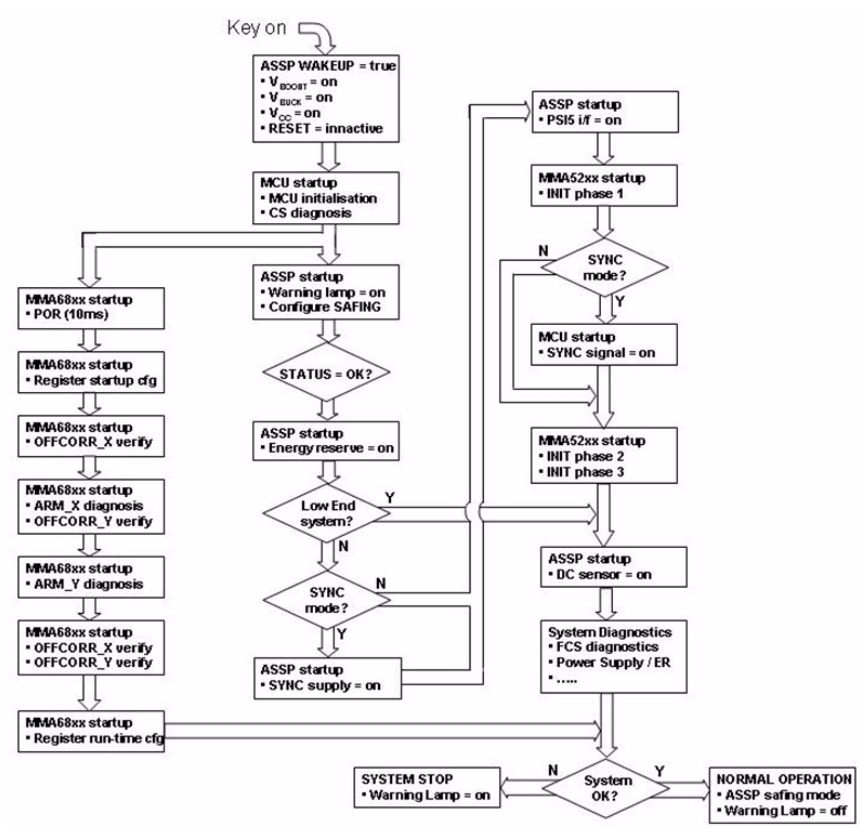


Figure 6-1. Boot Startup Architecture

6.1.1 Example of the BAM source code

This example of the BAM consists of initializing of all the devices on the main ECU board. Each device calls for one standalone initialization API function, and other required features are configured by separate driver functions.

Checking if devices work properly are performed. If all required parameters are set correctly, no device reports any internal error, and if all device tests and their peripherals are without error, the ARD application continues the BOM phase. Otherwise, the systems halts and does not continue its operation.

```
/* Init Airbag System Basis Chip */
  ret_asbc = Asbc_Init(ARD_SPI_ASBC, &Asbc_Config[0]); /* initialization of the ASBC device MC33789 */
  if(ret_asbc == ASBC_OK){
    /* Setup ASBC device */
    Gpt_Enable(); /* enable ASBC watchdog refresh - enable RTI interrupt */
    ret_asbc = Asbc_SetSafingMode(ARD_SPI_ASBC, ASBC_SAFING_CHANGE_TO_SAFING_MODE,
                                  ASBC_SAFING_TEST_DIS, ASBC_SAFING_ARM_OUT_0); /* set ASBC device to the
                                  Safing mode, disable FEN/FDIS arming testing mode */
    if(ret_asbc == ASBC_NOT_OK) Ard_Status = ARD_ERROR; /* ASBC device is not in SAFING mode */
    ret_asbc = Asbc_SetVregMode(ARD_SPI_ASBC, &Asbc_VregConfig[0]); /* configure voltage regulators */
    ret_asbc = Asbc_SetGpo(ARD_SPI_ASBC, ASBC_GPO_1, ASBC_GPO_DC_66_7, ASBC_GPO_LS_DRIVER); /* driver
                                                                warning lamp set ON (duty cycle 66,7%) */
    ret_asbc = Asbc_SetGpo(ARD_SPI_ASBC, ASBC_GPO_2, ASBC_GPO_DC_OFF, ASBC_GPO_HS_DRIVER); /* unused
                                                                                           output */
    ret_asbc = Asbc_SetLinMode(ARD_SPI_ASBC, &Asbc_LinConfig[0]); /* LIN physical layer configuration */
    ret_asbc = Asbc_SetPsi5Mode(ARD_SPI_ASBC, &Asbc_Psi5Config[1]); /* configure PSI5 interface - turn satellite
                                                               sensors interface OFF */
    /* Check ASBC device */
      /* Read System Basis Chip statuses */
      Asbc_Status.Asbc_StatFullEnable = ASBC_STAT_FULL_EN; /* truncated status of the ASBC device */
      ret_asbc = Asbc_GetStatus(ARD_SPI_ASBC, &Asbc_Status); /* common status of the ASBC device */
      ret_asbc = Asbc_GetLinStatus(ARD_SPI_ASBC, &Asbc_LinStatus); /* get LIN physical layer settings */
      ret_asbc = Asbc_GetPsi5Status(ARD_SPI_ASBC, &Asbc_Psi5Status); /* the status of the ASBC PSI5 interface */
      ret_asbc = Asbc_GetVregStatus(ARD_SPI_ASBC, ASBC_VREG_ESR_DIS, &Asbc_VregStatus); /* read status of the
                                  ASBC voltage regulators and measure state of the Energy Reserve capacitor */
  }else{
    Ard_Status = ARD_ERROR; /* Airbag System Basis Chip initialization failed */
  }


/* Init Central Accelerometer */


  if(Ard_Status != ARD_ERROR){ /* if the system basis chip started without error */
    ret_acc = Acc_Init(ARD_SPI_ACC, &Acc_Config[0]); /* setup central accelerator device */
    ret_acc = Acc_GetStatus(ARD_SPI_ACC, &Acc_Status); /* read the complete statuses of the ACC device */
    if(ret_acc != ACC_OK){ /* initalization or get ACC status failed */
      Ard_Status = ARD_ERROR; /* Central Accelerometer initialization failed */
```

```
    }
  }

/* Init SQUIB drivers */

  if(Ard_Status != ARD_ERROR){ /* if the ASBC and ACC started without error */
    ret_squib = Squib_Init(ARD_SPI_SQUIB1); /* the function initializes the SQUIB1 driver - device MC33797 */
    if(ret_squib == SQB_OK){ /* if SQUIB1 initialized without any errors */
      ret_squib = Squib_GetStatus(ARD_SPI_SQUIB1, &Sqb1_Status); /* get status of the 1A, 1B, 2A, 2B of the SQUIB1 */
      if(ret_squib == SQB_OK){ /* if return from the Squib_GetStatus are without error */
        ret_squib = Squib_Init(ARD_SPI_SQUIB2); /* the function initializes the SQUIB2 driver - device MC33797 */
        if(ret_squib == SQB_OK){ /* if SQUIB2 initialized without any errors */
          ret_squib = Squib_GetStatus(ARD_SPI_SQUIB2, &Sqb2_Status); /* get status of the 1A, 1B, 2A, 2B of the SQUIB2 */
          if(ret_squib != SQB_OK){ /* if error return from the Squib_GetStatus */
            Ard_Status = ARD_ERROR;
          }
        }else Ard_Status = ARD_ERROR;
      }else Ard_Status = ARD_ERROR;
    }else Ard_Status = ARD_ERROR;
  }
if(Ard_Status != ARD_ERROR){ /* if SQUIBs devices started without error - check all SQUIB1 and SQUIB2 parameters */
    /* SQUIB1 short to GND or to BATTERY */
    if(Sqb1_Status.Squib_1AShBatt == SQB_SH_TO_BATT_FAULT) Ard_Status = ARD_ERROR;
    if(Sqb1_Status.Squib_1AShGnd == SQB_SH_TO_GND_FAULT) Ard_Status = ARD_ERROR;
    if(Sqb1_Status.Squib_1BShBatt == SQB_SH_TO_BATT_FAULT) Ard_Status = ARD_ERROR;
    ....
    ...
    ...
```

Chapter 7 Software - Basic Operating System

Once the start up phase has completed and the warning lamp has been switched off, the system is ready to operate normally, at which time the airbag control algorithm will be running.

The control algorithm consists of three phases:

- **Acquisition Phase** – sensor data is acquired from all on-board and remote sensors
- **Decision Phase** – the decision is taken based on the available sensor data, and whether an airbag or airbags need to be fired
- **Deployment Phase** – if the decision is taken to fire airbags, the relevant squib drivers must be armed and fired in sequence

In normal operation mode, diagnostics and system status recording should operate. Period diagnostic checks should be carried out in a fixed sequence, to ensure that over a period equivalent to the time for system status updates in EEPROM to be made, a complete diagnostic check can be made.

7.1 Acquisition Phase

In the acquisition phase, the microcontroller reads the sensor data required to enable a deployment decision to be taken.

At the same time the microcontroller reads the sensor data, the safing block in MC33789 is loaded with the same sensor data through the SPI-monitor block. An independent decision can then be taken by the MC33789 safing block based on the sensor data whether to enable the squib drivers and allow deployment of the required airbag or airbags, which will be done under control of the application on the microcontroller.

There is a fixed order in which data has to be read into the MC33789 safing block, even if a sensor in the sequence is missing or has failed. Therefore, a dummy read of sensor data has to be made to maintain the sequence. For example, a read of a logical channel equivalent to a non-implemented channel in the PSI5 block, i.e. any fourth channel of a PSI5 interface will result in a response which contains the correct sequence number but not valid data.

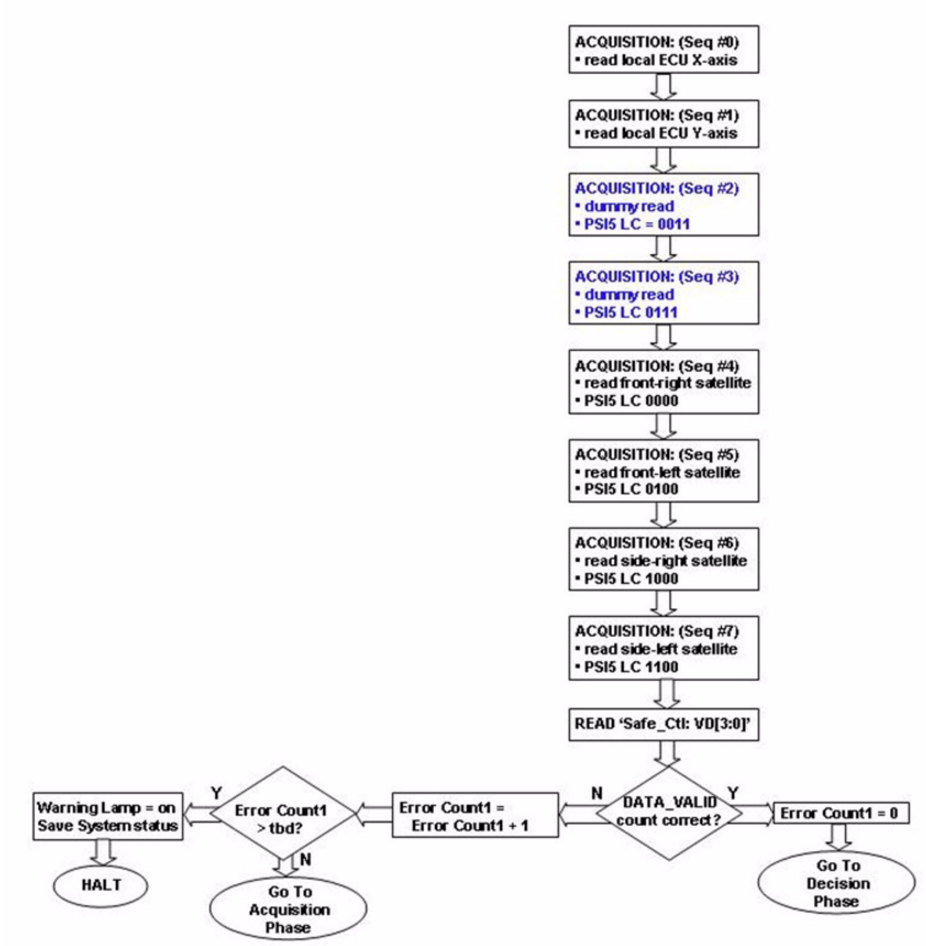


Figure 7-1. Acquisition Phase Flowchart

7.1.1 Source code of the Acquisition phase

Complete Acquisition phase including reading acceleration data from the main inboard sensor and satellite sensors is described in the following source code.

```
/* Read acceleration data from central accelerometer and from satellite sensors */

  /* Synchronization pulse starts */

  SyncPulseStart(); /* rising edge of the SATSYNC pulse */

  /* Acquisition Sequence #0 and #1 - read central accelerometer X-axis and Y-axis data */

    ret_acc = Acc_GetAccelData(ARD_SPI_ACC, ACC_X_OFFSETCANCEL_SIGNED_ARMENABLE,

                        ACC_Y_OFFSETCANCEL_SIGNED_ARMENABLE, &AccelerationData); /* read X and Y axis

                        accelerometer moving value and error status */

  /* Acquisition Sequence #2 - dummy reading (PSI5 LC = 0011) */

    Asbc_ReadSensor(ARD_SPI_ASBC, ASBC_SEQUENCE_IDENTIFIER_02, ASBC_LOG_PSI5_CHAN1_DUMMY,

                &SensorDummy, SensStatus); /* dummy reading */

  /* Acquisition Sequence #3 - dummy reading (PSI5 LC = 0111) */

    Asbc_ReadSensor(ARD_SPI_ASBC, ASBC_SEQUENCE_IDENTIFIER_03, ASBC_LOG_PSI5_CHAN2_DUMMY,

                &SensorDummy, SensStatus); /* dummy reading */
```

```
/* Acquisition Sequence #4 - read front-left satellite (PSI5 LC = 0000) */
  Asbc_ReadSensor(ARD_SPI_ASBC, ASBC_SEQUENCE_IDENTIFIER_04, ASBC_LOG_PSI5_CHAN1_SLOT1,
                  &SensorData_Driver, SensStatus); /* acceleration data from front left satellite sensor */
/* Acquisition Sequence #5 - read front-right satellite (PSI5 LC = 0100) */
  Asbc_ReadSensor(ARD_SPI_ASBC, ASBC_SEQUENCE_IDENTIFIER_05, ASBC_LOG_PSI5_CHAN2_SLOT1,
                  &SensorData_Passenger, SensStatus); /* acceleration data from front right satellite sensor */
/* Acquisition Sequence #6 - read side-right satellite (PSI5 LC = 1000) */
  Asbc_ReadSensor(ARD_SPI_ASBC, ASBC_SEQUENCE_IDENTIFIER_06, ASBC_LOG_PSI5_CHAN3_SLOT1,
                  &SensorData_RearRight, SensStatus); /* acceleration data from rear right satellite sensor */
/* Acquisition Sequence #7 - read side-left satellite (PSI5 LC = 1100) */
  Asbc_ReadSensor(ARD_SPI_ASBC, ASBC_SEQUENCE_IDENTIFIER_07, ASBC_LOG_PSI5_CHAN4_SLOT1,
                  &SensorData_RearLeft, SensStatus); /* acceleration data from rear left satellite sensor */
/* Complete synchronization pulse */
SyncPulseEnd(); /* falling edge of the SATSYNC pulse */
/* Read ASBC Safing status */
Asbc_Status.Asbc_StatFullEnable = ASBC_STAT_FULL_DIS; /* truncated status of the ASBC device */
ret_asbc = Asbc_GetStatus(ARD_SPI_ASBC, &Asbc_Status); /* common status of the ASBC device */
/* Check correct number of the valid data */
if(Asbc_Status.Asbc_SafingDataCount == 6){ /* check correct number of the valid data - expected number is "6" */
                                  /* 1. reading is from central accelerometer X-axis */
                                  /* 2. reading is from central accelerometer Y-axis */
                                  /* 3. reading is from front left satellite sensor */
                                  /* 4. reading is from front right satellite sensor */
                                  /* 5. reading is from side right satellite sensor */
                                  /* 6. reading is from side left satellite sensor */
  DataErrorCounter = 0; /* clear data invalid counter */
  Ard_Status = ARD_DECISION; /* go to Decision Phase */
}else{ /* Safing counter parameter Asbc_SafingDataCount contains a different number than expected */
  DataErrorCounter = DataErrorCounter + 1; /* increment data invalid counter */
  if(DataErrorCounter > ARD_DATA_INVALID_COUNT_LIMIT){ /* if the number of the invalid data exceed limit */
    Ard_Status = ARD_ERROR; /* reading attempts from sensors ended with failure (warning lamp ON and syst halt) */
  }else{ /* invalid counter did not exceed limit value */
    Ard_Status = ARD_ACQUISITION; /* system will stay here in the Acquisition Phase */
  }
}
```

7.2 Decision Phase

In the decision phase, the microcontroller interprets the sensor data read during the acquisition phase to calculate which, if any, squibs need to be fired. The decision phase follows the acquisition phase as long as the DATA_VALID count in the acquisition phase is correct.

The decision whether to fire a squib is always based on at least two sensor readings. Where two sensor readings confirm that a deployment is required in three successive decision phases, a flag is set which will trigger the deployment, in the deployment phase. If no deployment is necessary, the system will have time before the next acquisition phase starts to run diagnostic tests.

NOTE

The example flowchart in Figure 7-2 demonstrates a simple decision phase that is intended only to demonstrate the functionality of the reference demonstrator hardware, and is not intended to represent a true airbag application.

FRONT DECISION source code example is shown in chapter 7.1.2.1

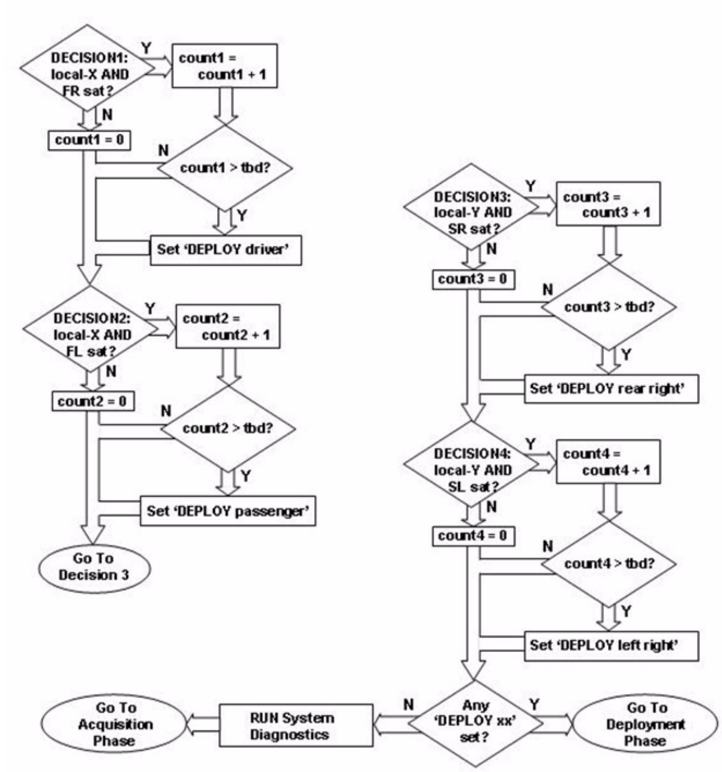


Figure 7-2. Decision Phase Flowchart

7.2.1 Example of the API Source Code Used in Decision Phase - Front Decision

An example of the SW implementation of the front decision is described in the following example. Any exceeding of the threshold values at driver or passenger place causes transition to the deployment phase and deployment of two front airbags. Decisions for the rear passengers are done in the same way.

```
/* FRONT DECISION */
if(AccelerationData.AccelDataX > ACC_X_ARM_THRESHOLD){ /* if data from  accelerometer (X-axis) exceed thresholds */
  /* FRONT RIGHT DECISION */
  if(SensorData_Passenger > Asbc_Config[0].Asbc_SafingThreshold2){ /* data from front right sensor exceed Threshold2 */
    FrontRightCounter = FrontRightCounter + 1; /* increment number of the exceeded acceleration thresholds from the front
                                                  right satellite sensor and from the central accelerometer */
    if(FrontRightCounter > ARD_DECISION_COUNT_LIMIT){ /* number of the exceeded accel values exceed counter limit */
      PassengerDeploy = DEPLOY_PASSENGER; /* passenger squib deployment required */
    }
  }else{ /* no thresholds were exceeded */
    FrontRightCounter = 0; /* clear front right counter */
    PassengerDeploy = NO_DEPLOY; /* reset deployment flag to default state */
  }
 /* FRONT LEFT DECISION */
  if(SensorData_Driver > Asbc_Config[0].Asbc_SafingThreshold2){ /* data from front left sensor exceed Threshold2 */
    FrontLeftCounter = FrontLeftCounter + 1; /* increment number of the exceeded acceleration thresholds from the front
                                                left satellite sensor and from the central accelerometer */
    if(FrontLeftCounter > ARD_DECISION_COUNT_LIMIT){ /* number of the exceeded accel values exceed counter limit */
      DriverDeploy = DEPLOY_DRIVER; /* driver squib deployment required */
    }
  }else{ /* no thresholds were exceeded */
    FrontLeftCounter = 0; /* clear front left counter */
    DriverDeploy = NO_DEPLOY; /* reset deployment flag to default state */
  }
}
```

7.3 Deployment Phase

The deployment phase is entered if the application has decided that at least one airbag needs to be deployed. Typically, more than one deployment is needed in any collision – any airbag deployment will also be backed up with at least one seatbelt pre-tensioner activation. Each of the four decisions taken in the decision phase is linked directly to an airbag and a related seatbelt pre-tensioner. Prior to activation of the pre-tensioners, the condition of the seatbelt switch is checked using the DC sensor on the MC33789.

As in a real airbag application, after the deployment phase, the system should return to the acquisition phase to attempt to deal with a second collision, except in the case that all airbags and pre-tensioners have been deployed already.

Note: the example flowchart here demonstrates a simple deployment phase intended only to demonstrate the functionality of the reference demonstrator hardware, and is not intended to represent a true airbag application.

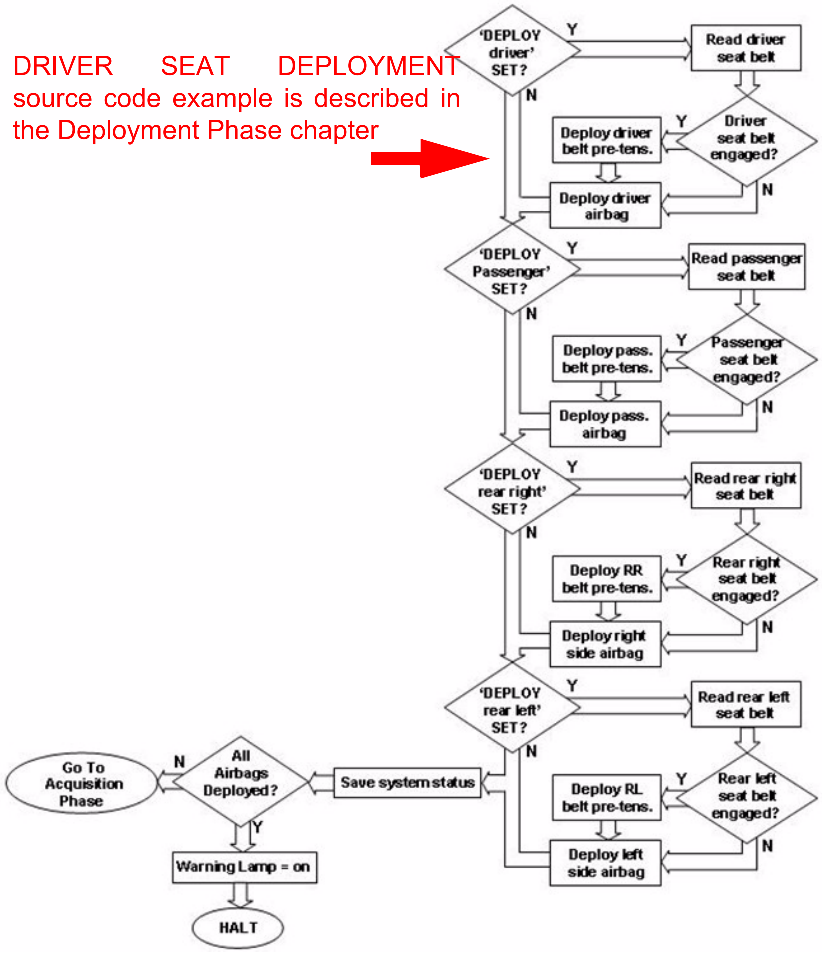


Figure 7-3. Deployment phase Flowchart

7.3.1 Example of the API Source Code Used in Deployment Phase

This source code example relates to the deployment of the driver seat. The other three seats would be driven by a similar code sequence. If deployment is required, based on the verdict from a previous decision phase. The pre-tensioner for the seat belt is deployed first before deployment of the main driver's airbag.

Commands to switch Low-FET and High-FET switches are sent to the appropriate SQUIB DRIVER IC. The low side squib driver must be activated prior to activating the high side squib driver.

```
/* DEPLOY DRIVER SEAT */
if((DriverDeploy == DEPLOY_DRIVER) && (GetPort(ARM)) && (GetPort(ARM_X))){ /* driver squib deployment required? */
  /* Deploy driver pre-tensioner (if the driver seat belt is engaged) */
  if(DriverBuckle == TRUE){ /* the driver seat belt is engaged */
    /* Deploy driver pre-tensioner (the SQUIB2(LO_1B) driver must be activated prior the SQUIB1(HI_1B) driver) */
    ret_squib = Squib_Fire(ARD_SPI_SQUIB2, CMD_FIRE_1BLS); /* switch ON 1B Low Side on the SQUIB2 */
    if(ret_squib == SQB_NOT_OK) Ard_Status = ARD_ERROR; /* if any error occures */
    ret_squib = Squib_Fire(ARD_SPI_SQUIB1, CMD_FIRE_1BHS); /* switch ON 1B High Side on the SQUIB1 */
    if(ret_squib == SQB_NOT_OK) Ard_Status = ARD_ERROR; /* if any error occures */
  }
  /* Deploy driver airbag = the SQUIB2(LO_1A) driver must be activated prior to activating the SQUIB1(HI_1A) driver */
  ret_squib = Squib_Fire(ARD_SPI_SQUIB2, CMD_FIRE_1ALS); /* switch ON 1A Low Side on the SQUIB2 */
  if(ret_squib == SQB_NOT_OK) Ard_Status = ARD_ERROR; /* if any error occures */
  ret_squib = Squib_Fire(ARD_SPI_SQUIB1, CMD_FIRE_1AHS); /* switch ON 1A High Side on the SQUIB1 */
  if(ret_squib == SQB_NOT_OK) Ard_Status = ARD_ERROR; /* if any error occures */
  DriverDeploy = DRIVER_DEPLOYED; /* set driver airbag status - driver airbag deployed */
}
```

Appendix A SW Concept

ARD software is built on basic low level MCU drivers, which provide access to the modules ADC, GPIO, EEPROM, GPT. etc. in the microprocessor, and provide all necessary MCU functions. The upper software layer contains drivers for all main ARD devices - Main Airbag ASIC MC33789 (ASBC Driver), Central Accelerometer MMA6801QR2 (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 are needed for all MCU derivatives (8/16/32b).

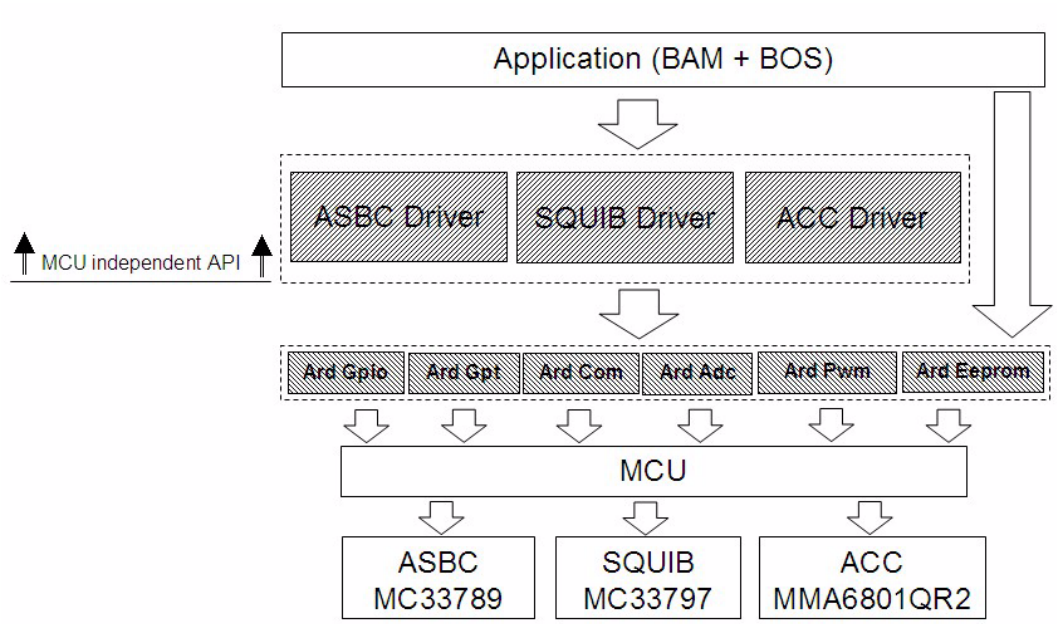


Figure 7-4. SW Design concept

A.1 Airbag System Basis Chip SW Driver

The ASBC driver is written as a separate software module. The main advantage is full HW abstraction and API independence in used MCU family. The driver API covers the entire functionality of the ASBC device, which means all registers can be configured/read using API functions.

The ASBC Driver is dependent on the COM layer (basic SPI communication) and on the GPT driver (General Purpose Timer), which provides timing functions that are needed primarily for watchdog control.

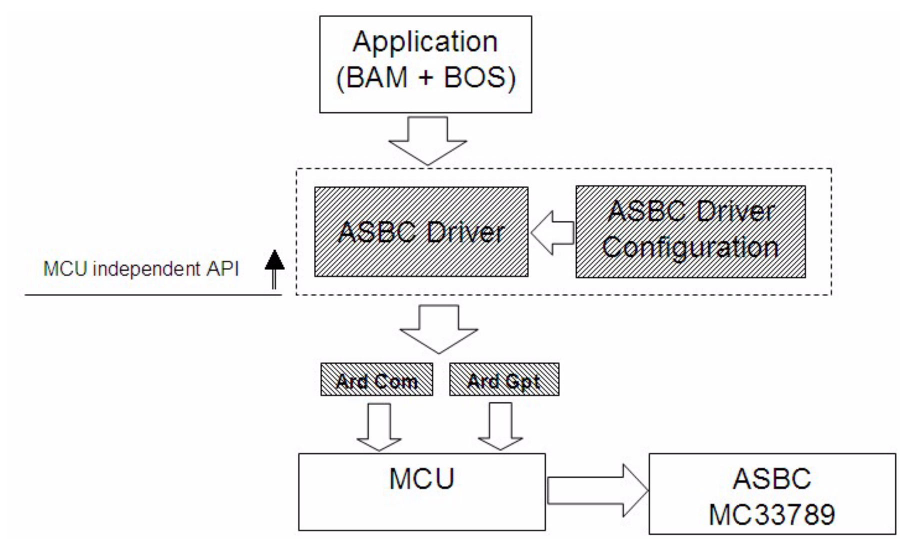


Figure 7-5. Airbag System Basis Chip SW Driver Concept

Table 7-1. Airbag System Basis Chip SW Driver API

Function Name	Function Parameters	Return Type	Function Description
Asbc_Init	Spi_Channel [in] *Config [in]	Asbc_ReturnType	Initialize the Airbag System Basis Chip and returns the confirmation of initialization. Multiple initialization configuration is supported via the Config parameter.
Asbc_GetStatus	Spi_Channel [in] *Status [out]	Asbc_ReturnType	Return the status of the ASBC. Only the general statuses are reported via this service.
Asbc_SetAnlMuxSource	Spi_Channel [in] Source [in]	Asbc_ReturnType	Allow to change the analog parameter which is connected to the AOUT output.
Asbc_SetDcsMuxSource	Spi_Channel [in] Source [in] Voltage [in]	Asbc_ReturnType	Determines which DC sensor input channel shell be connected for diagnostic output.
Asbc_SetVregMode	Spi_Channel [in] *Config [in]	Asbc_ReturnType	Set the ASBC Voltage regulator. Various configurations of voltage regulators are supported via the Asbc_VregConfig container.
Asbc_GetVregStatus	Spi_Channel [in] *Status [out]	Asbc_ReturnType	Return the status of the ASBC Voltage regulators. This also contains the Boost and Buck statuses.
Asbc_SetPsi5Mode	Spi_Channel [in] *Config [in]	Asbc_ReturnType	Set the ASBC PSI5 four satellite sensor interface. Various configurations of PSI5 interface are supported via the Asbc_Psi5Config container.
Asbc_GetPsi5Status	Spi_Channel [in] *Status [out]	Asbc_ReturnType	Return the status of the ASBC PSI5 interface.
Asbc_SetLinMode	Spi_Channel [in] *Config [in]	Asbc_ReturnType	Set the ASBC LIN transceiver mode. Via the Asbc_LinConfig configuration container various configurations are supported.
Asbc_GetLinStatus	Spi_Channel [in] *Status [out]	Asbc_ReturnType	Return the ASBC LIN transceiver status.
Asbc_SetGpo	Spi_Channel [in] GpoChannel [in] GpoPwmDutyCycle [in] GpoDriverConfig [in]	Asbc_ReturnType	Set the ASBC output channel mode. Various configuration for each output channel are supported via the Asbc_GpoDriverConfig configuration container.
Asbc_GetGpoStatus	Spi_Channel [in] GpoChannel [in] *Status [out]	Asbc_ReturnType	Return the ASBC output channel status. This includes the high/low side selection, thermal shutdown and the voltage level.
Asbc_ReadSensor	Spi_Channel [in] SequenceIdentifier [in] LogicalChannel [in]	Asbc_ReturnType	This function provide sensor request/response to retrieve sensor data from satellite interface block.
Asbc_FeedWatchdog	Spi_Channel [in] WD_Polarity [in]	Asbc_ReturnType	Update the ASBC Watchdog. A successful watchdog refresh is a SPI command (high), following another SPI command (low).
Asbc_ProgramCmd	Spi_Channel [in] Command [in] Data [in] SpiResponse [out]	Asbc_ReturnType	Send any ASBC command to the device and read its response.

A.2 ASBC API parameters detail descriptions

Brief description of input and output API parameters is in the following paragraphs. Descriptions contains only a verbal description of the parameter. Values which can variable acquired is described in the header file ASBC.h.

Parameters of the **Asbc_Init** API function:

- **Spi_Channel** (Asbc_SpiChannelType) - logical SPI channel number (not physical SPI channel)
- **Config** (Asbc_ConfigType) - input configuration structure:
  - **Asbc_SafingThreshold0** - 8 bits safing 0 threshold value
  - **Asbc_SafingDwellExt0** - extension of the arming pulse width (either 255 ms or 2.0 s) for threshold0
  - **Asbc_SafingThreshold1** - 8 bits safing 1 threshold value
  - **Asbc_SafingDwellExt1** - extension of the arming pulse width (either 255 ms or 2.0 s) for threshold1
  - **Asbc_SafingThreshold2** - 8 bits safing 2 threshold value
  - **Asbc_SafingDwellExt2** - extension of the arming pulse width (either 255 ms or 2.0 s) for threshold2
  - **Asbc_SafingThreshold3** - 8 bits safing 3 threshold value
  - **Asbc_SafingDwellExt3** - extension of the arming pulse width (either 255 ms or 2.0 s) for threshold3

  - **Asbc_SafingThreshold4** - 8 bits safing 4 threshold value
  - **Asbc_SafingDwellExt4** - extension of the arming pulse width (either 255 ms or 2.0 s) for threshold4
  - **Asbc_SafingThreshold5** - 8 bits safing 5 threshold value
  - **Asbc_SafingDwellExt5** - extension of the arming pulse width (either 255 ms or 2.0 s) for threshold5
  - **Asbc_SafingThreshold6** - 8 bits safing 6 threshold value
  - **Asbc_SafingDwellExt6** - extension of the arming pulse width (either 255 ms or 2.0 s) for threshold6
  - **Asbc_SafingThreshold7** - 8 bits safing 7 threshold value
  - **Asbc_SafingDwellExt7** - extension of the arming pulse width (either 255 ms or 2.0 s) for threshold7

Parameters of the **Asbc_GetStatus** API function:

- **Spi_Channel** (Asbc_SpiChannelType) - logical SPI channel number (not physical SPI channel)
- **Status** (Asbc_StatusType) output status structure containing the common status of the ASBC device:
  - **Asbc_VregSyncSuppOverTemp** - Sync supply over-temperature error
  - **Asbc_VregSensRegulOverTemp** - DC sensor regulator over-temperature error
  - **Asbc_VregBoostOverTemp** - Boost supply over-temperature error
  - Asbc_VregIgnState
  - **Asbc_WakeupPinState** - wake-up pin state
  - **Asbc_WdogState** - watchdog state
  - **Asbc_WdogErrStatus** - watchdog error status
  - **Asbc_SafingSequenceErr** - safing sequence error
  - **Asbc_SafingOffsetErr** - safing offset error
  - **Asbc_SafingMode** - safing mode status
  - **Asbc_SafingDataCount** - number of digital sensor messages received with valid sensor data
  - **Safing threshold settings** - these parameters are returned the same values as described in the initialization function **ASBC_Init**

Parameters of the **Asbc_SetAnlMuxSource** API function:

- **Spi_Channel** (Asbc_SpiChannelType) - logical SPI channel number (not physical SPI channel)
- **Source** (Asbc_AnlMuxSourceType) input parameter - analog source which will be connected to the MUX input

Parameters of the **Asbc_SetDcsMuxSource** API function:

- **Spi_Channel** (Asbc_SpiChannelType) - logical SPI channel number (not physical SPI channel)
- **Source** (Asbc_DcsMuxSourceType) input parameter - sensor channel selection determines which DC sensor input shall be connected for diagnostics output
- **Voltage** (Asbc_DcsMuxSourceType) input parameter - bias voltage selection determines which regulated voltage shall be used as a bias supply on the DC sensor output stage for diagnostics

Parameters of the **Asbc_SetSafingMode** API function:

- **Spi_Channel** (Asbc_SpiChannelType) - logical SPI channel number (not physical SPI channel)
- **SafingMode** (Asbc_SafingModeRequestType) input parameter - safing mode request
- **SafingTestEnable** (Asbc_SafingTestEnableType) input parameter - safing test enable
- **SafingLevel** (Asbc_SafingLevelType) input parameter - arming output level

Parameters of the **Asbc_SetVregMode** API function:

- **Spi_Channel** (Asbc_SpiChannelType) - logical SPI channel number (not physical SPI channel)
- **Config** (Asbc_VregConfigType) input configuration parameter - configuration of the ASBC voltage regulator:
  - **Asbc_VregSyncSupply** (Asbc_VregConfigType) input parameter - Sync supply control
  - **Asbc_VregBoost** (Asbc_VregBoostType) input parameter - Boost regulator control
  - **Asbc_VregBuck** (Asbc_VregBuckType) input parameter - Buck regulator control
  - **Asbc_VregEnergyReserve** (Asbc_VregEnergyReserveType) input parameter - energy reserve control

Parameters of the **Asbc_GetVregStatus** API function:

- **Spi_Channel** (Asbc_SpiChannelType) - logical SPI channel number (not physical SPI channel)
- **VregEnergyReserveTest** (Asbc_VregEnergyReserveTestType) input parameter - energy reserve test diagnostic control
- **Status** (Asbc_VregStatusType) output structure containing the status of the ASBC voltage regulators:
  - **Asbc_VregBoost** (Asbc_VregStatBoostType) - report boost voltage less/greater than threshold (~80% of target)
  - **Asbc_VregChargDischarFault** (Asbc_VregStatChargDischarFaultType) - CER charge/discharge switch failure status

  - **Asbc_VregSyncSupply** (Asbc_VregSyncSupplyType) - Sync supply status
  - **Asbc_VregBoostEnable** (Asbc_VregBoostType) - Boost regulator status
  - **Asbc_VregBuckEnable** (Asbc_VregBuckType) - Buck regulator status
  - **Asbc_VregEnergyReserve** (Asbc_VregEnergyReserveType) - energy reserve status
  - **Asbc_VregEnergyReserveValue** (uint8) - energy reserve test diagnostic status

Parameters of the Asbc_SetPsi5Mode API function:

- **Spi_Channel** (Asbc_SpiChannelType) - logical SPI channel number (not physical SPI channel)
- **Config** (Asbc_Psi5ConfigType) input configuration structure of the ASBC PSI5 interface:
  - **Asbc_PSI5Chann1Mode** (Asbc_PSI5Chann1ModeType) - PSI5 channel 1 mode - Synchronous SATSYNC (Steered Mode) or Synchronous TDM Mode
  - **Asbc_PSI5Chann1Enable** (Asbc_PSI5Chann1EnableType) - PSI5 channel 1 enable/disable
  - **Asbc_PSI5Chann1SynPuls** (Asbc_PSI5Chann1SynPulsType) - PSI5 channel 1 sync pulse enable/disable
  - **Asbc_PSI5Chann2Mode** (Asbc_PSI5Chann2ModeType) - PSI5 channel 2 mode - Synchronous SATSYNC (Steered Mode) or Synchronous TDM Mode
  - **Asbc_PSI5Chann2Enable** (Asbc_PSI5Chann2EnableType) - PSI5 channel 2 enable/disable
  - **Asbc_PSI5Chann2SynPuls** (Asbc_PSI5Chann2SynPulsType) - PSI5 channel 2 sync pulse enable/disable
  - **Asbc_PSI5Chann3Mode** (Asbc_PSI5Chann3ModeType) - PSI5 channel 3 mode - Synchronous SATSYNC (Steered Mode) or Synchronous TDM Mode
  - **Asbc_PSI5Chann3Enable** (Asbc_PSI5Chann3EnableType) - PSI5 channel 3 enable/disable
  - **Asbc_PSI5Chann3SynPuls** (Asbc_PSI5Chann3SynPulsType) - PSI5 channel 3 sync pulse enable/disable
  - **Asbc_PSI5Chann4Mode** (Asbc_PSI5Chann4ModeType) - PSI5 channel 4 mode - Synchronous SATSYNC (Steered Mode) or Synchronous TDM Mode
  - **Asbc_PSI5Chann4Enable** (Asbc_PSI5Chann4EnableType) - PSI5 channel 4 enable/disable
  - **Asbc_PSI5Chann4SynPuls** (Asbc_PSI5Chann4SynPulsType) - PSI5 channel 4 sync pulse enable/disable

Parameters of the **Asbc_GetPsi5Status** API function:

- **Spi_Channel** (Asbc_SpiChannelType) - logical SPI channel number (not physical SPI channel)
- **Status** (Asbc_Psi5StatusType) output structure containing the status of the ASBC PSI5 interface: - returned parameters are the same as is described in Asbc_SetPsi5Mode function above.

Parameters of the **Asbc_SetLinMode** API function:

- **Spi_Channel** (Asbc_SpiChannelType) - logical SPI channel number (not physical SPI channel)
- **Config** (Asbc_LinConfigType) input configuration structure of the ASBC LIN bus interface:
  - **Asbc_LinSlewRate** (Asbc_LinSlewRateType) - LIN slew rate selection
  - **Asbc_LinRXDMode** (Asbc_LinRXDModeType) - RxD output function
  - **Asbc_LinRXOut** (Asbc_LinRXOutType) - Rx output selection (for RxD satellite function)

Parameters of the **Asbc_GetLinStatus** API function:

- **Spi_Channel** (Asbc_SpiChannelType) - logical SPI channel number (not physical SPI channel)
- **Status** (Asbc_LinStatusType) output structure containing the status of the ASBC LIN bus interface:
  - **Asbc_LinSlewRate** (Asbc_LinSlewRateType) - LIN slew rate selection
  - **Asbc_LinRXDMode** (Asbc_LinRXDModeType) - RxD output function
  - **Asbc_LinRXOut** (Asbc_LinRXOutType) - Rx output selection (for RxD satellite function)

Parameters of the **Asbc_SetGpo** API function:

- **Spi_Channel** (Asbc_SpiChannelType) - logical SPI channel number (not physical SPI channel)
- **GpoChannel** (Asbc_GpoChannelType) - selected GPO pin
- **GpoPwmDutyCycle** (Asbc_GpoPwmDutyCycleType) - output PWM duty cycle
- **GpoDriverConfig** (Asbc_GpoDriverConfigType) - HS/LS driver configuration selection

Parameters of the **Asbc_GetGpoStatus** API function:

- **Spi_Channel** (Asbc_SpiChannelType) - logical SPI channel number (not physical SPI channel)
- **GpoChannel** (Asbc_GpoChannelType) - selected GPO pin
- **Status** (Asbc_GpoStatusType) output structure containing the status of the selected output:
  - **Asbc_GpoDriverConfig** - HS/LS driver configuration selection
  - **Asbc_GpoDriverOn13** - driver ON 1/3 VPWR comparator result
  - **Asbc_GpoDriverOn23** - driver ON 2/3 VPWR comparator result
  - **Asbc_GpoDriverOff13** - driver OFF 1/3 VPWR comparator result

— **Asbc_GpoDriverOff23** - driver OFF 2/3 VPWR comparator result

Parameters of the **Asbc_ReadSensor** API function:

- **Spi_Channel** (Asbc_SpiChannelType) - logical SPI channel number (not physical SPI channel)
- **SequenceIdentifier** (Asbc_PSI5SequenceIdentifierType) - PSI5 sequence identifier (used for synchronizing samples)
- **LogicalChannel** (Asbc_PSI5LogicalChannelType) - PSI5 logical channel selection
- **SensorData** (uint16) - data from selected satellite sensor
- **SensorStatus** (Asbc_SensorStatusType) - satellite sensor response status

Parameters of the **Asbc_FeedWatchdog** API function:

- **Spi_Channel** (Asbc_SpiChannelType) - logical SPI channel number (not physical SPI channel)
- **WD_Polarity** (Asbc_WdLevelType) - watchdog polarity value

Parameters of the **Asbc_ProgramCmd** API function:

- **Spi_Channel** (Asbc_SpiChannelType) - logical SPI channel number (not physical SPI channel)
- **Command** (Asbc_SpiChannelType) - non sensor command
- **Data** (uint16) - data
- **SpiResponse** (uint16) - response to the sent command

A.3 Central Accelerometer Driver

The ACC driver is created as a separate software module. The main advantage is full HW abstraction and API independence in used MCU family. The driver API covers the entire functionality of the main accelerometer, which means all accelerometer functionality can be controlled using API functions.

The ACC Driver is dependent on the COM layer (basic SPI communication), and on the GPIO driver (General Purpose Input/Output), which provides basic functions for controlling input/output MCU pins.

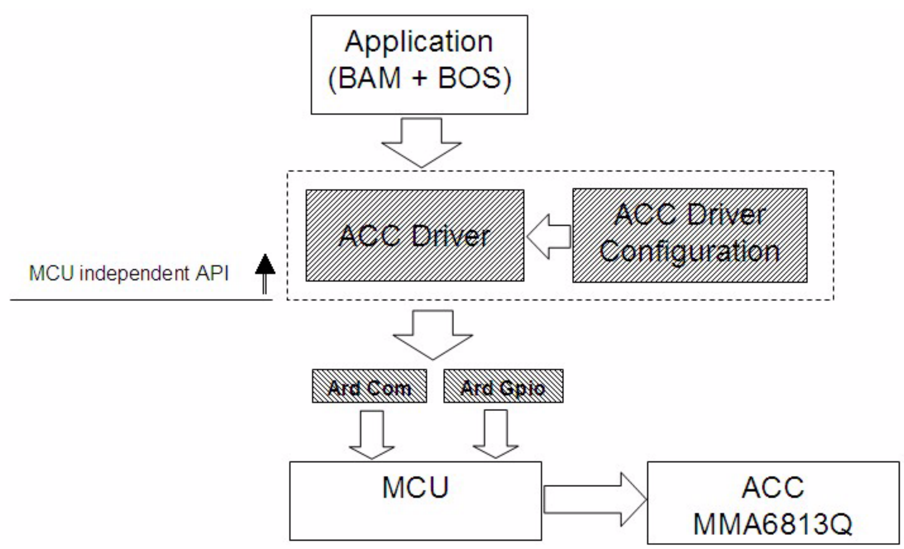


Figure 7-6. Central Accelerometer SW driver concept

Table 7-2. Central Accelerometer SW driver API

Function Name	Function Parameters	Return Type	Function Description
Acc_Init	Spi_Channel [in] *Config [in]	Acc_ReturnType	Initialize the central accelerometer device and returns the confirmation of initialization. Multiple initialization configuration is supported via the Config parameter.
Acc_GetStatus	Spi_Channel [in] *Status [out]	Acc_ReturnType	Return the whole status of the Mesquite accelerometer device.

Table 7-2. Central Accelerometer SW driver API

Function Name	Function Parameters	Return Type	Function Description
Acc_GetAccelData	Spi_Channel [in] AccelCmdX [in] AccelCmdY [in] *Status [out]	Acc_ReturnType	Read the X and Y axis accelerometer moving values and other necessary statuses.
Acc_ProgramCmd	Spi_Channel [in] RegAddress [in] Data [in] SpiResponse [out]	Acc_ReturnType	Read/write independently any IC register.

A.4 ACC Parameters Detail Descriptions

A brief description of input and output API parameters is in the following paragraphs. Descriptions contain only a verbal description of the parameter. Values which each variable acquires is described in the header file ACC.h.

Parameters of the **Acc_Init** API function:

- **Spi_Channel** (Acc_SpiChannelType) - logical SPI channel number (not physical SPI channel)
- **Config** (Acc_ConfigType) - input configuration structure:
  - **Acc_ConfSignData** - this variable determines the format of acceleration data results
  - **Acc_OffsetMoni** - offset monitor circuit enable/disable
  - **Acc_ArmOutput** - mode of operation for the ARM_X/PCM_X and ARM_Y/PCM_Y pins
  - **Acc_XAxisSelfTest** - enable or disable the self-test circuitry for X axis
  - **Acc_YAxisSelfTest** - enable or disable the self-test circuitry for Y axis
  - **Acc_XLowPassFilter** - the low pass filter selection bits independently select a low-pass filter for X axis
  - **Acc_YLowPassFilter** - the low pass filter selection bits independently select a low-pass filter for Y axis
  - **Acc_XArmPulseStretch** - pulse stretch time for X arming outputs
  - **Acc_YArmPulseStretch** - pulse stretch time for Y arming outputs
  - **Acc_XArm_PosWin_CountLimit** - X axis positive arming window size definitions or arming count limit definitions function (depending on the state of the Acc_ArmOutput variable)
  - **Acc_YArm_PosWin_CountLimit** - Y axis positive arming window size definitions or arming count limit definitions function (depending on the state of the Acc_ArmOutput variable)
  - **Acc_XArm_NegWinSize** - X axis negative arming window size definitions (meaning depend on the state of the Acc_ArmOutput variable)
  - **Acc_YArm_NegWinSize** - Y axis negative arming window size definitions (meaning depend on the state of the Acc_ArmOutput variable)
  - **Acc_XArmPositiveThreshold** - this value contain the X axis positive threshold to be used by the arming function
  - **Acc_YArmPositiveThreshold** - this value contain the Y axis positive threshold to be used by the arming function
  - **Acc_XArmNegativeThreshold** - this value contain the X axis negative thresholds to be used by the arming function
  - **Acc_YArmNegativeThreshold** - this value contain the Y axis negative thresholds to be used by the arming function

Parameters of the **Acc_GetStatus** API function:

- **Spi_Channel** (Acc_SpiChannelType) - logical SPI channel number (not physical SPI channel)
- **Status** (Acc_StatusType) output status structure containing the complete status of the ACC device:
  - **Acc_SerialNumber** - device serial number
  - **Acc_LotNumberHigh** - device high lot number value
  - **Acc_LotNumberMidd** - device midd lot number value
  - **Acc_LotNumberLow** - device low lot number value
  - **Acc_PartNumber** - device part number
  - **Acc_XPositiveTestDeflection** - device self test positive deflection values for X axis
  - **Acc_YPositiveTestDeflection** - self test positive deflection values for Y axis
  - **Acc_XFullScaleAccelerationRange** - X self test magnitude selection
  - **Acc_YFullScaleAccelerationRange** - Y self test magnitude selection
  - **Acc_DeviceReset** - this device reset flag is set during device initialization following a device reset
  - **Acc_X_OffsetOverRange** - the offset monitor over range flag is set if the acceleration signal of the X axis reaches the specified offset limit

- **Acc_Y_OffsetOverRange** - the offset monitor over range flag is set if the acceleration signal of the Y axis reaches the specified offset limit
- **Acc_SpiMisoError** - the MISO data mismatch flag is set when a MISO Data mismatch fault occurs
- **Acc_DeviceInitFlag** - the device initialization flag is set during the interval between negation of internal reset and completion of internal device initialization
- **Acc_SigmaDeltaOverRange** - the sigma delta modulator over range flag is set if the sigma delta modulator for either axis becomes saturated
- **Acc_InterDataError** - the internal data error flag is set if a customer or OTP register data CRC fault or other internal fault is detected
- **Acc_FuseWarning** - the fuse warn bit is set if a marginally programmed fuse is detected
- **Acc_InitEnd** - the ENDINIT bit is a control bit use to indicate that the user has completed all device and system level initialization tests, and that Mesquite will operate in normal mode
- **Acc_SignData** - this parameter determines the format of acceleration data results
- **Acc_OffsetMoni** - offset monitor circuit is enable/disable
- **Acc_ArmOutput** - the ARM Configuration type select the mode of operation for the ARM_X/PCM_X, ARM_Y/PCM_Y pins
- **Acc_XAxisSelfTest** - enable or disable the self-test circuitry for X axis
- **Acc_YAxisSelfTest** - enable or disable the self-test circuitry for Y axis
- **Acc_XLowPassFilter** - the low pass filter selection bits independently select a low-pass filter for X axis
- **Acc_YLowPassFilter** - the low pass filter selection bits independently select a low-pass filter for Y axis
- **Acc_XArmPulseStretch** - pulse stretch time for X arming outputs
- **Acc_YArmPulseStretch** - pulse stretch time for Y arming outputs
- **Acc_XArm_PosWin_CountLimit** - X axis positive arming window size definitions or arming count limit definitions function (depending on the state of the Acc_ArmOutput variable)
- **Acc_YArm_PosWin_CountLimit** - Y axis positive arming window size definitions or arming count limit definitions function (depending on the state of the Acc_ArmOutput variable)
- **Acc_Arm_XNegWinSize** - X axis negative arming window size definitions (meaning depend on the state of the Acc_ArmOutput variable)
- **Acc_Arm_YNegWinSize** - Y axis negative arming window size definitions (meaning depend on the state of the Acc_ArmOutput variable)
- **Acc_XArmPositiveThreshold** - this value contain the X axis positive threshold to be used by the arming function
- **Acc_YArmPositiveThreshold** - this value contain the Y axis positive threshold to be used by the arming function
- **Acc_XArmNegativeThreshold** - this value contain the X axis negative thresholds to be used by the arming function
- **Acc_YArmNegativeThreshold** - this value contain the Y axis negative thresholds to be used by the arming function
- **Acc_CountValue** - value in the register increases by one count every 128 μs and the counter rolls over every 32.768 ms
- **Acc_XOffsetCorrection** - the most recent X axis offset correction increment/decrement value from the offset cancellation circuit
- **Acc_YOffsetCorrection** - the most recent Y axis offset correction increment/decrement value from the offset cancellation circuit

Parameters of the **Acc_GetAccelData** API function:

- **Spi_Channel** (Acc_SpiChannelType) - logical SPI channel number (not physical SPI channel)
- **AccelCmdX** (Acc_XAccelerationDataType) - X axis acceleration data request
- **AccelCmdY** (Acc_YAccelerationDataType) - Y axis acceleration data request
- **Status** (Acc_AccelStatusType) output data structure containing the accelerometer X/Y moving values and device status:
  - **AccelDataX** - X axis acceleration data
  - **AccelDataY** - Y axis acceleration data
  - **AccelRespTypeX** - type of the X axis acceleration response
  - **AccelRespTypeY** - type of the Y axis acceleration response
  - **Acc_DeviceReset** - device reset flag is set during device initialization following a device reset
  - **Acc_X_OffsetOverRange** - the offset monitor over range flag is set if the acceleration signal of the X axis reaches the specified offset limit
  - **Acc_Y_OffsetOverRange** - the offset monitor over range flag is set if the acceleration signal of the Y axis reaches the specified offset limit

— **Acc_SpiMisoError** - the MISO data mismatch flag is set when a MISO Data mismatch fault occurs
— **Acc_DeviceInitFlag** - the device initialization flag is set during the interval between negation of internal reset and completion of internal device initialization
— **Acc_SigmaDeltaOverRange** - the sigma delta modulator over range flag is set if the sigma delta modulator for either axis becomes saturated
— **Acc_InterDataError** - the internal data error flag is set if a customer or OTP register data CRC fault or other internal fault is detected
— **Acc_FuseWarning** - the fuse warn bit is set if a marginally programmed fuse is detected
— **Acc_CountValue** - value in the register increases by one count every 128 µs and the counter rolls over every 32.768 ms

Parameters of the **Acc_ProgramCmd** API function:

- **Spi_Channel** (Acc_SpiChannelType) - logical SPI channel number (not physical SPI channel)
- **RegAddress** (uint16) - address of the selected IC register
- **Data** (uint16) - data
- **SpiResponse** (uint16) - response to the sent command

A.5 SQUIB Driver

The SQUIB driver is created as a separate software module. The main advantage is full HW abstraction and API independence in used MCU family. The driver API covers the entire functionality of the squib driver, which means all firing commands and devices statuses can be controlled by API functions.

The SQUIB Driver is dependent on the COM layer (basic SPI communication) and on the GPIO driver (General Purpose Input/Output), which provides basic functions for reading status on the arming pins.

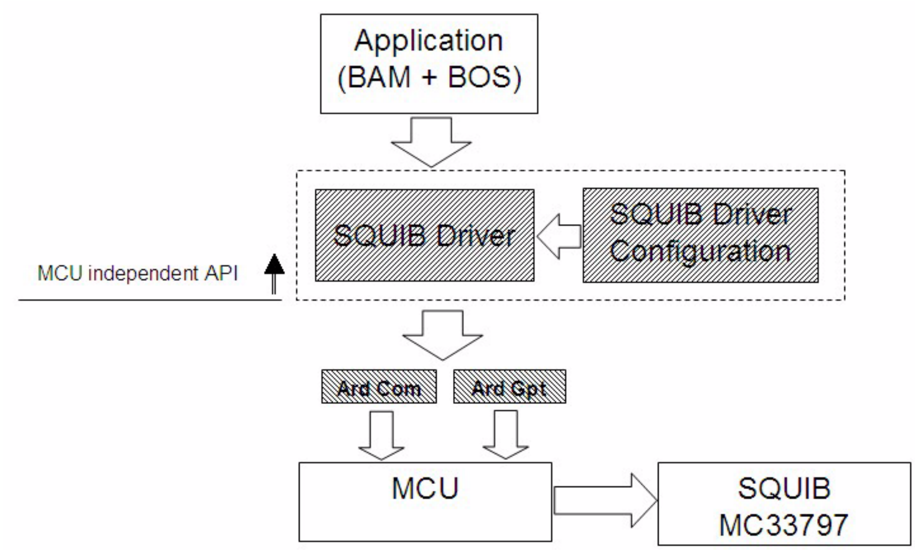


Figure 7-7. SQUIB SW Driver Concept

Table 7-3. SQUIB SW Driver API

Function Name	Function Parameters	Return Type	Function Description
Squib_Init	Spi_Channel [in]	Squib_ReturnType	Initialize the SQUIB device and returns the confirmation of the initialization.
Squib_Fire	Spi_Channel [in] Squib_Fire [in]	Squib_ReturnType	This function provide explosion of the selected SQUIB driver
Squib_GetStatus	Spi_Channel [in] *Status [out]	Squib_ReturnType	Return the status of the SQUIB drivers (1A, 1B, 2A and 2B) and common status of the SQUIB IC.
Squib_ProgramCmd	Spi_Channel [in] Command [in] Data [in] Delay [in] SpiResponse [out]	Squib_ReturnType	Send any SQUIB command to the IC device and read its response.

A.6 SQUIB Parameters Detail Descriptions

Brief description of input and output API parameters is in the following paragraphs. Descriptions contains only a verbal description of the parameter. Values which each variable acquires is described in the header file SQUIB.h.

Parameters of the **Squib_Init** API function:

- **Spi_Channel** (Squib_SpiChannelType) - logical SPI channel number (not physical SPI channel)

Parameters of the **Squib_GetStatus** API function:

- **Spi_Channel** (Squib_SpiChannelType) - logical SPI channel number (not physical SPI channel)
- **Status** (Squib_StatusType) output status structure containing the complete status of the ACC
  - **Squib_Stat1ACurrTime** - firing current in 1A squib line and records the “ON” time in which the IMEAS current is above the threshold for 1A squib
  - **Squib_Stat1BCurrTime** - firing current in 1B squib line and records the “ON” time in which the IMEAS current is above the threshold for 1B squib
  - **Squib_Stat2ACurrTime** - firing current in 2A squib line and records the “ON” time in which the IMEAS current is above the threshold for 2A squib
  - **Squib_Stat2BCurrTime** - firing current in 2B squib line and records the “ON” time in which the IMEAS current is above the threshold for 2B squib
  - **Squib_Stat1ACurrent** - line 1A FET driver current limit measurement status
  - **Squib_Stat1BCurrent** - line 1B FET driver current limit measurement status
  - **Squib_Stat2ACurrent** - line 2A FET driver current limit measurement status
  - **Squib_Stat2BCurrent** - line 2B FET driver current limit measurement status
  - **Squib_Stat1ALowSideThermalShut** - 1A Low Side Squib driver thermal shutdown status
  - **Squib_Stat1AHighSideThermalShut** - 1A High Side Squib driver thermal shutdown status
  - **Squib_Stat1BLowSideThermalShut** - 1B Low Side Squib driver thermal shutdown status
  - **Squib_Stat1BHighSideThermalShut** - 1B High Side Squib driver thermal shutdown status
  - **Squib_Stat2ALowSideThermalShut** - 2A Low Side Squib driver thermal shutdown status
  - **Squib_Stat2AHighSideThermalShut** - 2A High Side Squib driver thermal shutdown status
  - **Squib_Stat2BLowSideThermalShut** - 2B Low Side Squib driver thermal shutdown status
  - **Squib_Stat2BHighSideThermalShut** - 2B High Side Squib driver thermal shutdown status
  - **Squib_Stat1VdiagResult** - firing supply voltage (VDIAG_1) diagnostics - voltage level on the VDIAG_1 pin
  - **Squib_Stat1HSSafingSens** - High Side Safing sensor diagnostics - monitors the VFIRE_XX pin connection to the VDIAG_1 pin
  - **Squib_Stat2VdiagResult** - firing supply voltage (VDIAG_2) diagnostics - voltage level on the VDIAG_2 pin
  - **Squib_Stat2HSSafingSens** - High Side Safing sensor diagnostics - monitors the VFIRE_XX pin connection to the VDIAG_2 pin
  - **Squib_1AShBatt** - Squib short-to-battery diagnostics - voltage level on the SENSE_1A pin
  - **Squib_1AShGnd** - Squib short-to-ground diagnostics - voltage level on the SENSE_1A pin
  - **Squib_1BShBatt** - Squib short-to-battery diagnostics - voltage level on the SENSE_1B pin
  - **Squib_1BShGnd** - Squib short-to-ground diagnostics - voltage level on the SENSE_1B pin
  - **Squib_2AShBatt** - Squib short-to-battery diagnostics - voltage level on the SENSE_2A pin
  - **Squib_2AShGnd** - Squib short-to-ground diagnostics - voltage level on the SENSE_2A pin
  - **Squib_2BShBatt** - Squib short-to-battery diagnostics - voltage level on the SENSE_2B pin
  - **Squib_2BShGnd** - Squib short-to-ground diagnostics - voltage level on the SENSE_2B pin
  - **Squib_Stat1ALowSideCont** - continuity status for the Low Side driver SQB_LO_1A connection
  - **Squib_Stat1BLowSideCont** - continuity status for the Low Side driver SQB_LO_1B connection
  - **Squib_Stat2ALowSideCont** - continuity status for the Low Side driver SQB_LO_2A connection
  - **Squib_Stat2BLowSideCont** - continuity status for the Low Side driver SQB_LO_2B connection
  - **Squib_1AOpnShBatt** - Squib 1A harness short-to-battery status with an open Squib
  - **Squib_1AOpnShGnd** - Squib 1A harness short-to-ground status with an open Squib
  - **Squib_1BOpnShBatt** - Squib 1B harness short-to-battery status with an open Squib
  - **Squib_1BOpnShGnd** - Squib 1B harness short-to-ground status with an open Squib
  - **Squib_2AOpnShBatt** - Squib 2A harness short-to-battery status with an open Squib
  - **Squib_2AOpnShGnd** - Squib 2A harness short-to-ground status with an open Squib
  - **Squib_2BOpnShBatt** - Squib 2B harness short-to-battery status with an open Squib
  - **Squib_2BOpnShGnd** - Squib 2B harness short-to-ground status with an open Squib
  - **Squib_StatVfireBTested** - reports VFIRE testing has been finished

— **Squib_StatVfire** - reports of the voltage level on the VFIRE_XX pin
— **Squib_StatV1diagV1** - firing supply voltage status - VDIAG_V1 voltage on the VDIAG1 pin
— **Squib_StatV1diagV2** - firing supply voltage status - VDIAG_V2 voltage on the VDIAG1 pin
— **Squib_StatV1diagV3** - firing supply voltage status - VDIAG_V3 voltage on the VDIAG1 pin
— **Squib_StatV1diagV4** - firing supply voltage status - VDIAG_V4 voltage on the VDIAG1 pin
— **Squib_StatV2diagV1** - firing supply voltage status - VDIAG_V1 voltage on the VDIAG2 pin
— **Squib_StatV2diagV2** - firing supply voltage status - VDIAG_V2 voltage on the VDIAG2 pin
— **Squib_StatV2diagV3** - firing supply voltage status - VDIAG_V3 voltage on the VDIAG2 pin
— **Squib_StatV2diagV4** - firing supply voltage status - VDIAG_V4 voltage on the VDIAG2 pin
— **Squib_StatFen1** - status of the FEN_1 arming input pin
— **Squib_StatFen2** - status of the FEN_2 arming input pin
— **Squib_StatFen1Latch** - FEN1 latch status
— **Squib_StatFen2Latch** - FEN2 latch status
— **Squib_StatRdiag** - reports status of the R_DIAG resistor
— **Squib_StatRlimit1** - reports the R_LIMIT_1 resistor value - reference currents derived by the R_LIMIT_1 and R_LIMIT_2 resistors
— **Squib_StatRlimit2** - reports the R_LIMIT_2 resistor value - reference currents derived by the R_LIMIT_1 and R_LIMIT_2 resistors
— **Squib_DeviceType** - identifier the squib IC as a four- or two-channel squib driver IC
— **Squib_StatVfireRtn1** - reports the resistance on the VFIRE_RTN1 pin for open pin connections
— **Squib_StatVfireRtn2** - reports the resistance on the VFIRE_RTN2 pin for open pin connections
— **Squib_Stat1AResistance** - Squib 1A resistance value
— **Squib_Stat1BResistance** - Squib 1B resistance value
— **Squib_Stat2AResistance** - Squib 2A resistance value
— **Squib_Stat2BResistance** - Squib 2B resistance value
— **Squib_Stat1ALoopsShorts** - reports shorts between 1A squib lines and other firing loops
— **Squib_Stat1BLoopsShorts** - reports shorts between 1B squib lines and other firing loops
— **Squib_Stat2ALoopsShorts** - reports shorts between 2A squib lines and other firing loops
— **Squib_Stat2BLoopsShorts** - reports shorts between 2B squib lines and other firing loops
— **Squib_Stat1ALoopsShortsAddIC** - reports shorts between squib 1A loop and other loops on additional ICs
— **Squib_Stat1BLoopsShortsAddIC** - reports shorts between squib 1B loop and other loops on additional ICs
— **Squib_Stat2ALoopsShortsAddIC** - reports shorts between squib 2A loop and other loops on additional ICs
— **Squib_Stat2BLoopsShortsAddIC** - reports shorts between squib 2Bloop and other loops on additional ICs

Parameters of the **Squib_Fire** API function:

- **Spi_Channel** (Squib_SpiChannelType) - logical SPI channel number (not physical SPI channel)
- **Squib_Fire** (Squib_FireType) - firing commands for squibs pairs or for separate Low/High side

Parameters of the **Squib_ProgramCmd** API function:

- **Spi_Channel** (Squib_SpiChannelType) - logical SPI channel number (not physical SPI channel)
- **Command** (Squib_ProgCmdType) - Squib command
- **Data** (uint8) - data
- **Delay** (uint8) - Squib diagnostic delay time
- **SpiResponse** (uint8) - response to the sent command

Appendix B Airbag Reference Demonstrator Implementation details

B.1 Airbag Reference Demonstrator Schematics

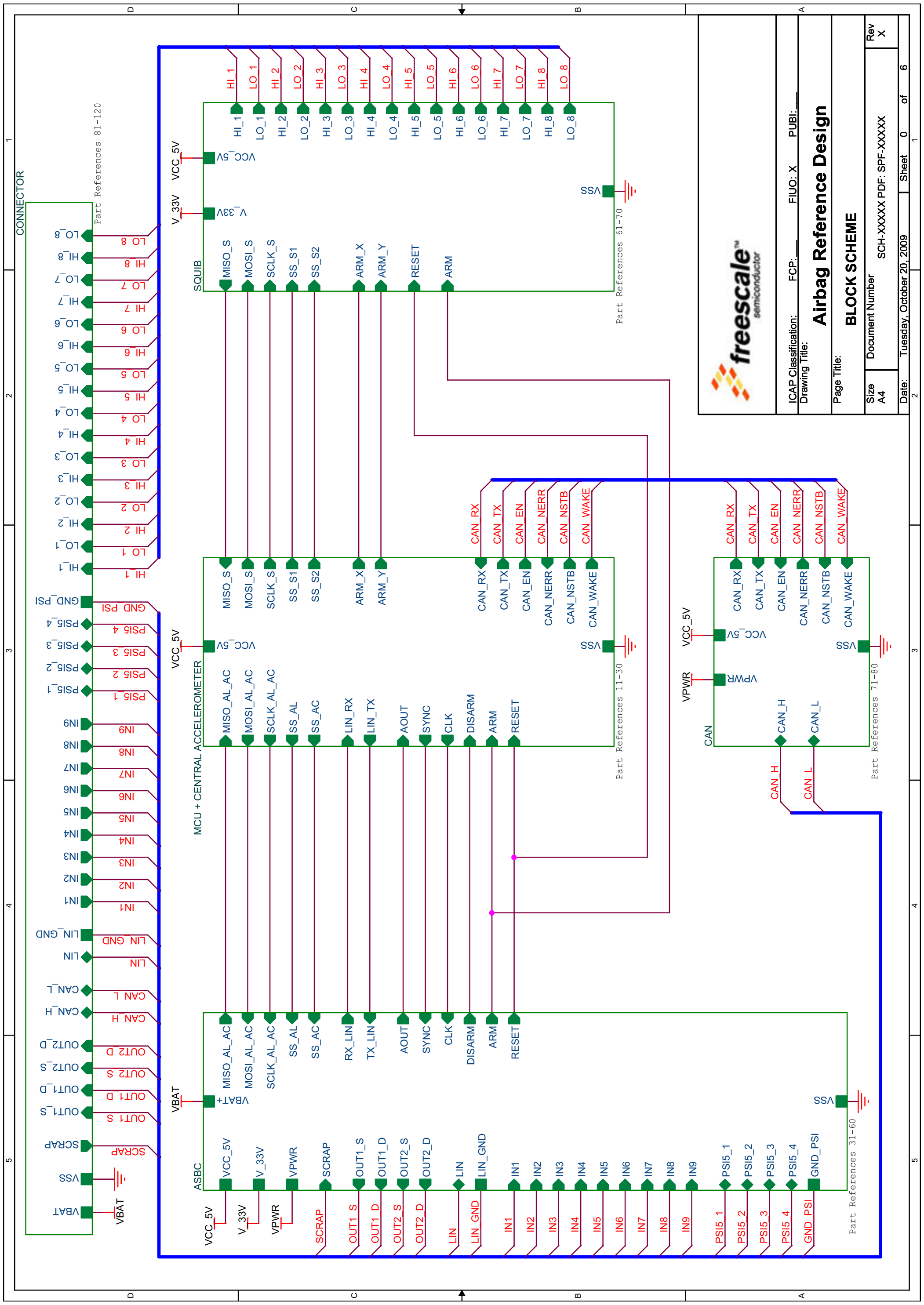


Figure 7-8. Block Schematic of the ARD Board

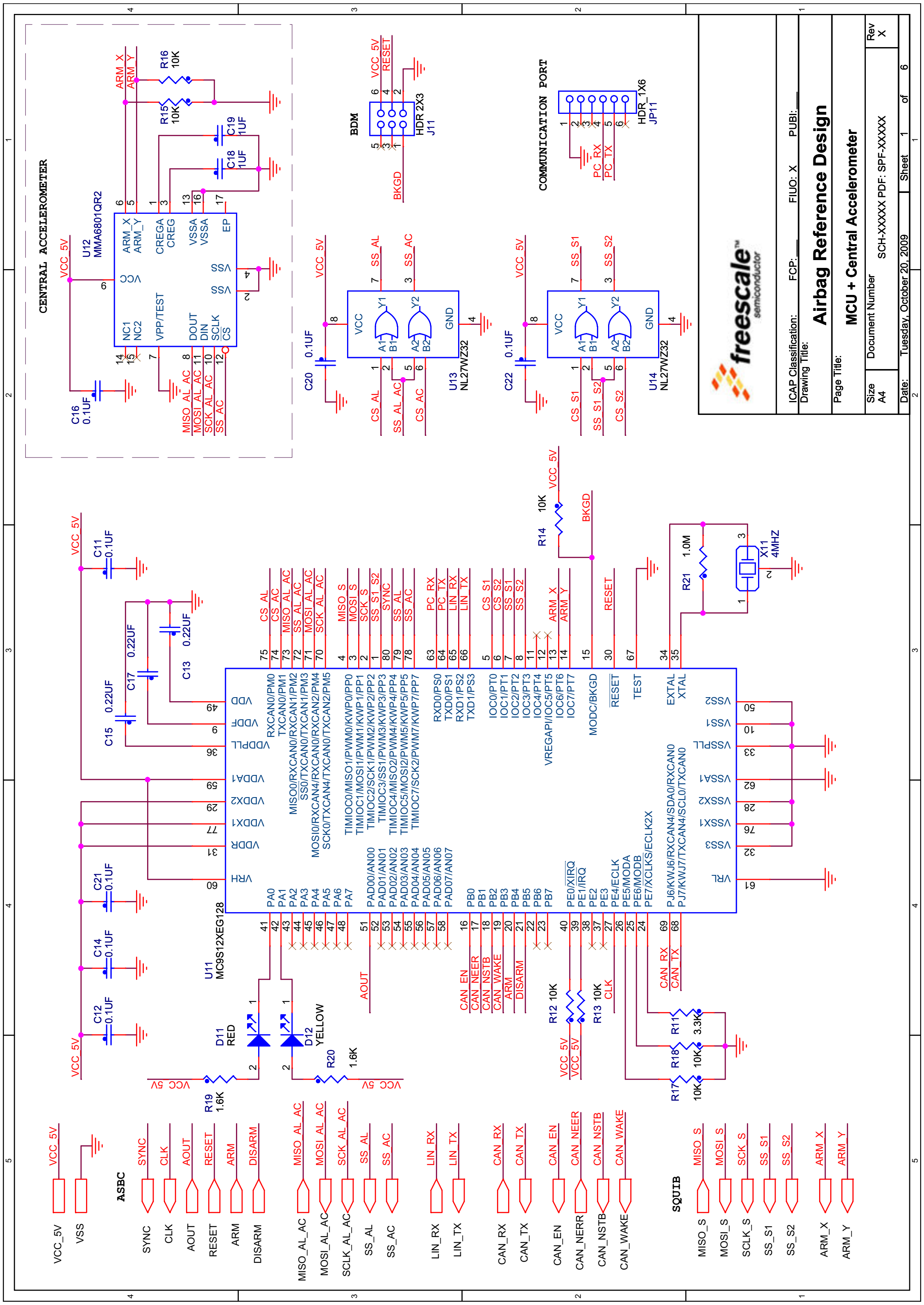


Figure 7-9. ARD Board - MCU + Central Accelerometer

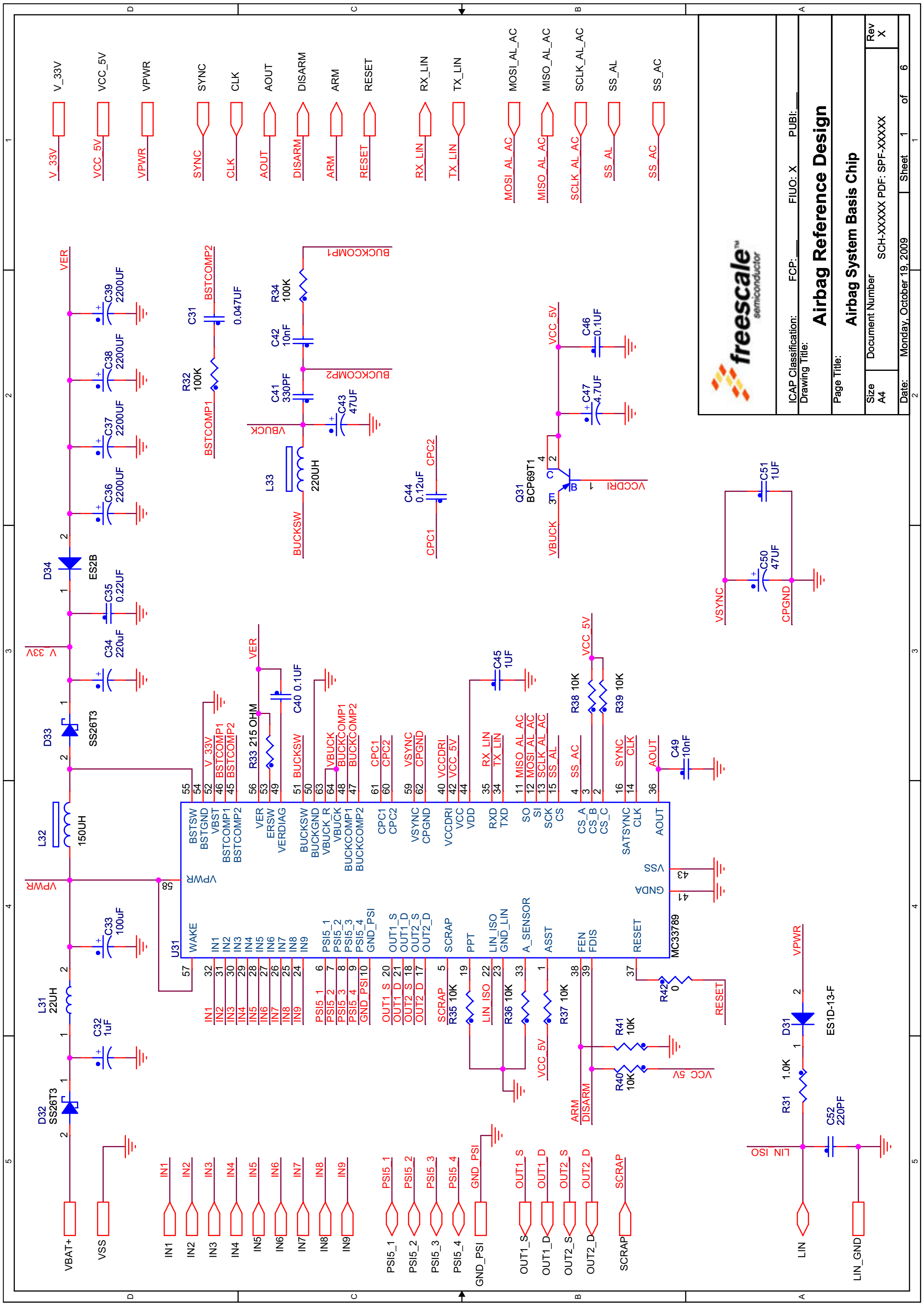


Figure 7-10. Airbag System Basis Chip

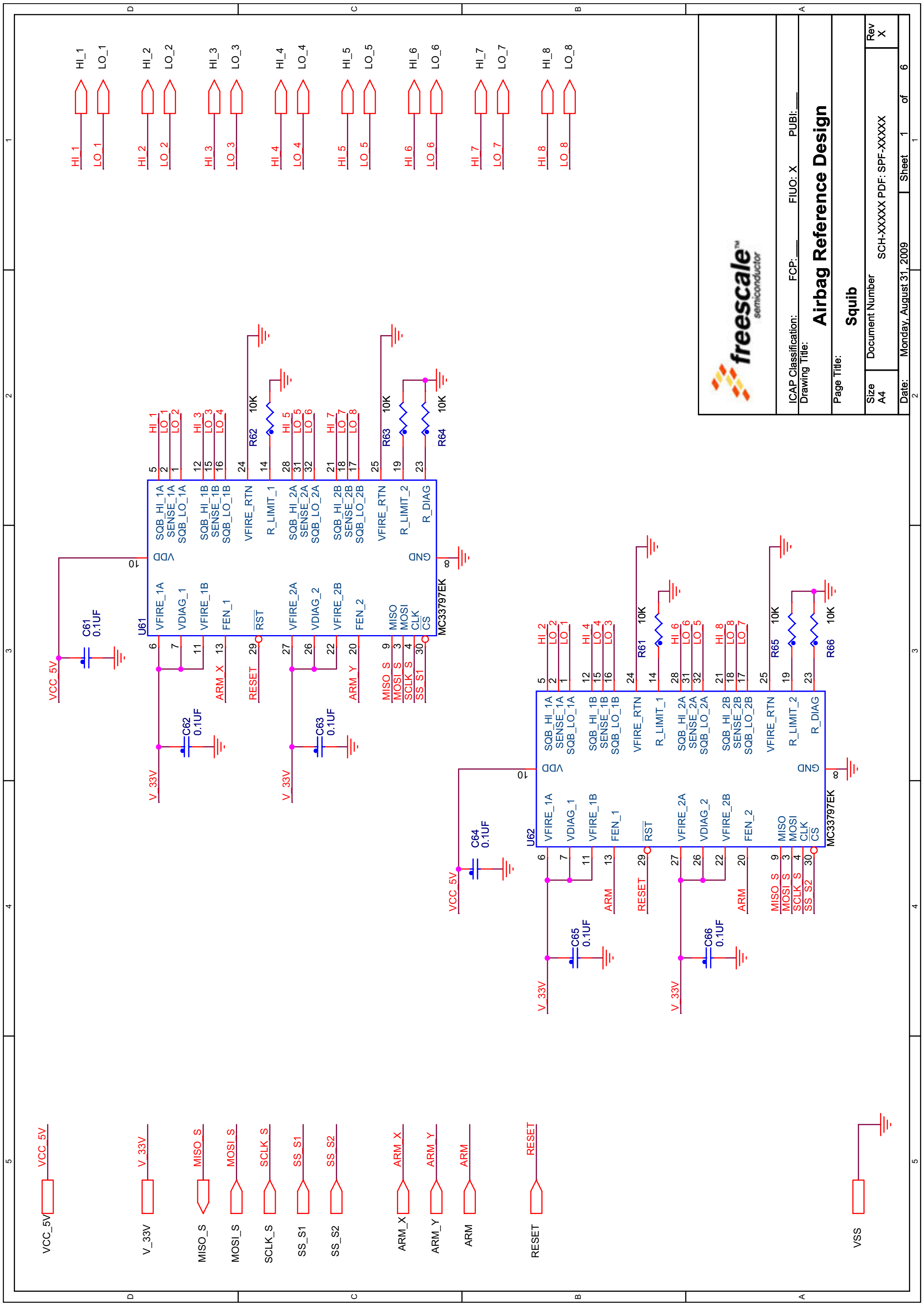


Figure 7-11. Squibs

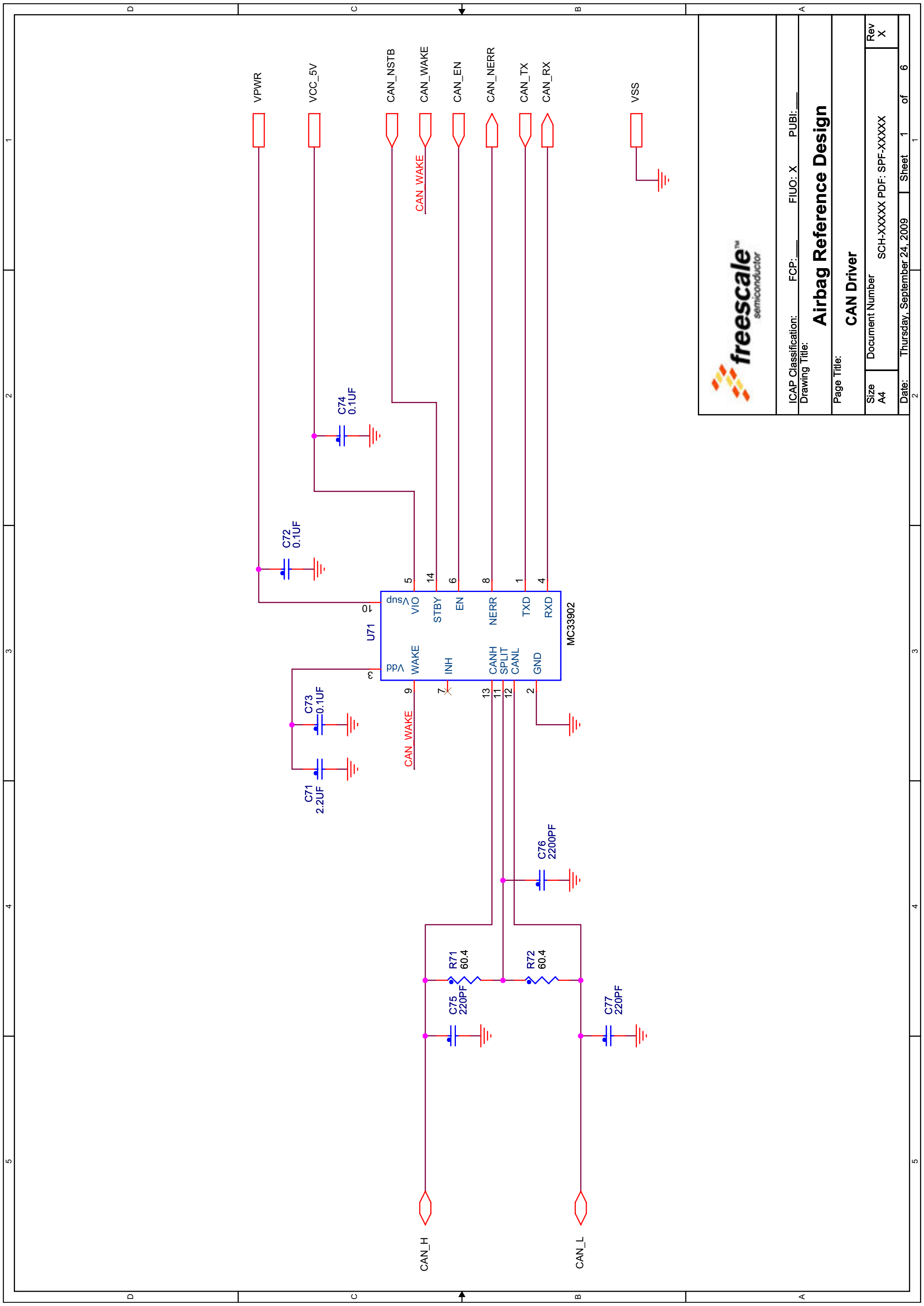


Figure 7-12. CAN transceiver

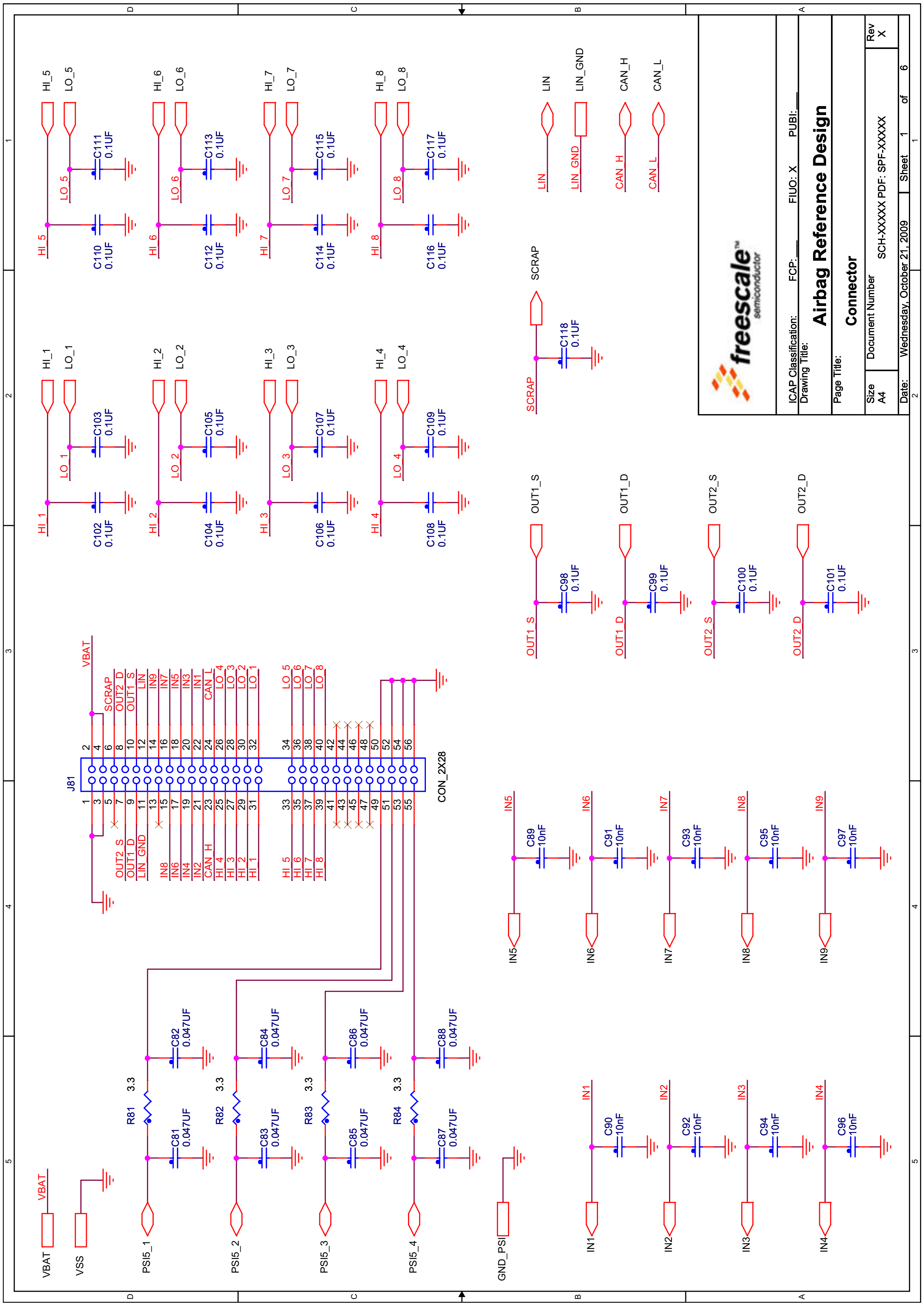


Figure 7-13. Main Automotive Connector

B.2 ARD Placement and Layout

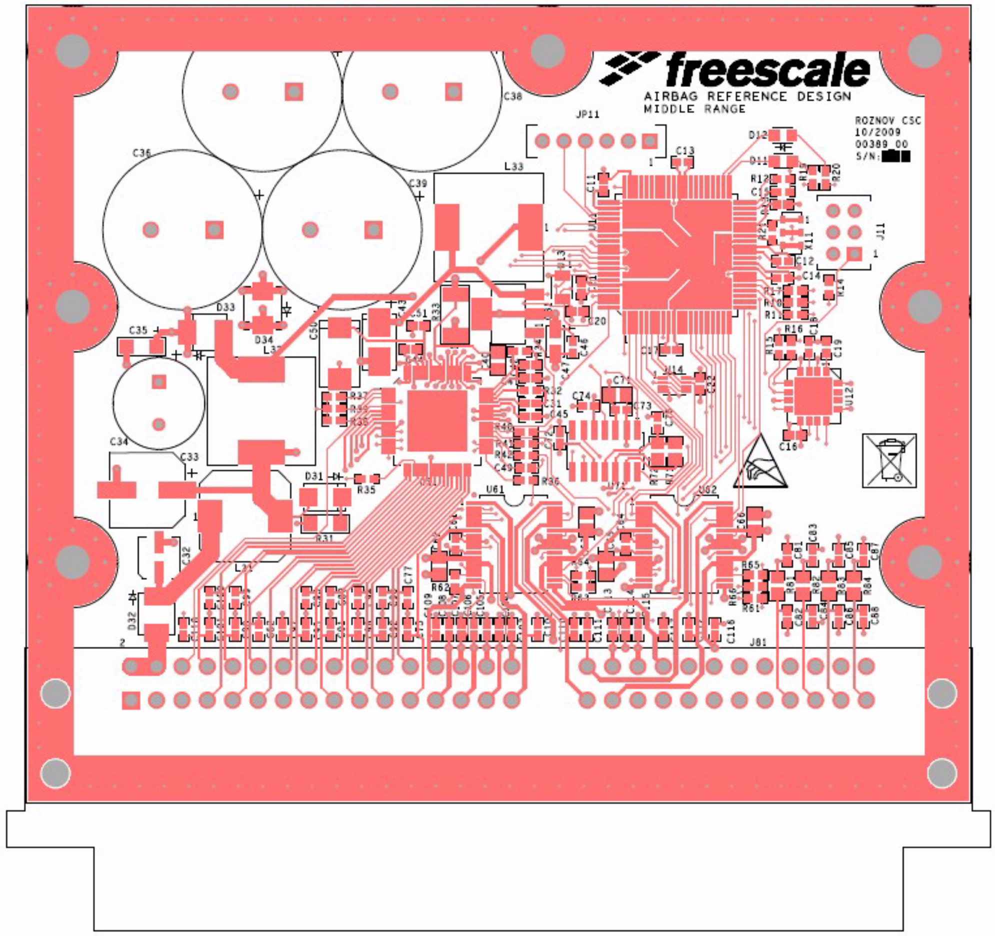


Figure 7-14. Top View and Placement

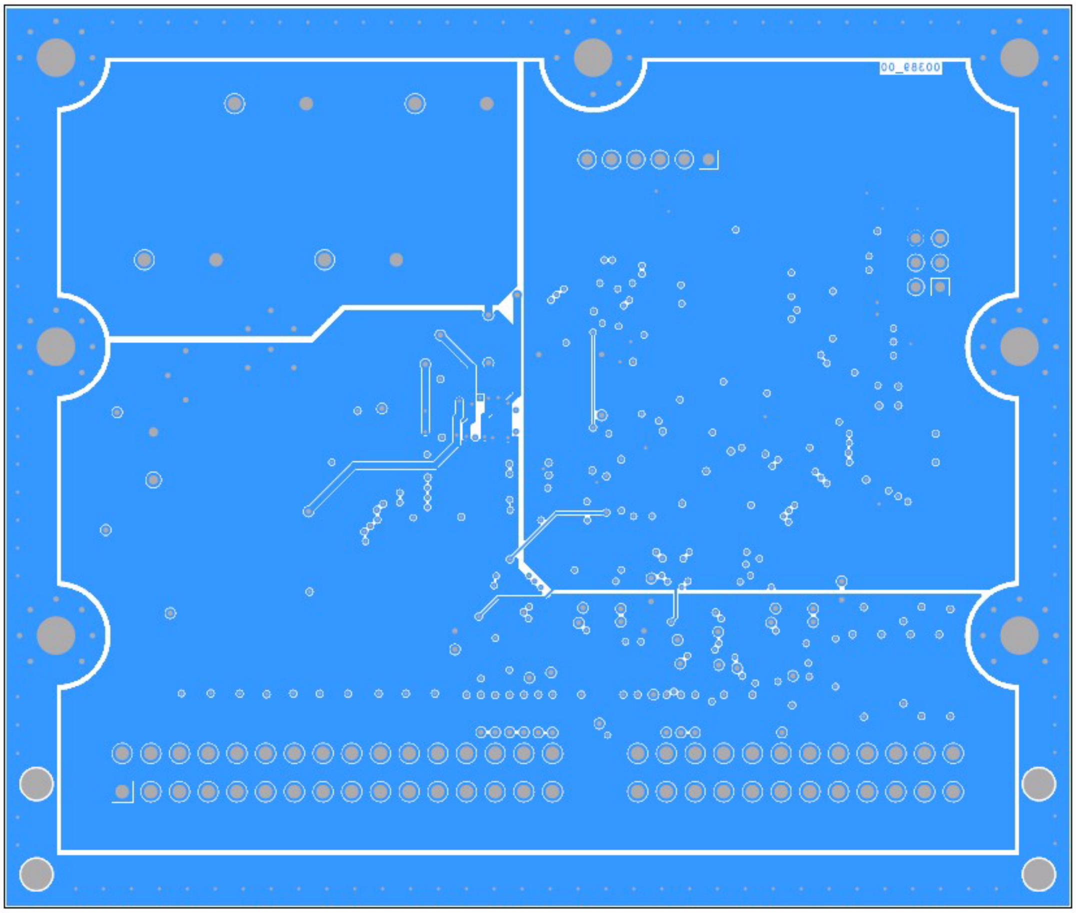


Figure 7-15. Bottom View

B.3 Bill of Materials

Table 7-4. Bill of Materials

Item Number	Quantity	Part Reference	Value	Description
1	34	C11,C12,C14,C16,C21,C22,C46,C61,C64, C72,C73,C74,C98,C99,C100,C101,C102, C103,C104,C105,C106,C107,C108,C109, C110,C111,C112,C113,C114,C115,C116, C117,C118	0.1 µF	CAP CER 0.10UF 25V 10% X7R 0603
2	3	C13,C15,C17	0.22 µF	CAP CER 0.22UF 16V 10% X7R 0603
3	4	C18,C19,C45,C51	1.0 µF	CAP CER 1.0UF 25V 10% X5R 0603
4	9	C31,C81,C82,C83,C84,C85,C86,C87,C88	0.047 µF	CAP CER 0.047UF 50V 10% X7R 0603
5	1	C32	1.0 µF	CAP ALEL 1.0UF 50V 20% - SMT
6	1	C33	100 µF	CAP ALEL 100UF 25V 20% - SMT
7	1	C34	220 µF	CAP ALEL 100UF 50V 20% - RADIAL TH
8	1	C35	0.22 µF	CAP CER 0.22UF 50V 5% X7R 1206
9	4	C36,C37,C38,C39	2200 µF	CAP ALEL 2200UF 35V +30/0% - RADIAL
10	5	C40,C62,C63,C65,C66	0.1 µF	CAP CER 0.1UF 50V 5% X7R 0805
11	1	C41	330 pF	CAP CER 330PF 50V 5% C0G 0603
12	11	C42,C49,C89,C90,C91,C92,C93,C94,C95, C96,C97	10 nF	CAP CER 0.01UF 50V 5% X7R 00603
13	1	C43	47 µF	CAP TANT 47UF 16V 10% - 6032-28
14	1	C44	-0.12 µF	CAP CER 0.12UF 50V 10% X7R 0603

Table 7-4. Bill of Materials

Item Number	Quantity	Part Reference	Value	Description
15	1	C47	4.7 μF	CAP TANT 4.7UF 10V 10% - 3216-18
16	1	C50	47 μF	CAP TANT 47UF 25V 10% - 7343
17	3	C52,C75,C77	220 pF	CAP CER 220PF 50V 10% X7R 0603
18	1	C71	2.2 μF	CAP CER 2.2UF 25V 10% X7R 0805
19	1	C76	2200 pF	CAP CER 2200PF 50V 5% X7R 0603
20	1	D11	RED	LED RED SGL 2MA 0805 SMT
21	1	D12	YELLOW	LED YEL SGL 2MA 0805 SMT
22	1	D31	ES1D-13-F	DIODE RECT 1A 200V SMA SMT
23	2	D32,D33	SS26T3	DIODE SCH PWR 2A 60V SMB
24	1	D34	ES2B	DIODE RECT ULTRA FAST 2A 100V DO-214AA
25	1	J11	HDR 2X3	HDR 2X3 TH 2.54MM CTR 340H AU
26	1	J81	CON_2X28	CON 2X28 ASM RA TH 3MM SP 30.7MM - 118L
27	1	JP11	HDR_1X6	HDR 1X6 TH 100MIL SP 408H AU
28	1	L31	22UH	IND PWR 22UH@100KHZ 2.25A 20% SMT
29	1	L32	150UH	IND PWR 150UH@100KHZ 1.35A 20% SMT
30	1	L33	220UH	IND PWR 220UH@100KHZ 1.15A 20% SMT
31	1	Q31	BCP69T1	TRAN PNP AUD 1A 20V SOT223
32	1	R11	3.3K	RES MF 3.30K 1/10W 1% 0603
33	20	R12,R13,R14,R15,R16,R17,R18,R35,R36, R37,R38,R39,R40,R41,R61,R62,R63,R64, R65,R66	10K	RES TF 10K 1/10W 5% RC0603
34	2	R19,R20	1.6K	RES MF 1.6K 1/10W 1% 0603
35	1	R21	1.0M	RES MF 1.0M 1/10W 1% 0603
36	1	R31	1.0K	RES MF 100K 1/4W 1% 1206
37	2	R32,R34	100K	RES TF 100K 1/10W 1% 0603
38	1	R33	215 OHM	RES MF 215 OHM 1/2W 1% 2010
39	1	R42	0	RES MF ZERO OHM 1/10W 0603
40	2	R71,R72	60.4	RES MF 60.4 OHM 1/8W 1% 0805
41	4	R81,R82,R83,R84	3.3	RES MF 3.30 OHM 1/8W 1% 0805
42	1	U11	MCc9S12XEG128	IC MCU 16BIT 128K FLASH 12K RAM 50MHZ 5.5V QFP80
43	1	U12	MMA6801QR2	
44	2	U13,U14	NL27WZ32	IC GATE OR DUAL 2-INPUT 1.65-5.5V US8
45	1	U31	MC33789	IC CTRL AIRBAG 5.2-20V LQFP64EP
46	2	U61,U62	MC33789EK	IC SQUIB DRV AIRBAG FOUR CHANNEL 5V SOICW32
47	1	U71	MC33902	IC HS CAN XCVR 5V SOIC14
48	1	X11	4MHZ	XTAL 4MHZ RSN 6V SMT

Freescale does not assume liability, endorse, or warrant components from external manufacturers that are referenced in circuit drawings or tables. While Freescale offers component recommendations in this configuration, it is the customer’s responsibility to validate their application.

Appendix C Acronyms

ACC	Central Accelerometer
ADC	Analog To Digital Converter
API	Application Protocol Interface
ARD	Airbag Reference Demonstrator
ASBC	Airbag System Basis Chip
BAM	Boot Assist Module
BOS	Basic Operation System
CAN	Controller Area Network
COM	Serial Communication Port
ECU	Electronic Control Unit
EEPROM	Electrically Erasable Programmable Read-Only Memory
GUI	Graphical User Interface
GPT	General Purpose Timer
GPO	General Purpose Output
LIN	Local Interconnect Network
MUX	Multiplexer
N/A	Not Applicable
PCB	Printed Circuit Board
PSI5	Peripheral Sensor Interface 5
SPI	Serial Peripheral Interface
SW	Software
SQUIB	Automobile AirBag
VREG	Voltage Regulator
WD	Watchdog

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