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Application Note

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MPC5606S Graphical Cluster Hardware Design

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Contents

1 Introduction

Freescale’s MPC5606S device has been designed to cover instrument cluster applications that require up to 64 MHz of execution speed, direct drive of up to six stepper motors drivers, TFT display use, sound generation and visual alarms, inter-module communications like CAN/LIN, external or complementary memory interface (QUADSPI), and very low power consumption for both normal operation and low-power modes.

This application note includes guidelines for the minimum necessary external components and power supply requirements to properly set up the MPC5606S in a cluster application.

NOTE

The schematics in this document are provided for reference purposes only. As such, Freescale does not make any warranty, implied or otherwise, as to the suitability of circuit design or component selection (type or value) used in these schematics for hardware design using the Freescale MPC5606S family of microprocessors. If you use any part of these schematics as a basis for hardware design, do so at their own risk; Freescale does not assume any liability for such a hardware design.

1.1 Objective

This document aims to serve as a general guide for starting a design based on the MPC5606S. Starting from a set of requirements listed in Table 2, the final implementation is an automotive cluster module comprised of both hardware and software components. The following figure shows a picture of the MPC5606S cluster after it is complete.

Figure 1. MPC5606 instrument cluster

1.2 Typical high-level functional requirements

Instrument clusters are designed to provide to a driver the information required for a safe and comfortable drive. They indicate vehicle status and direction, indicate gear status, provide feedback on commanded functions (such as left and right turns), and sound alarms, just to name some of the types of information that clusters provide. To cover all these requirements, some vehicle manufacturers design their clusters based on some or all of the features included in Table 1. Notice that the features listed in this table are not the only ones and they have grown as vehicles and technology have evolved. The number of features that a cluster may include is limited by the manufacturer's design and the market needs and for which the vehicle is designed.

Table 1. Typical cluster's functional features

Feature	Hardware options	Description	MPC5606S solutions
• Gauges	1 Motors 2 Displays	Provide feedback of the vehicle speed, RPM, motor liquid levels, or battery charge. Nowadays, this information is shown using some types of motors or displays.	1 Up to 6 stepper motors 2 LCD and TFT display driver
• Alarms	Sounds	Indicate a potential failure of the vehicle, or caution information like an open door, and so on.	Sound Generation Module (SGM)
• Simple HMI	Buttons	Some special functions like trip information, vehicle efficiency, and so on may be required to be shown or programmed by the driver.	GPIO with interrupt capability; eMIOS/input capture
• Illumination and indicators	Lamps or LEDs	A comfort feature that aids the vehicle driver in properly reading the cluster information.	GPIO/eMIOS/PWM
• Time	Microcontroller or digital circuit	A common feature that can be included directly in the cluster or in some other vehicle module.	RTC/API
• Communications	CAN, LIN, and so on	Allows the vehicle modules to be synchronized with other modules and to automate several other functions like light intensity, inter-module diagnostics, and so on.	CAN and LIN
• Low-power requirements RUN and low-power mode (LPM)[1]	Hardware design in conjunction with MCU features in low power	The combination of the cluster hardware design and MCU power consumption during normal operation and during low power modes results in the final power consumption demanded from the power supply.	Run, Halt, Stop, or Standby

[1] MPC5606S supports several modes of operation for Run and LPM modes; refer to the device's data sheet for details on the different operating modes supported.

1.3 MPC5606S cluster requirements

The following table shows the general or high-level requirements used to develop the actual cluster based on the MPC5606S. Table 2 contains both hardware and software requirements.

Table 2. Typical cluster features

Requirement number	Type	Description
1	HW	The design must be based on the MPC5606S device.
2	HW	Module must meet a low power consumption of 500 μA.
3	HW	The design must be focused on voltage reference, proper grounding, analog, decoupling, bulk capacitor, power supply, and clocking.
4	HW	The design must use SBC05 (MC33906AE) part from Freescale (switched power supply to provide 3.3V and 5V).
5	HW	The design must include a reverse battery up to 20V.
6	HW	The physical form of the PCB must match a form factor of the current market tendencies.
7	HW	The design must include one 32 MB QSPI external memory (Spansion S25FL256SD).
8	HW	The maximum current consumption for the 5V power supply must not be above 500 mA.

Table 2. Typical cluster features (continued)

Requirement number	Type	Description
9	HW	The design must use a special purpose connector for all the external signals and power to emulate a real cluster.
10	HW	The design must include one 4.2-inch TFT display (480 × 272 18-bit RGB) with integrated backlighting (Sharp LQ042T5DZ01).
11	HW	The cluster must have four mechanic gauges: two big pointers (Speed and RPM) and two small pointers (Fuel and Temp).
12	HW	The design must be enabled with a JTAG debugger connector.
13	HW	The design must take into account EMC/ESD considerations, such as analog decoupling, bulk capacitors, and signal filtering
14	HW	Low-Power mode should consume less than 500 µA.
15		Include 12 tell-tale icons driven from BATT with FETs (BSS138), with the following functions: 1 OVERTEMP 2 CHECK ENGINE 3 BREAK 4 SEAT BELT 5 LOW BATTERY 6 LOW FUEL 7 LOW OIL 8 ABS 9 HI BEAM 10 TURN LEFT 11 TURN RIGHT 12 FOG
16	HW	Include amplification circuitry and a speaker to be used with the Sound Generation Module (SGM) included in the MPC5606S.
17	HW	Enable hardware for CAN communications.
18	HW	Enable hardware for LIN communications.
19	SW	The SGM should emulate the hazard and the left/right turn relays emulation (mechanical relay sound).
20	SW	Stepper motors must have stall detection for return to zero calibration at module startup and automatic position reset when turning the cluster on.
21	SW	Implement graphics to be shown on the TFT display.

NOTE

This cluster implementation should not be used as a final solution but as a hardware guide to start developing a final cluster product.

In addition to the hardware and software design elements, the cluster application also requires a mechanical design that includes:

- *A faceplate* that shows the RPM, Temperature, Gas, and Odometer scales as well as the tell-tale icons. The faceplate is formed with two pieces: an acrylic or transparent plastic and a sticker or overlay that includes all the icons and scales.
- *A plastic case or housing* that goes in front of all the design, giving the appearance of a complete cluster. The plastic case was designed using a 3D modeling software (CAD). The advantage in using this type of software is that it allows you to export all the dimensions and vectors required to match the two pieces of the project—the electronic board and the plastic case—with excellent results.

Figure 2 shows an example of how a cluster prototype looks on the software design tool.

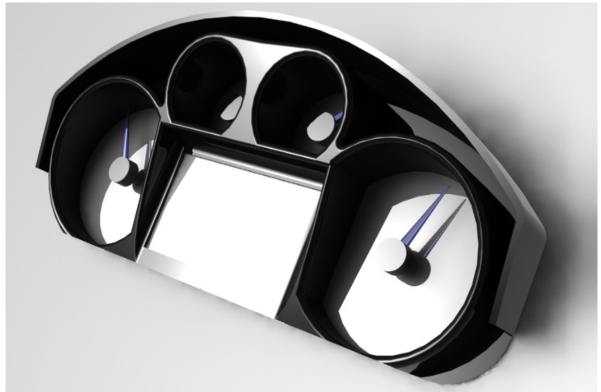

Figure 2. 3D Mechanical design example

Once the mechanical design is finished, it is printed using a 3D printer, then the plastic piece is ready to be assembled with the electronic board. This type of implementation provides a great highlight to the final prototype.

1.4 Cluster hardware architecture

Figure 3 shows the MPC5606S modules to be used to cover the cluster reference design for this particular application note. Notice that this application does not use all the MPC5606S modules. For the additional features that this device supports, please refer to MPC5606SRM, *MPC5606S Microcontroller Reference Manual*, at freescale.com.

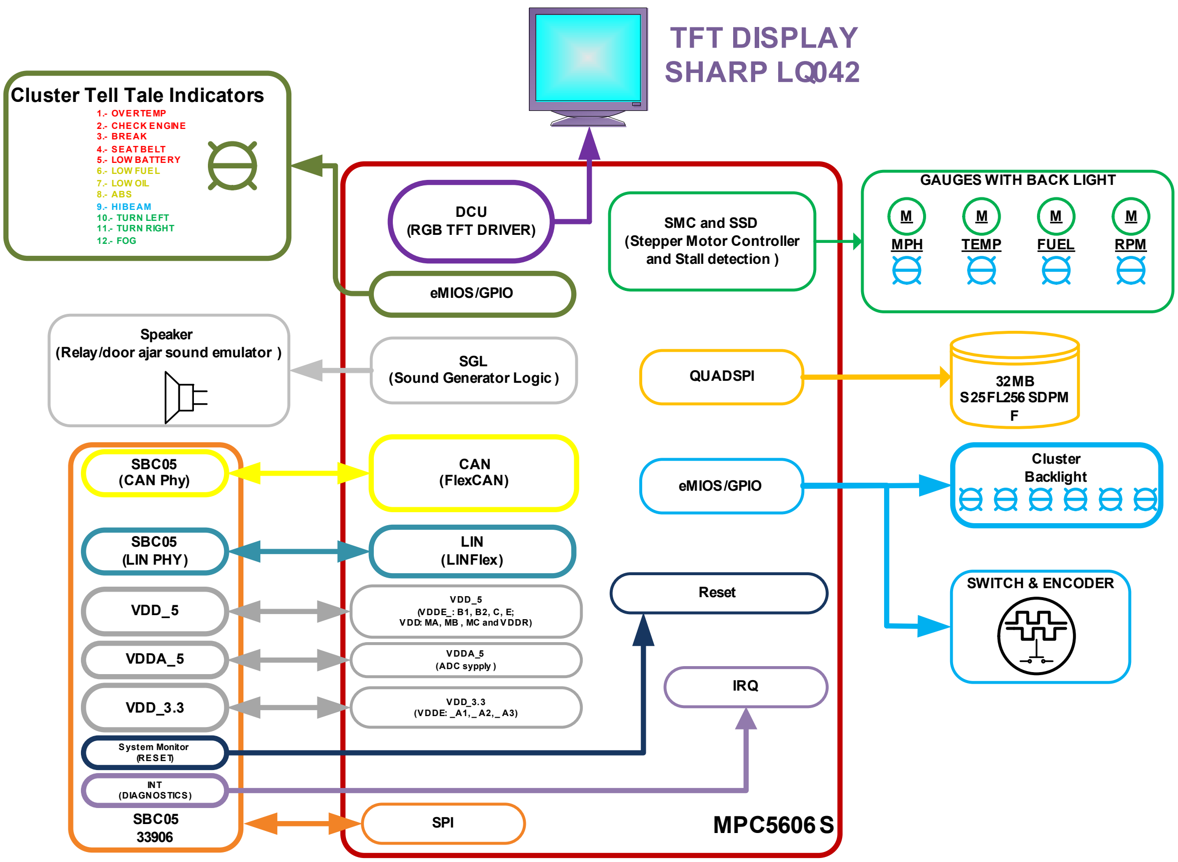

Figure 3. MPC5606 cluster architecture

The system is the result of the following components' interaction:

- The Stepper Motor Control (SMC) module is capable of driving up to four stepper motors and the Stepper Stall Detection (SSD) module provides the capability to perform the return to zero calibration required in most low- to middle-end cluster applications.
- DCU is used to display and drive the menus and animations on a TFT display. These animations are provided by the Altia™ libraries, and the animation application is provided as an object exported from the Altia tool chain that is integrated with the overall cluster application.[1]
- RTC module keeps the timing control of the software scheduler.
- SGL (Sound Generator Logic) module supports generation of audio frequency tones to emulate a relay sound for left and right turns, or a door ajar alarm sound as required.
- GPIO (General-Purpose Input Output) are used to turn on the corresponding LEDs for the turn left or right signals and to activate or deactivate the tell-tale indicators. Also, an encoder is used to scroll the images on the TFT display and as the input signal to modify the backlight dimming; if the encoder button is pressed for five seconds, the cluster will enter to sleep mode.
- PWM function from the eMIOS module is used to control the dimming function over the backlight LEDs.

1. Altia is a Freescale partner company that collaborates in the graphics development for some of our microcontrollers by generating target code that can be later integrated to the software project. For further information about Altia, visit altia.com.

- LIN and CAN modules are implemented in hardware; future implementations will enable the software communications. For further information, you can refer to this project at freescale.com
- DSPI module is connected to the SBC05. SBC05 is mainly used to provide the 3.3 V and 5 V to the MCU and external flash memory QSPI. This SBC05 supports the power supply diagnostics, MCU reset control, and provides the CAN and LIN physical interfaces that are not enabled in this application.
- QSPI module is a serial interface to drive a 32 MB external flash memory.

2 Hardware implementation

The MPC5606S cluster has been designed from the hardware requirements listed in Table 3. The following must be considered when starting any design using the MPC5606S:

- MPC5606S has up to four different signals multiplexed at each of its pins, so special caution needs to be taken as to which of these signals is the most convenient to be used per pin, since some of these multiplexed signals are present in different pins.

The following sections describe the hardware sections implemented for the MPC5606S cluster design.

2.1 Power supply

The goal of the power supply section of any embedded system containing a processor built on Power Architecture® technology is to deliver a stable, accurate voltage to the processor. This is referred to as the power delivery system, or PDS. A high-quality PDS is necessary to achieve the maximum operating frequency of the processor, and as current demand rises, the need to maintain a stable supply also rises. Indeed, a common cause of system failure, or of an inability to operate a device at full speed, is often traceable to design errors in the PDS.

The current application runs at the maximum core speed of 64 MHz. This is one of the main aspects of the design: because of special considerations in the powerup supply (see MPC5606S, *MPC5606S Microcontroller Data Sheet* for details), a device was selected that provides the power supply that meets these requirements: SBC05 MC33906. Caution needs to be taken, however, to meet the required power consumption, since the MC33906 device can provide only up to 500 mA. Figure 4 shows the power supply schematic used for the design.

NOTE

Q2 transistor used does not match with MPC5606S data sheet because the listed components were not available at the time of board construction.

C7 was added to the VDD12 power supply to be able to use different values of capacitance, but 40 µF is the recommended value.

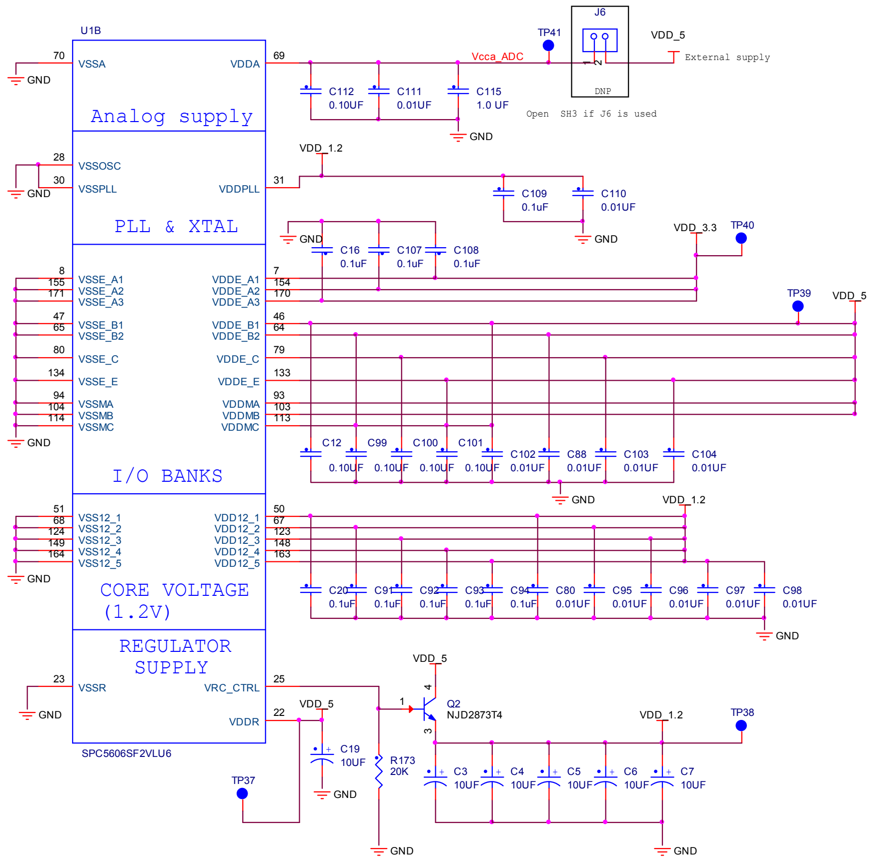

Figure 4. MPC5606S power supply pins

2.1.1 Decoupling capacitance

The general, the guidance from the chip's data sheet regarding the decoupling capacitance requirements is to use a 100 nF capacitor between each VDD/VSS pair and a stabilizing 10 µF capacitor between VDDR and VSS. Improved stability on the power supplies may be achieved by placing a pair of capacitors at each pin pair, but the best results are achieved by optimizing the location of the capacitance as a priority (place the capacitor as close as possible to its microcontroller pin).

Notice that 0.01 µF capacitors are included in all of the power supplies (see Figure 4) to provide noise rejection for the higher frequencies in case the cluster's electrical environment demands it; thus, the values for these capacitors may need to be adjusted accordingly. Designers need to be sure to consider the capacitor ESR characteristics to match with the maximum allowed for the MPC5606S.

Large capacitors are for regulator stability and should be located near the external ballast transistor. The number of capacitors is not important, only the overall capacitance value and the overall ESR value.

2.1.2 SBC05 (MC33906) integration

SBC05 or MC33906 represents the state of the art in power supplies with multi-output power supply integrated circuits (IC) with HSCAN and LIN transceivers optimized for the automotive market. Local and bus failure diagnostics, protection, and fail-safe operation mode are provided. The MC3390x family integrates the LIN interface that fulfills LIN protocol specifications 2.0, 2.1, and SAEJ2602-2.

The following figure shows a block diagram for the MC3390x family. This MC5606S cluster application uses the MC33906 version; Table 3 lists the main properties that the MC33906 provides to the cluster application.

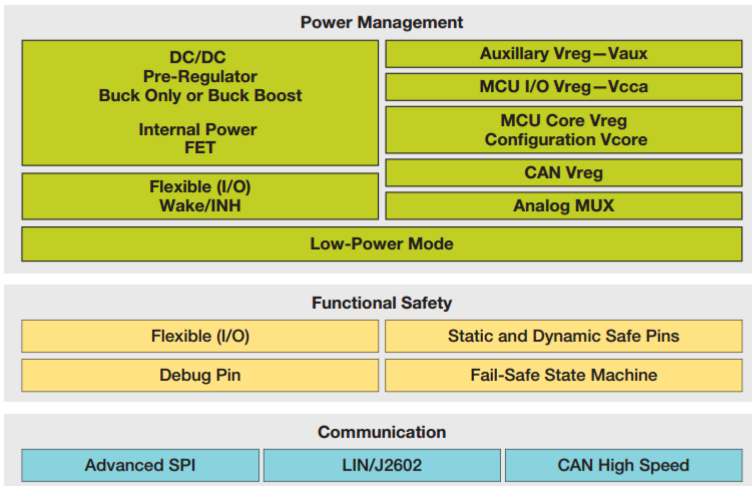

Figure 5. Power SBC0X family block diagram

Table 3. Power SBC family

Function	MC33906	MC33907	MC33908
Pre-regulator 5%	**1.0A (Buck or Boost_440 kHz)**	1.5A (Buck or Boost_440 kHz)	2A (Buck or Boost_440 kHz)
MCU core supply VCore/2%	**0.5A (Linear)**	0.8A (SPMS_2.4 MHz)	1.5A (SPMS_2.4 MHz)
MCU I/O ATD supply VCCA/1%	**100 mA (int) +/-1% or 300 mA (ext.) +/-3%**	100 mA (int) +/-1% or 300 mA (ext.) +/-3%	100 mA (int) +/-1% or 300 mA (ext.) +/-3%
Auxiliary ECU supply Vaux/3%	**Up to 300 mA tracker/auxiliary**	Up to 300 mA tracker/auxiliary	Up to 300 mA tracker/auxiliary
Can_5V Supply (VCAN)	**100 mA**	100 mA	100 mA
CAN interfaces	**1**	1	1
LIN interfaces	**1**	1	1
I/Os	**6 (incl. F/S inputs)**	6 (incl. F/S inputs)	6 (incl. F/S inputs)
Watchdog	**Challenger**	Challenger	Challenger
LowQ Voff/Von	**25 mA**	25 mA	25 mA
AMUX and battery sense	**Yes**	Yes	Yes
Fail safe	**Independent I/O**	Independent I/O	Independent I/O
Package	**LQFP48eP**	LQFP48eP	LQFP48eP

The following schematic section shows the configuration used for the MC33906. The main sections are:

- MC33906 receives power directly from battery.
- The configuration used to generate the Vpre (voltage for the pre-regulator) is a SMPS (switched mode power supply) Buck configuration.
- The CAN and LIN signals are directly connected to the MC33906 which serves as the physical interface.
- R174 configures the device to generate 5 V at VCORE and 3.3 V at VAUX pins.
- Additionally, the SBC05 generates VCCA voltage that can be used as a highly regulated voltage reference for the VDDA of the MPC5606S.
- The reset pin from the SBC05 is connected directly to the MPC5606S to reset the microcontroller in case of a voltage failure if that is required.
- SBC05 is connected to the MPC5606S via DSPI, so the SBC05 can be configured and initialized as required with several options available. For further information please refer to the chip's data sheet.

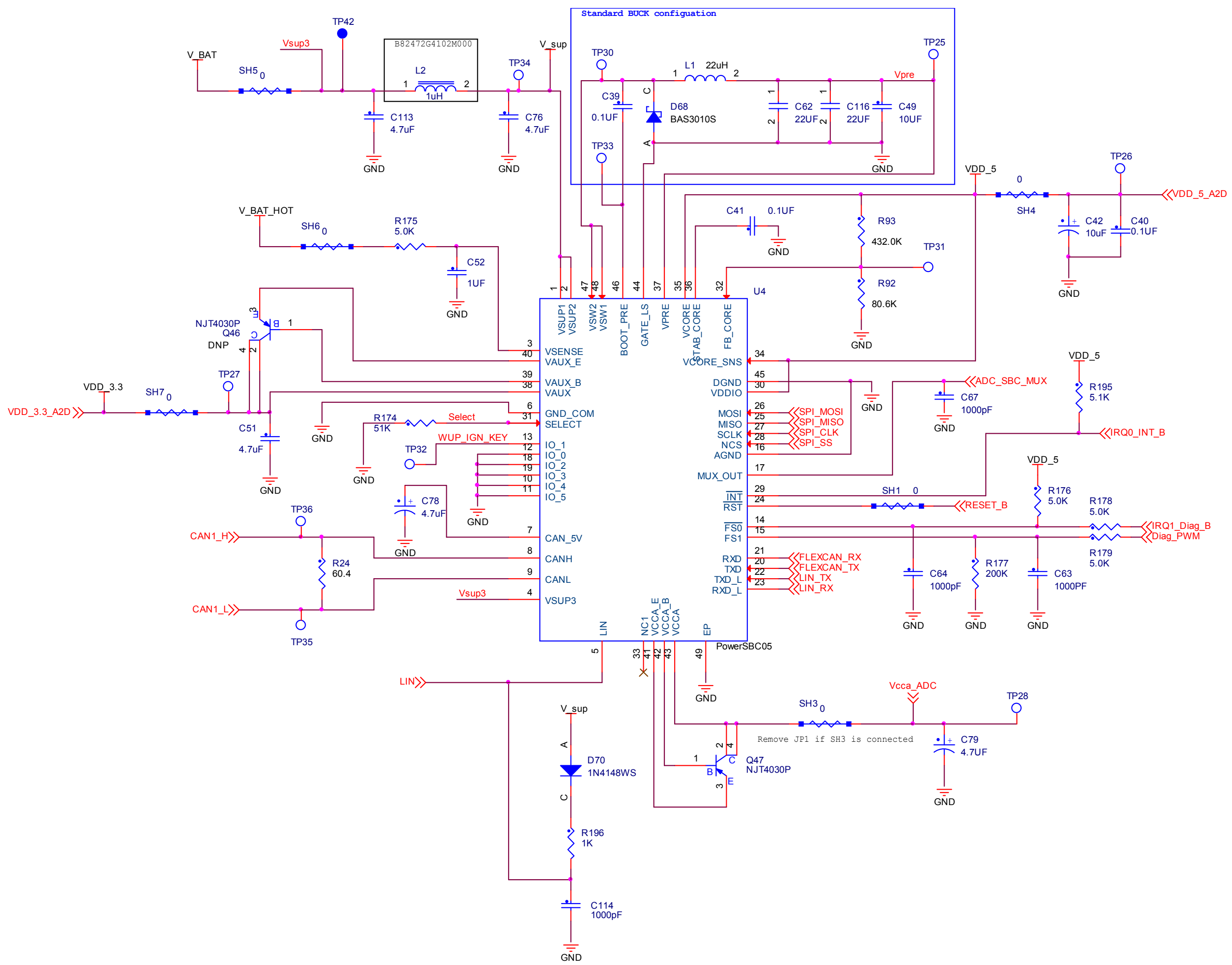

Figure 6. SBC05 (MC33906) configuration

The following table shows the battery current estimations total and actual measurement for this cluster implementation:

Table 4. Battery current delivery

Module	Quantity	Max individual current consumption (mA)	Total current consumption (mA)
TFT Display Backlight	1	150	150
Tell-tale LEDS	16	20	320
Gauge background LEDS	20	20	400
Gauge pointer LED	4	20	80
SBC (5V and 3.3 rails)	1	190	190
Total			990
Actual Measured			890[1]

[1] Average measurement, but current could reach the 990 mA at moments that all the modules were active in the application.

The following table shows the VDD_3.3 current estimations, total, and actual measurement for this cluster implementation:

Table 5. Power SBC 3.3V current consumption

Module	Quantity	Max Individual Current Consumption (mA)	Total Current Consumption (mA)
Spectrum	1	30	30
TFT Display Digital	1	20	60
QSPI Memory	1	38	38
Total			128
Actual Measured			124[1]

[1] Average current measured.

The following Table 6 shows the VDD_5 current estimations, total, and actual measurement for this cluster implementation:

Table 6. Power SBC 5V current consumption

Module	Quantity	Max Individual Current Consumption (mA)	Total Current Consumption (mA)
Spectrum	1	160	160
Stepper Motors	4	20	80
Speaker amplifier	1	50	50
Total			290
Actual Measured			268[1]

[1] Average current measured.

2.2 Oscillator design

Figure 7 shows the crystal circuit used to provide the external clock to the MPC5606S. Notice that R201 is not required, but it is recommended that you leave its space to easily accommodate different crystals during the cluster development; this R201 is used for crystals that require external bias resistor. C31 and C30 use the nominal value from the microcontroller's data sheet.

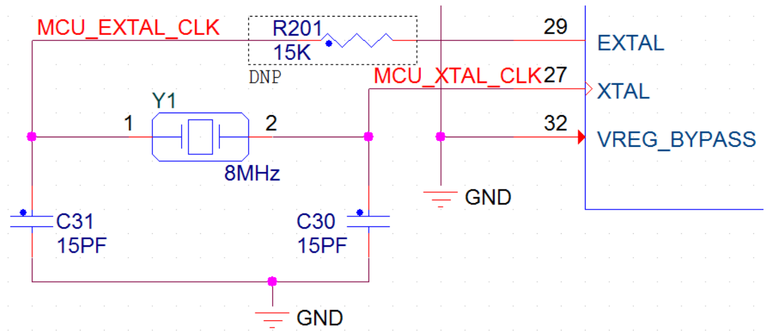

Figure 7. Crystal connections

2.3 Sound driver

This application includes a sound driver designed to be driven by the Sound Generation Logic (SGL) included in the device. The SGL is configured to generate monotonic sounds in this cluster application; however, the SGL module is also capable of generating more complex and higher quality sounds, like text-to-speech conversion applications, by combining DMA and PWMs.

The sounds generated in this application correspond to predefined values stored in memory as PWM values. When PWM values are passed to the SGL via interrupts, the SGL combines the PWM values to generate a sound signal through the SOUND pin of the MPC5606S. The external hardware required to complement MPC5606S sound generation is a very basic common emitter topology as you can see in Figure 8 below. The SGL module generates three sounds: the Door Ajar alarm, the Seat Belt alarm, and a relay simulation sound. See **ER03** in Section 5, "MPC5606S Cluster Errata."

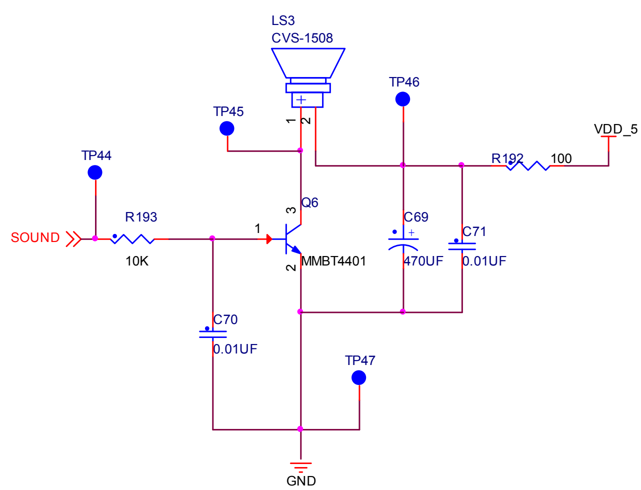

Figure 8. Sound amplifier

2.4 Motor control and SSD

The MPC5606S motor control SMC module directly drives the stepper motors used in the application; these module pins are shared with the stepper stall detection (SSD) that is used to determine the motor return to zero position. The SSD module is used only during the cluster startup to determine the zero position to the four indicators used.

The SMC provides six 4-pin interfaces to connect to the coils used on the stepper motor. Each of the motors has to be calibrated; their calibration will vary depending on the motor electric characteristics and the load presented in the motor shaft. The stepper motor functions will typically be supplied at 5 V and, since power is being switched across coils, there is the potential of spikes being induced back onto this power supply. Therefore, it is prudent to take care when routing these signals and when connecting the power supply to avoid undesirable effects on sensitive signals like clocks or data buses.

Figure 9 shows the SMC electrical connection on this design.

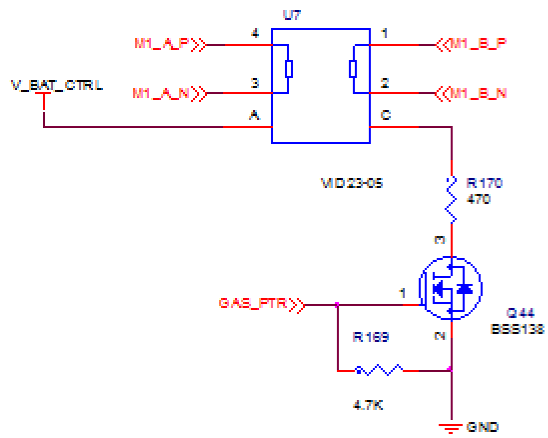

Figure 9. External motor circuit

The stepper motor used is the VID2305, which has the following electrical characteristics:

- Transparent pointer shaft
- Superior illumination intensity
- Compatible with LED PLCC-2 package
- High speed rotation: 400 Hz
- High step resolution: 1/12°
- Wide working temperature: –40 ~ 105 ºC.
- Low current consumption: less than 20 mA, 5V, 2 × 100 mW
- Extremely robust construction: Φ30 mm × 7.6 mm
- Long lifetime: long-time design for ten year work lifetime

Notice that the 20 mA power consumption of the VID2305 is within the MPC5606S operational range. In Figure 9, Q44 is used to drive the LED embedded in the VID2305. The pin used to drive this LED can be dimmed since it is connected to an eMIOS channel with PWM capability to cover dimming control if required; however, the current software implementation only performs dimming control on the gauges' backlight LEDs. See Section 2.5, "Encoder," for further details.

2.5 Encoder

Even when the MPC5606S does not directly support the encode/decode function of the eMIOS module, this functionality can be easily implemented using simple GPIO functionality. The way it is implemented in this cluster application is that software samples the GPIO state of the two channels connected to the encoder and determines the encoder direction depending on the previous and current states of the encoder pins; then the PWM duty is updated according to the number of turns of the encoder. Figure 10 shows the encoder circuit used in the MPC5606S cluster.

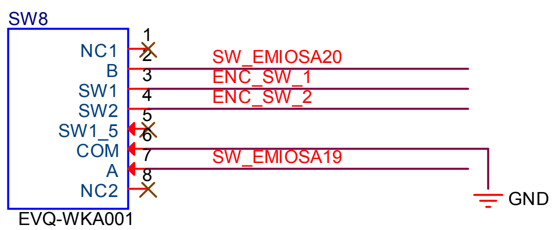

Figure 10. Encoder circuit

In this application, the encoder:

- Controls the scrolling of images presented on the LQ042 TFT display.
- Sets the required dimming intensity. Press the encoder's button once, then scroll up or down to change the dimming, and then press again to get out of the dimming control.
- Puts the device in STANDBY mode if the encoder button is pressed for 5 seconds. To wake up the cluster, the battery must be reconnected.

2.6 Display driver

In this application, the MPC5606S directly drives a LQ042 TFT display; Figure 11 shows the electrical connection.

The DCU module is used to drive the LQ042 display in this application, the DCU is a display controller designed to drive TFT LCD displays capable of driving screens with resolution as high as Wide Quarter Video Graphics Array (WQVGA), with 16 layers and 4 planes with real time alpha-blending. The DCU generates all the necessary signals required to drive the display: up to 24-bit RGB data bus, Pixel Clock, Data Enable, Horizontal-Sync, and Vertical-Sync.

The display driver is included on certain versions of the MPC560xS chips; see the data sheet for further details.

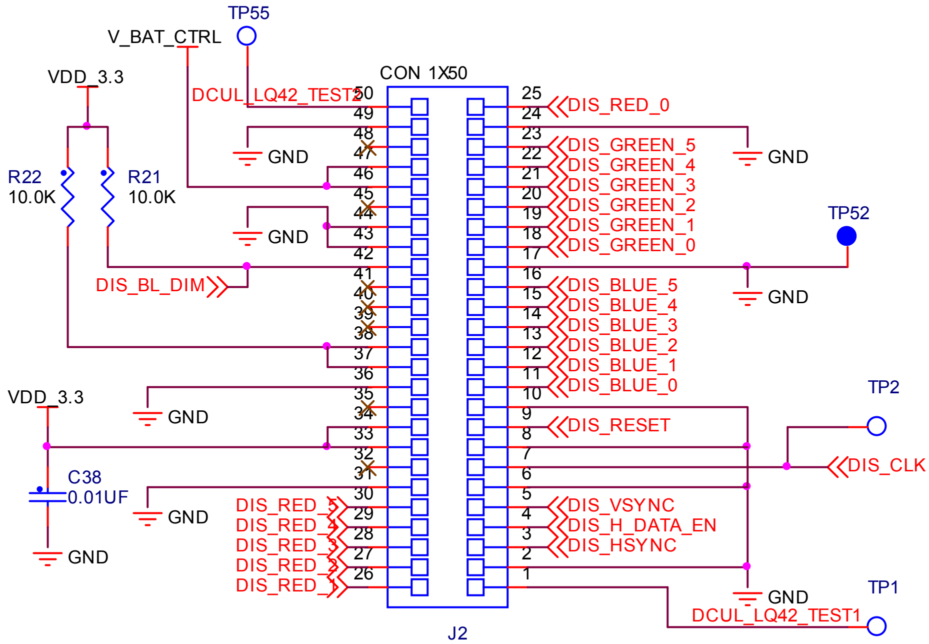

Figure 11. LQ042 electrical connections

NOTE

In the schematic design for this cluster, J2 connector ended up with the wrong signal order (they were flipped on both sides); however, Figure 11 shows the correct signal connections. See **ER01** in Section 5, "MPC5606S Cluster Errata."

Table 7. LQ042 display pin assignment

MCU PIN	MPC5606S SIGNAL	LQ042 TFT display
18	DCU_HSYNC	DIS_HSYNC
19	DCU_DE	DIS_HDATA_EN
17	DCU_VSYNC	DIS_VSYNC
20	DCU_PCLK	DIS_CLK
126	GPIO[114]_PJ9	DIS_RESET
11	DCU_B2	DIS_BLUE_0
12	DCU_B3	DIS_BLUE_1
13	DCU_B4	DIS_BLUE_2
14	DCU_B5	DIS_BLUE_3
15	DCU_B6	DIS_BLUE_4
16	DCU_B7	DIS_BLUE_5
1	DCU_G2	DIS_GREEN_0
2	DCU_G3	DIS_GREEN_1
3	DCU_G4	DIS_GREEN_2

Table 7. LQ042 display pin assignment (continued)

MCU PIN	MPC5606S SIGNAL	LQ042 TFT display
4	DCU_G5	DIS_GREEN_3
5	DCU_G6	DIS_GREEN_4
6	DCU_G7	DIS_GREEN_5
167	DCU_R2	DIS_RED_0
168	DCU_R3	DIS_RED_1
169	DCU_R4	DIS_RED_2
172	DCU_R5	DIS_RED_3
173	DCU_R6	DIS_RED_4
174	DCU_R7	DIS_RED_5
144	EMIOSA21	DIS_BL_DIM

Note: DCU_LQ42-TEST1/2 not connected to MCU and is only for LQ042 test purposes.

Note: See **ER01** in Section 5, "MPC5606S Cluster Errata," for cautions on the LQ042 connections.

Depending on the operating environment, it may also be important to consider the location and operating frequency of the display to be driven by the device. It is typical for the panel to be connected directly to the same board as the MPC5606S; however, if the panel must be at a greater distance, then the drive strength of the MCU pins must be considered. Similarly, a fast clock rate for a panel may require a higher drive strength capability for the pins which may in turn cause impedance matching problems with the panel.

The best way to examine the panel drive strength requirements is to simulate how the pin drive strength affects signal integrity. High drive strength may create undesirable ringing and spurious edges on the signal. If this result is found, then standard impedance matching techniques may be used. Flat Flexible Cables (FFC) are most commonly used to connect the panel to the board and these should also be considered when simulating behavior. At its simplest, the insertion of a resistor in series with the DCU signals may be sufficient to address the problem. Based on Freescale simulations, values of 39 ohms or 79 ohms (when FFC in use) are good starting points for impedance matching resistors. See Figure 12 for an example of how to connect the DCU pins to a generic TFT LCD panel. (For further information, see MPC5645SQRUG, *MPC5645S Hardware Design Guide*).

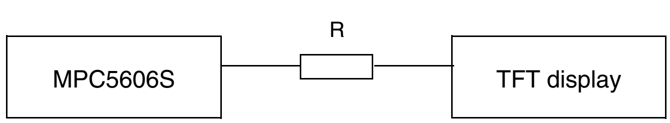

Figure 12. TFT with series resistor

NOTE

If pad compensation is required, then resistors should be inserted for each signal line.

2.7 QUADSPI

MPC5606 has a QUADSPI module that directly connects to devices that support the communication protocol with the same name. QUADSPI protocol supports serial communications for single, dual, and quad modes of operation. This module can also be configured to be used as the third DSPI channel. Not all the MPC560xS devices support this feature; refer to the MPC5606S data sheet for more details. The maximum speed for the QUADSPI module will depend on some hardware factors like pad length, memory interface max capacitance, and the memory electrical specifications, but speeds of up to 48 MHz can be achieved if the mentioned hardware factors are minimized.

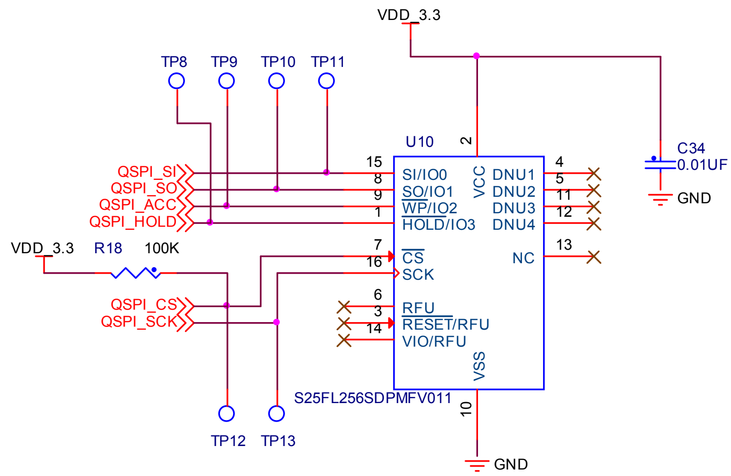

Figure 13. QUADSPI electrical connections for a 32 MB/256 MB memory

As a general guideline to get the best memory performance, keep the memory as close as possible to the MCU and the pad's length as short as possible.

2.8 Analog inputs

MPC5606S converts from 0–5V in common mode conversion range. The cluster design has been enabled to monitor several types of analog signals: ANS3 and ANS4 that can be used to monitor any desired signal within the range of 9–18V (Figure 14 top). These signals should be connected at J4 connector shown at the bottom of Figure 14.

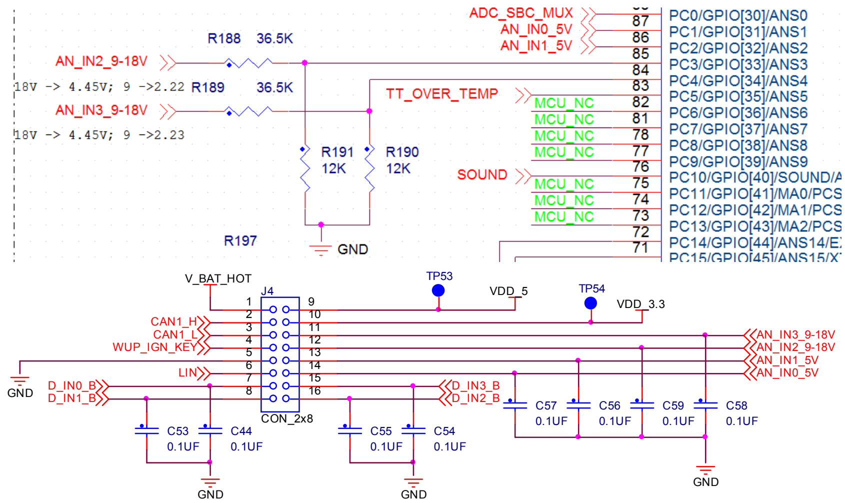

Figure 14. Backlight circuit

Also, this cluster has a pair of analog channels available to be connected to ANS0 and ANS1, which are also available at J4 connector. These two signals are not escalated, so the connected signal should be within the ANx channel max values to avoid damage to the device. See MPC5606S, *MPC5606S Microcontroller Data Sheet* to get these max values.

Some additional inputs are available at J4, such as the possibility to provide external 12V, 5V, and 3.3V power. Also, some digital inputs are available for generic application D_IN0_B–D_IN3_B and the WUP_IGN_KEY input connected to an interrupt pin that can be used to wake up the cluster. J4 provides the access point to CAN and LIN busses.

2.9 Backlight

The cluster design uses a two-color LED rail around each of the four gauges. One of the rails is integrated with white LEDs and the other with red LEDs. Six white and six red LEDs are used to surround the RPM and Odometer gauges and four white and four red are used to surround the Temperature and Gas gauges.

White LEDs are always on but they turn off when any of the gauges reach the maximum value in their scales, then the red rail of LEDs are turned on. The following figure shows the circuit used for this design.

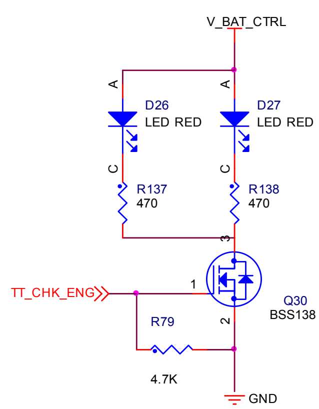

Figure 15. Backlight circuit

2.10 JTAG

The MPC5606S cluster has been enabled with a JTAG debugger connector to allow further development or tests required during the prototype stage. Figure 16 shows the JTAG connector used for the cluster design. The resistors marked with DNP are placed as optional as well as R8, R9, R10, R15 and R16. The first DNP group is placed there as option to enhance the signal integrity in case the debugger struggles to communicate with the device. The series resistors are there for protection, but they also can be removed if not required to protect against excessive current through the JTAG pins.

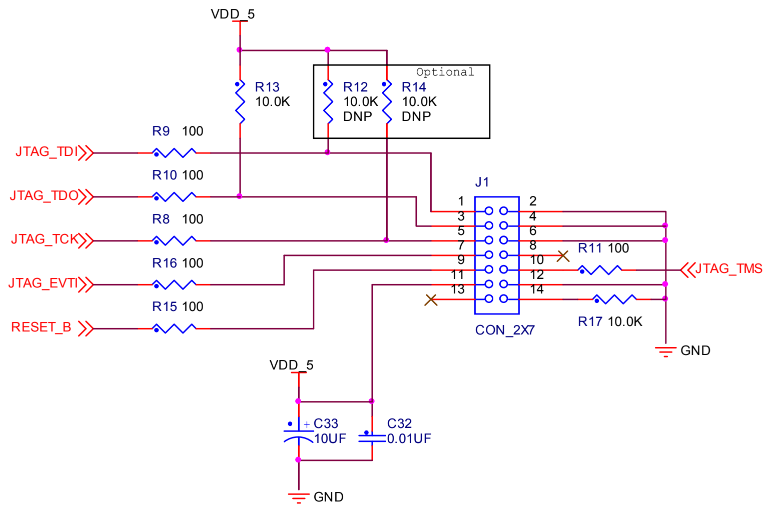

Figure 16. JTAG electrical connections

3 Conclusion

This application note serves as a starting hardware and software reference for developing a cluster application. Specific design development—like additional EMC considerations, signal integrity due to battery glitches, and so on—will be required for the final cluster electrical environment.

In this application, MPC5606S demonstrates that a complete cluster implementation can be achieved with a subset of internal modules like DCU, eMIOS, RTC, SGL, MC, SSD, and GPIO. Several modules can be used to enhance the cluster functionality like DSPI, I2C, LIN, CAN, QUADSPI, and ADC.

This application also integrates the SBC05 (MC33906), which provides a complete solution for the power supply. The SBC05 provides the required MCU startup and adds a higher degree of integration to the design, since it includes the LIN and CAN physical interfaces, 3.3 V and 5 V power supplies, and even the analog reference voltage.

4 References

Document number	Title	Availability
MPC5645SQRUG	*MPC5645S Hardware Design Guide*	freescale.com
MPC5606SRM	*MPC5606S Microcontroller Reference Manual*	
MPC5606S	*MPC5606S Microcontroller Data Sheet*	
AN4442	*Integrating the MPC5643L and MC33907/08 for Safety Applications*	
MC33906_7_8FS	*MC33906/07/08 Fact Sheet*	

5 MPC5606S Cluster Errata

The following errata are only for this hardware implementation and are not related in any way to the MPC5606S chip errata.

Item number	Description
ER01	LQ042 display connector was installed with the signals flipped on both sides.
WA01	A twisted flex cable was used to fix this issue.
ER02	TP54 and TP40 present discontinuity.
WA02	TP54 and TP40 must be shorted for VDD_3.3 signal.
ER03	LS2 polarized buzzer used in place of a speaker.
WA03	Speaker used to replace the LS2 buzzer.
ER04	Q46 missing in the design.
WA04	Q46 installed in cluster board even when marked as DNP (do not populate in the design).

6 Acknowledgements

I would like to thank all the support given by my local team in Mexico and the support given by the FAE team during the cluster design reviews.

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