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Using the ASB520
MC68HC908QT2
Based Infrared
Remote Control
Reference PC Board

Designer Reference
Manual

M68HC08
Microcontrollers

DRM045/D
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Using the ASB520 MC68HC908QT2 Based Infrared Remote Control Reference PC Board

Reference Design

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Revision History

Revision History

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DRM045   Using the ASB520 MC68HC908QT2 Based Infrared Remote Control Reference PC Board

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Designer Reference Manual — DRM045

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Designer Reference Manual — DRM045

Section 1. Introduction and Setup

1.1 Introduction

Motorola's ASB520, MC68HC908QT2 Infrared Remote Control Reference PC Board and software are designed to demonstrate how a simple, limited function, dedicated remote control system could be designed. The objective is to keep the design simple so a user can pick portions of interest to his design and turn them into an application specific system. This system is specifically programmed to control an APEX model 1201 DVD player.

A few of the more noteworthy features of the reference PC board are listed as follows:

- 8-pin MC68HC908QT2 microcontroller
- Infrared LED and driver
- Visible LED to show activity
- Six user push buttons
- MON08 programming interface for in-circuit FLASH programming
- Battery holder for 3-AA cells
- Microcontroller current monitor jumper block

A photograph of the reference PC board appears in **Figure 1-1**.

1.2 About this Manual

Key items can be found in the following locations in this manual:

- Setup instructions are found in **1.3 Setup Guide**.
- Schematics are found in **4.2 Schematic**.
- Pin assignments for MON08 connector J1 are shown in **Table 3-1. MON08 Pin Assignments**.
- User interfaces are described in **2.3 LEDs**.
- For those interested in the design aspects of the reference PC board's circuitry, a description is provided in **Section 5. Design Considerations**.
- System testing, hardware and software, are described in detail in **Section 6. System Testing**.

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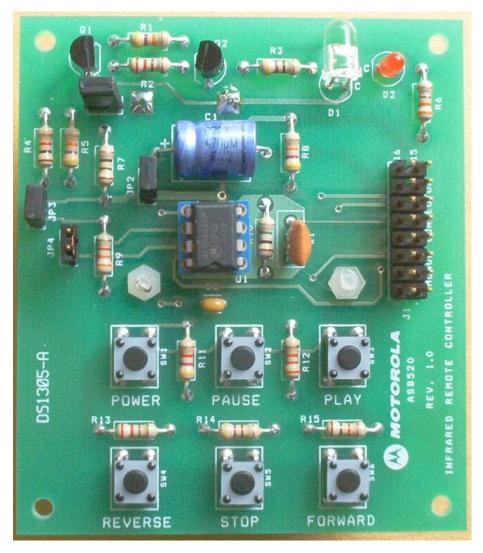
Figure 1-1. MC68HC908QT2 IR Reference PC Board Photograph

1.3 Setup Guide

Setup for the reference design PC board can be broken into two parts.

- The first is normal user operation mode.
- The second is MC68HC908QT2 FLASH programming configuration. FLASH programming is explained in **Section 6. System Testing**.

It is assumed for user operational mode, the MC68HC908QT1 has been programmed with the remote control program. If not, refer to **Section 6. System Testing** for FLASH programming information.

Figure 2-1. PC Board shows the locations of the various jumper blocks and MON08 connector.

For user operation mode, shorting jumpers need to be installed to jumper blocks JP1–JP4. Shorting jumper block JP1 is not necessary if the small PC board trace under jumper block JP1, on the bottom side of the PC board, has not been cut for microcontroller current monitoring.

Installation of 3-AA Alkaline batteries into the battery holder mounted on the bottom of the PC board is also required for setup. Note battery polarity on the battery holder. The PC board is now ready for use as an infrared remote control.

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Section 2. Operational Description

2.1 Introduction

The following subsections describe the operation of the ASB520, MC68HC908QT2 infrared remote control reference design system. LEDs, switches, jumper blocks and FLASH programmer headers, and current monitor jumper block are described here. **Figure 2-1** shows the locations of these items.

2.2 Push Buttons

There are six push button switches resident on the lower portion of the reference PC board. They are labeled as switches SW1–SW6 on the PC board schematic. Each button has a dedicated function. The switches are labeled as POWER, PAUSE, PLAY, REVERSE, STOP, and FORWARD. These labels describe the button's operation function related to control of a DVD player.

2.3 LEDs

There are two LEDs located in the upper right hand corner of the PC board. The LED labeled D1 is an infrared LED and the one labeled D2 is a visible red LED and is used to show system activity.

2.3.1 Red Activity Indicator LED

D2 is a visible red LED and is used to show IR LED activity. It blinks as long any push button is depressed

2.3.2 Infrared LED

D1 is an infrared LED. It is modulated to control the DVD.

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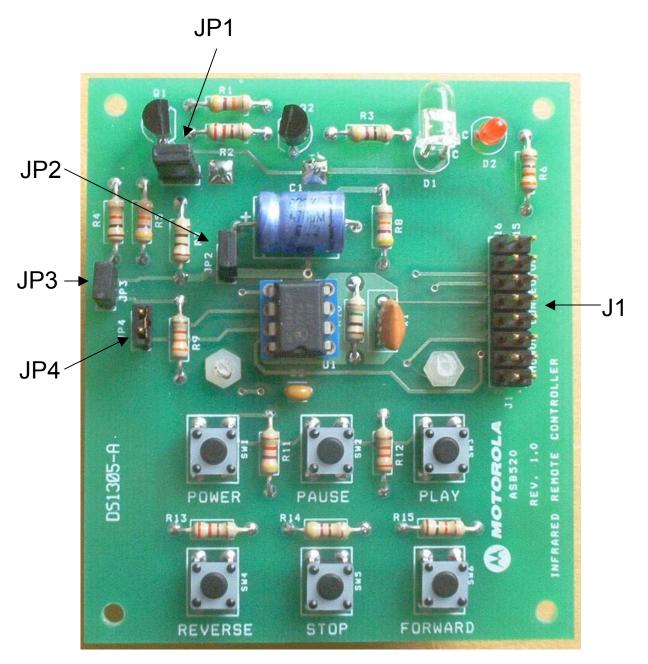DRM045

Operational Description

JP1

JP2

JP3

JP4

J1

Figure 2-1. PC Board

2.4 Header and Jumpers Blocks

There is one 16-pin header (2 x 8-pin), J1, and four 2-pin jumper blocks, JP1–JP4, on the PC board. See **Figure 2-1** for their locations on the PC board.

The header and jumper functions are described as follows.

J1: Jumper block J1 is used to program the MC68HC908QT2, located in the center of the PC board. The connections to this board follow the standard MON08 connector scheme. It is also used to put the ASB520 system into test mode. In a production environment, J1 could be replaced by a "bed of nails" test fixture to reduce PC board parts costs.

JP1: Jumper block JP1 is on the PC board measure the current consumed by the microcontroller. Its primary purpose is to measure stop current of the microcontroller. A small trace on the bottom of the PC board must be cut to use this feature. When using this feature to measure stop current you should remove shorting jumper JP2. Removing the shunt from JP2 removes the system's 470 μF bulk capacitor. Removing that capacitor will improve accuracy of the current measurement, as large capacitors have leakage current associated with them. Select the lowest voltage rating bulk capacitor for your circuit as possible because lower voltage rated ones tend to have less leakage than higher voltage ones for a given capacitance value.

JP2: Jumper block JP2 disconnects the bulk capacitor during FLASH programming and optionally during stop current monitoring. The value of the capacitor is large enough to cause power switching issues when using the Cyclone programmer. During the programming procedure, the Cyclone programmer cycles power to the target PC board. Large value bulk capacitors greater than approximately 100 μF present excessive currents to the Cyclone programmer and interfere with the POR circuit of the target's microcontroller as voltage on larger capacitance devices do not discharge fast enough during voltage cycling.

The purpose for the bulk capacitor is two fold: First is tends to help lower the effects of the battery's internal resistance during periods of high current demands while the IR LED is being modulated. This is a particular benefit toward the battery's end of life period, when its internal resistance is increasing. Second, if a system uses RAM to store user information, the bulk capacitor will retain voltage to the microcontroller during battery changes.

JP3: Jumper block JP3 disconnects pullup resistor, R9, during FLASH programming.

JP4: Jumper block JP4 disconnects LED drive circuitry during FLASH programming.

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2.5 Microcontroller Current Monitor Jumper Block

Jumper block JP1 is intended as a connection on the PC board to measure the stop current of the MC68HC908QT2. To use the feature, you must cut the small PC board trace located on the bottom side of the PC board between the two pins of the jumper block. After cutting the trace, and when not using an amp meter to measure system current a shunt must be installed on JP1.

Section 3. Pin Description

3.1 Introduction

There is one connector resident on the control board, labeled J1. It is the MON08 connector. The following subsection describes signals on connector J1.

3.2 16-Pin Connector J1

Signals to and from the MON08 connector are grouped together on 16-pin (2 x 8-pin) ribbon cable connector J1. Pin assignments for connector J1 are shown in **Table 3-1**. In a production environment, J1 could be replaced by a "bed of nails" test fixture to reduce PC board parts costs.

Table 3-1. MON08 Pin Assignments

Pin Number	Function
1, 3, 4, 5, 7, 9, 11,14, 16	No connect
2	GND
6	V_{TST} (PTA2)
8	COM (PTA0)
10	MOD1 (PTA4)
12	MOD0 (PTA1)
13	OSC1 (PTA5)
15	V_{DD}

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Pin Description

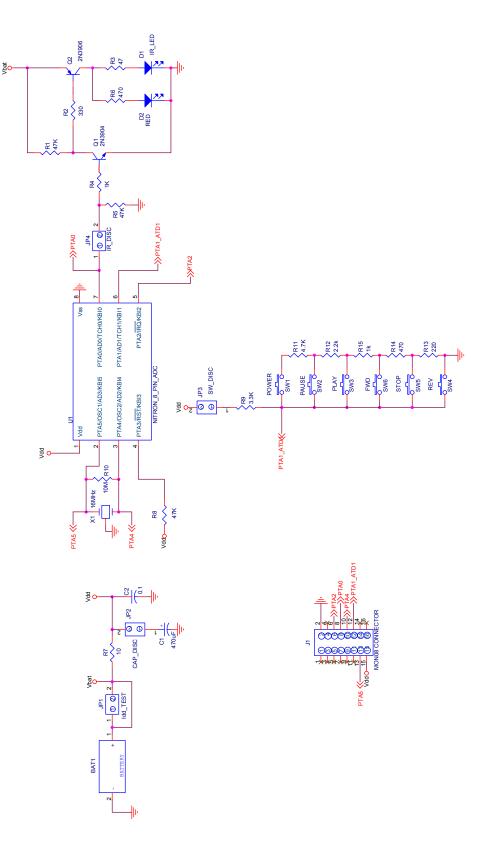Freescale Semiconductor, Inc.

Section 4. Schematic and Parts List

4.1 Introduction

Schematic and parts list detail are documented in this section.

4.2 Schematic

A schematic of the reference design PC board appears in **Figure 4-1**. Unless otherwise specified, capacitor values are in microfarads, resistor values are in ohms. All resistors are specified as 1/4-watt ± 5%, and interrupted lines coded with the same letters are electrically connected.

Schematic and Parts List

Figure 4-1. ASB520 PC Board Schematic

4.3 Parts List

The following parts list describes the parts content for the IR reference PC board.

Table 4-1. Reference PC Board Parts List

Designators	Qty.	Description	Manufacturer	Part Number
BAT1	1	3-AA Battery Holder	Digi-Key	2464K-ND
C1	1	470 μF Cap@6.3WV	Digi-Key	P5508-ND
C2	1	0.1 μF Capacitor	Digi-Key	399-2127-ND
D1	1	Infrared LED	Digi-Key	160-1061-ND
D2	1	Red LED	Digi-Key	160-1061-ND
J1	1	2 x 8 Pin Header[1]	Digi-Key	S2211-36-ND[1]
JP1–JP4	4	2 Pin Header[1]	Digi-Key	S1211-36-ND[1]
Q1	1	2N3904	Digi-Key	2N3904-ND
Q2	1	2N3906	Digi-Key	2N3906-ND
R1, R8, R5	3	47K Ohm Resistor[2]	Digi-Key	47QBK-ND
R3	1	47 Ohm Resistor[2]	Digi-Key	47QBK-ND
R4, R15	2	1K Ohm Resistor[2]	Digi-Key	1.0KQBK-ND
R13	1	220 Ohm Resistor[2]	Digi-Key	220QBK-ND
R2	1	330 Ohm Resistor[2]	Digi-Key	330QBK-ND
R6, R14	2	470 Ohm Resistor[2]	Digi-Key	470QBK-ND
R7	1	10 Ohm Resistor[2]	Digi-Key	10QBK-ND
R9	1	3.3K Ohm Resistor[2]	Digi-Key	3.3KQBK-ND
R11	1	4.7K Ohm Resistor[2]	Digi-Key	4.7KQBK-ND
R10	1	1 Meg Ohm Resistor[2]	Digi-Key	1.0MQBK-ND
R12	1	2.2K Ohm Resistor[2]	Digi-Key	2.2KQBK-ND
SW1–SW6	6	Momentary Push Button Switch	Digi-Key	CKN9009-ND
U1	1	Nitron 8-pin DIP with A/D and 1.5K FLASH	Digi-Key	MC68HC908QT1CP
X1	1	16.00 MHz Resonator	Digi-Key	X908-ND
No Designator (optional)	1	8-pin socket for U1	Digi-Key	A400-ND
No Designator	1	2-56 x 3/8" nylon screw	Any	Any
No Designator	1	2-56 nylon nut	Any	Any
No Designator	1	Tape, double-sided foam 1/8" x 1"[3]	Digi-Key	3M4008-ND
No Designator	1	ASB520 Bare PCB	DS Electronics	ASB520
No Designator	4	Shunts for JP1–JP4	Digi-Key	S9000-ND
No Designator	3	AA Alkaline Battery	Any	Any

1. Shipped in strips of 36 x 1 or 36 x 2. Cut to length.
2. All resistors are 1/4 W with a tolerance of 5% unless otherwise noted.
3. Cut to size.

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Schematic and Parts List

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Section 5. Design Considerations

5.1 Introduction

Microcontroller systems, in general, have a number of important design considerations related to PC board layout and grounding considerations. These design considerations are discussed in **5.2 Grounding**, **5.3 Infrared and Visible LED Drive Circuit**, and **5.4 Switch Circuitry**. A description of two of the reference board's major circuits are included in **5.3 Infrared and Visible LED Drive Circuit** and **5.4 Switch Circuitry**.

5.2 Grounding

PC board layout is an important design consideration. In particular, ground planes and how grounds are tied together influence noise immunity. To maximize oscillator noise immunity, it is a good practice have ground plane under the resonator, X1. One good grounding practice is to carry all of the ground connections, in a star configuration, to a single point which could be the power supply's bulk capacitor or in this case, the battery ground terminal.

5.3 Infrared and Visible LED Drive Circuit

Figure 5-1 is the driver schematic, used to drive both LEDs on the PC board. Because the microcontroller will not source or sink enough current to drive the two LEDs, a discrete driver is necessary. This circuit uses two transistors. The first transistor is a small signal NPN, followed by a small signal PNP transistor.
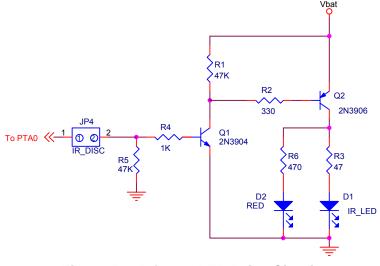

Figure 5-1. Infrared LED Drive Circuit

A logic 1 from port A, bit 0 will turn the NPN transistor on, driving its collector low. The low level applied to the base of the PNP transistor, Q2, will drive its emitter to collector into conduction, illuminating the two LEDs. Resistor R5 is in place to guarantee that Q1 is biased off during initial power on and before the microcontroller's program has configured port A, bit 1 to behave as a digital output.

5.4 Switch Circuitry

A simple circuit is used to give the ability of reading several switches into an A/D port. **Figure 5-2** shows the circuit. This circuit has the advantage of using only one I/O pin for the six switches. Using a switch matrix and the keyboard interrupt pins is an alternative approach, but in this case would require a microcontroller with more I/O pins.
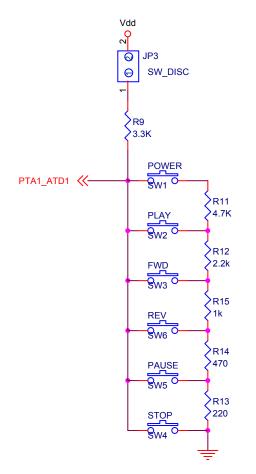

Figure 5-2. Switch Circuitry

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The spreadsheet in **Table 5-1** gives the decimal values seen by the A/D, based on which switch is depressed. Because the voltage from the switches is ratiometric to V_{DD}, power supply variation will have no effect on A/D readings.

Table 5-1. Switch Input A/D Values

Switch	Ideal Value	Minus 6%	Plus 6%
No switch	255	239.7	255
Power	170.5	160.3	180.7
Play	127.7	120	153.3
Forward	79.9	75.1	84.7
Reverse	40.8	38.4	43.3
Pause	14.8	13.9	15.6
Stop	0	0	0

The ±6% values in **Table 5-1** indicate worst case values, as the resistors used in the design are ±5%. The software uses the minimum values from the table to decode the switches.

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Section 6. System Testing

6.1 Introduction

This section will first explain how to program the control program into FLASH memory of the MC68HC908QT2 microcontroller. It will then, in detail, provide functional testing of both hardware and user software for the ASB520 infrared remote control reference design.

6.2 Hardware/Software Testing Summary

Because the PC board has minimal user interface, hardware testing will be performed in stages.

- First the control program will be programmed into the MC68HC908QT2's FLASH memory.

- The keyboard and red LED will be tested next.

- Finally, the ASB520 PC board will be used to control a DVD.

6.3 FLASH Programming

The following steps are used to initially program the MC68HC908QT2:

1. If installed, remove the batteries from the battery holder located on the bottom of the PC board

2. Remove jumpers JP1–JP4.

3. Connect the P&E Microcomputer Systems, Inc. MON08 Cyclone's ribbon cable from the programmer to J1, noting the location of pin 1 on J1.

Follow the P&E Microcomputer Systems, Inc. instructions to program the MC68HC908QT2, with the remote control program file. The file name to program into the device is ASB520.S19.

After FLASH programming is complete, disconnect the Cyclone's ribbon cable connected to J1 of the ASB520 PC board.

In a production environment, the Cyclone Programmer can be setup so that a single press of a button will initiate an automatic programming operation. The Application Program would be pre-loaded into nonvolatile memory in the Cyclone and no PC would need to be present during production programming.

6.4 LED and Push Button Test Code

Test code is embedded in the ASB520 control program. This test code will test the switches, LED drive circuitry and visible LED, D2. The infrared led, D1, is illuminated, but you can't see it. To run the test program, follow the next 12 steps:

1. Connect a jumper lead between pins 2 and 6 on connector J1.
2. Install shorting jumpers on jumper blocks JP1–JP4
3. Install 3-AA Alkaline batteries into the battery holder mounted on the bottom of the PC board. Note battery polarity on the battery holder. When the last battery is installed, you will see the red LED, D2, flash five times.
4. Depress the POWER switch, SW1. The red LED will flash once, delay for approximately 2 seconds, flash again and continue that sequence until the button is released. You will note the POWER button is SW1; thus one blink. (This is the sequence for the remainder of the switches.)
5. Depress the PAUSE switch, SW2. The red LED will flash twice, delay for approximately 2 seconds, flash twice again and continue that sequence until the button is released.
6. Depress the PLAY switch, SW3. The red LED will flash three times, delay for approximately 2 seconds, flash three times again and continue that sequence until the button is released.
7. Depress the REVERSE switch, SW4. The red LED will flash four times, delay for approximately 2 seconds, flash four times again and continue that sequence until the button is released.
8. Depress the STOP switch, SW5. The red LED will flash five times, delay for approximately 2 seconds, flash five times again and continue that sequence until the button is released.
9. Depress the FORWARD switch, SW6. The red LED will flash six times, delay for approximately 2 seconds, flash six times again and continue that sequence until the button is released.
10. Remove one battery. It doesn't matter which one.
11. Remove the jumper lead from connector J1.
12. Replace the battery. (The system is now in user mode.)

All hardware except for the infrared diode, D1, has been tested at this point.

6.5 DVD Player Control Test

To test the infrared diode and the rest of the system in user mode, install a music CD in the APEX model 1201 DVD player. Music CDs appear to respond faster than video CD's in this CD player.

To test the software, infrared diode and the rest of the ASM520 PC board, follow these steps:

1. Configure the television and DVD player, following the instructions provided with the DVD player.
2. On the DVD player, depress the power switch on the left side of the DVD player to turn it on.
3. On the DVD player, depress the OPEN/CLOSE switch located to the right of the DVD drawer to open the DVD drawer.
4. Install a music CD in the APEX model 1201 DVD player.
5. Depress the OPEN/CLOSE switch on the DVD player to close the DVD drawer.
6. Wait for the yellow LED, located on the lower right hand end of the DVD player, labeled MP3/CD JPEG to illuminate. It can take up to 10 seconds on this DVD player.
7. Point the ASB520 board with LED D1 toward the DVD player and depress the POWER switch on the ASB520 PC board to turn the DVD player off.
8. Verify the yellow MP3/CD JPEG LED turns off.
9. Point the ASB520 board with LED D1 toward the DVD player and again, press the POWER switch on the ASB520 PC board. In approximately 10 seconds, the MP3/CD JPEG LED will once again illuminate. This delay is a function of the DVD player and not the controller.
10. Point the ASB520 board with LED D1 toward the DVD player and depress the PLAY switch on the ASB520 PC board. The first song on the CD will play.
11. Point the ASB520 board with LED D1 toward the DVD player and depress the PAUSE switch on the ASB520 PC board. The music will stop playing.
12. Point the ASB520 board with LED D1 toward the DVD player and depress the PLAY switch on the ASB520 PC board. The music will resume at the point it was paused.
13. Point the ASB520 board with LED D1 toward the DVD player and depress the STOP switch on the ASB520 PC board. The music will stop playing.
14. Point the ASB520 board with LED D1 toward the DVD player and depress the PLAY switch on the ASB520 PC board. The music will restart at the beginning of the song.

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15. Point the ASB520 board with LED D1 toward the DVD player and depress the REVERSE switch on the ASB520 PC board. The music will back-up, at a high rate, until it reaches the beginning of the song, at which time it will restart the song.

16. Point the ASB520 board with LED D1 toward the DVD player and depress the FORWARD switch on the ASB520 PC board. The music will play very fast.

17. Point the ASB520 board with LED D1 toward the DVD player and depress the PLAY switch on the ASB520 PC board. The music will resume at normal rate.

18. Power to the DVD player may now be turned off by depress the power switch on the left side of the DVD player.

This completes the hardware and software testing of the ASB520 infrared remote controller system.

The controller is ready for use with the APEX model 1201 DVD player.

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