Interfacing DACs to the NS9750

Version 1.00

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1 Overview

1.1 Digital-to-Analog Converters (DAC)

A digital-to-analog converter produces a voltage or current output that varies based on the data input that it receives from a microprocessor. DACs can produce audio, video, or virtually any other waveform. The NS9750 processor interfaces with many DACs without glue, which means that it is easy to control DACs over the Internet. This document describes how the NS9750 can interface with various DACs using serial and parallel protocols. Many varieties of DACs are available, each with different speeds, resolutions, output ranges, cost, and interface options. Some of the many vendors that provide DACs that can interface to the NS9750 include Texas Instruments, Fairchild Semiconductor, Cirrus Logic, Intersil, Linear Technology, and National Semiconductor.

1.2 DAC Functionality

A DAC has two reference voltages and produces an output somewhere between these voltages, based on the data word that the microprocessor provides. The lower of the two references is usually ground. The higher voltage reference is usually provided by an external component, but in some cases it is part of the DAC's internal circuitry. Different DACs produce different output voltages. The DAC should be chosen so that it produces the voltage range needed by the application. Sometimes, if the application needs high voltages or power, it is necessary to amplify the DAC's output.

The next three tables show the output voltages that 8-bit, 12-bit, and 16-bit DACs would produce with six different input numbers. These output voltages are based on having ground (0 volts) for the low reference and 2.2 volts for the high reference. The output voltages were calculated by using this formula:

Output Voltage = ((voltage reference range) / (highest DAC output number)) * input data

8-bit DAC	
Input Number	Output Voltage
0	0
58	0.500
116	1.000
174	1.501
232	2.001
255	1.200

12-bit DAC	
Input Number	Output Voltage
0	0
931	0.5001
1861	0.9998
2792	1.4999
3723	2.0001
4095	2.2000

16-bit DAC	
Input Number	Output Voltage
0	0
14894	0.49998
29787	0.99994
44683	1.50000
59577	1.99999
65535	2.00000

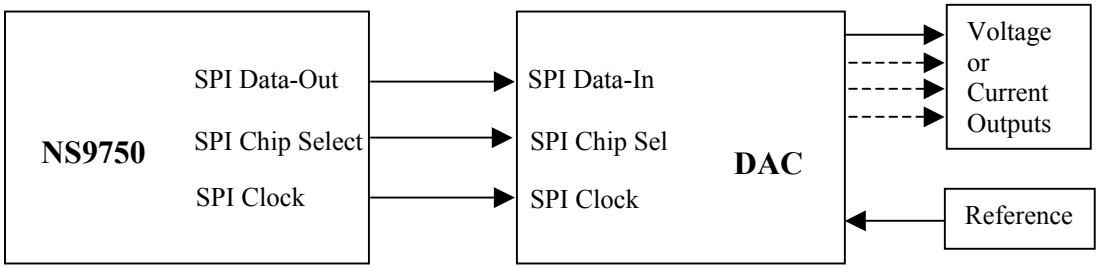
2 Serial Interfacing

SPI is a trademark of Motorola Inc.

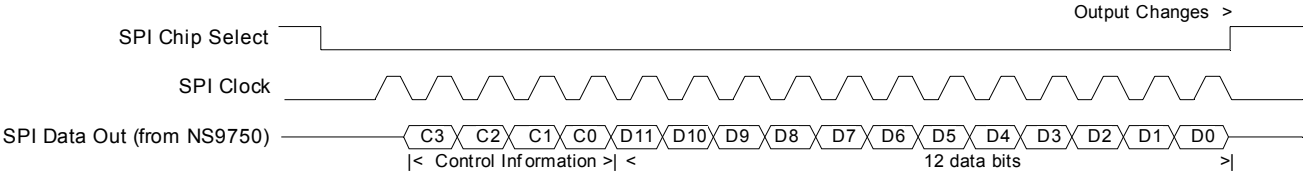
2.1 Interfacing with SPI

Interfacing the NS9750 to many DAC devices can be accomplished just by connecting the NS9750's SPI signals. The data sent to the DAC sets the DAC's output voltage. The DAC could have one or more outputs and many features such as power-down mode. The NS9750 controls the DAC's features and output voltages by sending command data with the SPI's Data-Out pin.

2.1.1 DACs controlled by the SPI Protocol



The protocol for communication with a multiple output 12-bit DAC is shown below. A 4-bit command chooses which output channel to control, and the next 12 bits set the chosen channel's output voltage. Although DAC devices vary in terms of number of bits, bit order, speed, leading or trailing zeros, the basic access is always the same.



2.1.2 Configuring the SPI Channel

Any of the four SPI channels can be used to communicate with a DAC. These steps are required:

1- Configure the GPIO pins for the SPI function.
2- Configure the Serial module to the SPI Master mode with the Serial Control Registers.
3- Set the bit rate with the Bit-Rate Register to the fastest speed the DAC can handle.

2.1.3 Communicating with the SPI DAC

In most cases, an interrupt-driven routine is used to communicate with the DAC because the DAC needs a small amount of data separated by the SPI Chip Select signal going high. When an interrupt driven routine is used, data is transmitted out the SPI pins by writing data to the Serial FIFO Data Register.

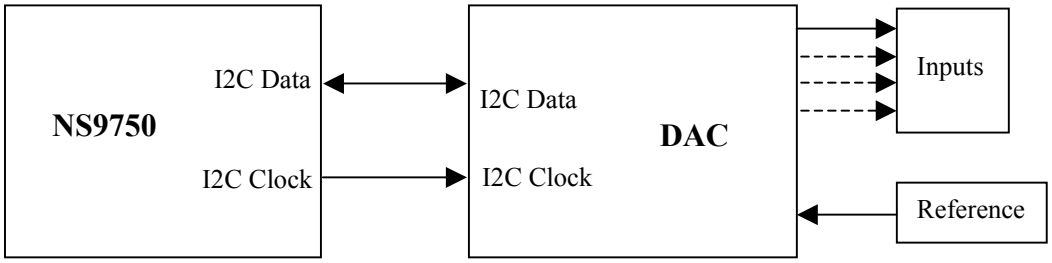
2.1.4 Examples of DAC Components

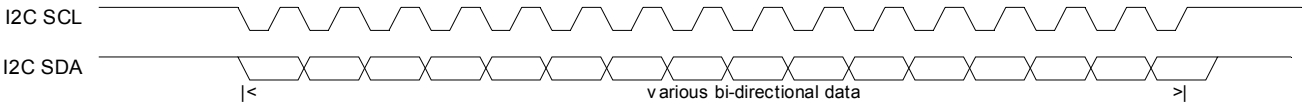
The DACs listed in this table interface to the NS9750 without glue, using the SPI protocol.

SPI Interface Digital to Analog Converters from Maxim							
Name	Bits	Outputs	Settling Time (us)	Supply Voltage	Current (uA)	Package	Price (1K)
MAX5203	16	1	25	2.7 to 3.6	1500	10/µMAX	$3.33
MAX5202	16	1	25	2.7 to 3.6	1500	10/µMAX	$3.33
MAX5207	16	1	25	2.7 to 3.6	1500	10/µMAX	$2.83
MAX5206	16	1	25	2.7 to 3.6	1500	10/µMAX	$2.83
MAX5236	10	2	15	2.7 to 3.6	450	10/µMAX	$3.59
MAX5234	12	2	15	2.7 to 3.6	450	10/µMAX	$6.35
MAX5232	10	2	15	2.7 to 3.6	525	16/QSOP	$4.48
MAX5230	12	2	15	2.7 to 3.6	525	16/QSOP	$7.75
MAX5711	10	1	4	2.7 to 5.5	150	6/SOT23	$1.20 @ 2.5k
MAX5722	12	2	4	2.7 to 5.5	205	8/µMAX (µSOP)	$4.38
MAX5742	12	4	4	2.7 to 5.5	395	10/µMAX	$5.67
MAX5741	10	4	4	2.7 to 5.5	395	10/µMAX	$2.95
MAX5721	10	2	4	2.7 to 5.5	205	8/µMAX (µSOP)	$2.49
MAX5712	12	1	4	2.7 to 5.5	150	6/SOT23	$1.35 @ 2.5k
MAX5309	10	8	5	2.7 to 5.5	1700	16/TSSOP	$5.30
MAX5308	10	8	5	2.7 to 5.5	1700	16/TSSOP	$5.30
MAX5307	12	8	5	2.7 to 5.5	1700	16/TSSOP	$9.30
MAX5306	12	8	5	2.7 to 5.5	1700	16/TSSOP	$9.30
MAX5385	8	1	20	2.7 to 5.5	230	6/SOT23	$0.95
MAX5383	8	1	20	2.7 to 3.6	230	6/SOT23	$0.95
MAX5106	8	4	6	2.7 to 5.5	1000	16/QSOP	$2.80
MAX5105	8	4	6	2.7 to 5.5	1000	20/QSOP	$2.80
MAX5223	8	2	50	2.7 to 5.5	220	8/SOT23	$1.25
MAX5259	8	8	10	2.7 to 3.6	1400	16/QSOP	$2.30
MAX5144	14	1	1	2.7 to 3.6	200	10/µMAX	$6.50
MAX5143	14	1	1	2.7 to 3.6	200	8/µMAX (µSOP)	$6.50
MAX5444	16	1	1	2.7 to 3.6	200	10/µMAX	$9.95
MAX5443	16	1	1	2.7 to 3.6	200	8/µMAX (µSOP)	$9.95
MAX5365	6	1	20	2.7 to 5.5	230	6/SOT23	$0.65
MAX5363	6	1	20	2.7 to 3.6	230	6/SOT23	$0.65

2.2 Interfacing with I2C

I2C is a 2-wire interface that the NS9750 supports. Some DACs can interface to the NS9750 using the I2C protocol.





2.2.1 Examples of I2C DAC Components

The DACs shown in this table interface to the NS9750 without glue, using the I2C protocol.

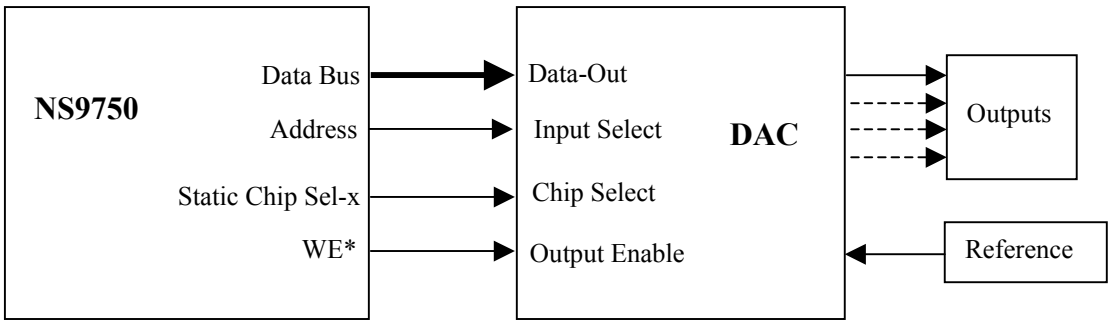
I2C Digital to Analog Converters from Maxim							
Name	Bits	Outputs	Settling Time (us)	Supply Voltage	Current (uA)	Package	Price (1K)
MAX5822	12	2	4	2.7 to 5.5	205	8/µMAX (µSOP)	$4.79
MAX5821	10	2	4	2.7 to 5.5	205	8/µMAX (µSOP)	$2.62
MAX5812	12	1	4	2.7 to 5.5	170	6/SOT23	$2.58
MAX5842	12	4	4	2.7 to 5.5	395	10/µMAX	$6.73
MAX5841	10	4	4	2.7 to 5.5	395	10/µMAX	$3.65
MAX5811	10	1	4	2.7 to 5.5	170	6/SOT23	$1.75
MAX5382	8	1	20	2.7 to 5.5	230	5/SOT23	$0.95
MAX5380	8	1	20	2.7 to 3.6	230	5/SOT23	$0.95

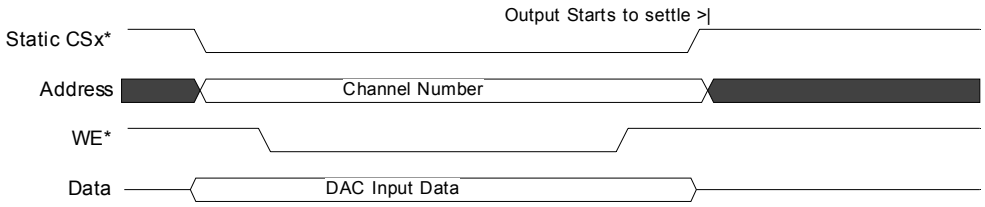
3 Parallel Interfacing

Digitizing video and other fast signals require the faster speeds that parallel DACs offer. These devices interface to the NS9750 as if the they were static RAM memory locations. The NS9750 has four static RAM chip selects that can be used to interface with DACs. The NS9750 writes data to the DAC's input as it would any static RAM memory location. At a minimum, the data bus, a static chip select signal, and WE (write enable) signal must be connected to the DAC. Sometimes a few address lines are needed if the DAC has multiple output channels or additional features.

3.1 Parallel Connections

The next diagrams show a DAC that can be connected to the NS9750 as any static RAM device would be. The address chooses the output channel as if the channel were a memory location. The Chip Select and Write Enable signals function in the usual way. Their wait states are configured according to the DACs timing spec. After the data is written to the DAC, its output reaches its final value in the time specified by the settling time spec.





3.2 Examples of Parallel DAC Components

This table lists the parallel DAC components from Analog Devices that interface with the NS9750, without glue, as if they were static RAM devices:

Parallel Digital to Analog Converters from Analog Devices							
Name	Bits	Inputs	Settling Time	Supply Voltage	Power	Package	Price (1K)
AD5330	8	1	6 us	2.5V-5.5V	1.25mW	SOP	$2.38
AD5331	10	1	7 us	2.5V-5.5V	1.25mW	SOP	$2.56
AD5332	8	2	6 us	2.5V-5.5V	1.8mW	SOP	$3.60
AD5333	10	2	7 us	2.5V-5.5V	2.25mW	SOP	$3.66
AD5334	8	4	6 us	2.5V-5.5V	4.5mW	SOP	$4.09
AD5335	10	4	7 us	2.5V-5.5V	4.5mW	SOP	$4.70
AD5336	10	4	7 us	2.5V-5.5V	4.5mW	SOP	$4.88
AD5340	12	1	8 us	2.5V-5.5V	1.25mW	SOP	$3.96
AD5341	12	1	8 us	2.5V-5.5V	1.25mW	SOP	$3.66
AD5342	12	2	8 us	2.5V-5.5V	2.3mW	SOP	$6.10
AD5343	12	2	8 us	2.5V-5.5V	2.3mW	SOP	$5.73
AD5344	12	4	8 us	2.5V-5.5V	4.5mW	SOP	$9.70

4 DAC Manufacturer Links

The manufacturers in this list produce DACs that can interface to the NS9750:

http://www.analog.com/

http://www.maxim-ic.com/DACDACRef.cfm

http://www.cirrus.com/en/products/

http://www.fairchildsemi.com/parametric/select.jsp

http://www.linear-tech.com/prod/prod_home.html?product_family=atod

http://www.national.com/appinfo/DAC/

http://www.ti.com/

http://www.intersil.com/product_tree/