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APPLICATION NOTE 3210

Quick-Start: Driving 7-Segment Displays with the MAX6954

Abstract: This article is how-to guide, intended as a quick learning aid for engineers considering using the MAX6954 to drive 7-segment monocolor LEDs.

The MAX6954 is a versatile display driver, capable of controlling a mix of discrete, 7-segment, 14-segment, and 16-segment LED displays through a serial interface. This application note shows a typical application and configuration for driving sixteen mono-color, 7-segment LEDs using the MAX6954.

See the MAX6954 data sheet for additional information about MAX6954 features.

"Quick-Start: Driving 16-Segment Displays with the MAX6954" and "Quick-Start: Driving 14-Segment Displays with the MAX6954" are similar application notes that discuss configuring the MAX6954 for 16-segment and 14-segment applications, respectively.

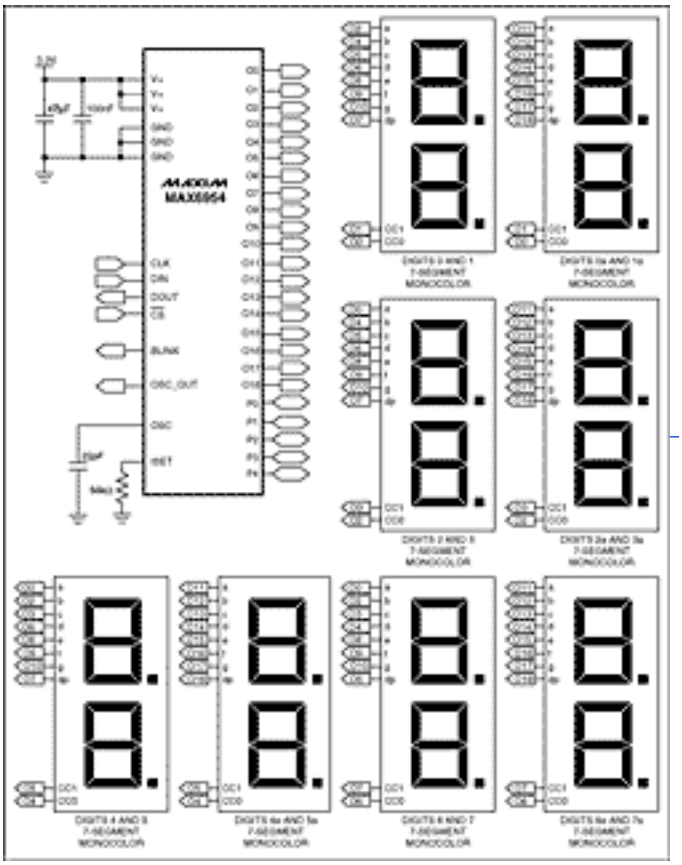

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Figure 1. MAX6954 7-segment application circuit.

A common application for the MAX6954 is driving up to sixteen 7-segment mono-color LEDs. This application note guides the user through the process of connecting the MAX6954 to 7-segment displays and configuring the internal registers to control the displays using the included hexadecimal font map.

The MAX6954 utilizes a multiplex technique that reduces driver pin count by using ports alternately as cathode

and anode drivers. This differs from the standard LED multiplex connection, which uses separate driver pins for anodes and cathodes. The technique is discussed in "Charlieplexing - Reduced Pin-Count LED Display Multiplexing". Table 1 lists the connection scheme for 7-segment digits that is compatible with the MAX6954 multiplex scheme and the built in hexadecimal font map. The letters in Table 1 correspond to the segment labels shown in **Figure 2**. **Figure 1** illustrates a sixteen digit, 7-segment application circuit for the MAX6954.

Table 1. Connection Scheme for Sixteen 7-Segment Digits

Digit	O0	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12	O13	O14	O15	O16	O17	O18
0 0a	CC0		1a		1b	1c	1d	1dp	1e	1f	1g	2a	2b	2c	2d	2e	2f	2g	2dp
1, 1a		CC1	1a		1b	1c	1d	1dp	1e	1f	1g	2a	2b	2c	2d	2e	2f	2g	2dp
2, 2a	1a		CC2		1b	1c	1d	1dp	1e	1f	1g	2a	2b	2c	2d	2e	2f	2g	2dp
3 3a	1a			CC3	1b	1c	1d	1dp	1e	1f	1g	2a	2b	2c	2d	2e	2f	2g	2dp
4 4a	1a		1b	1c	CC4		1d	1dp	1e	1f	1g	2a	2b	2c	2d	2e	2f	2g	2dp
5 5a	1a		1b	1c		CC5	1d	1dp	1e	1f	1g	2a	2b	2c	2d	2e	2f	2g	2dp
6, 6a	1a		1b	1c	1d	1dp	CC6		1e	1f	1g	2a	2b	2c	2d	2e	2f	2g	2dp
7, 7a	1a		1b	1c	1d	1dp		CC7	1e	1f	1g	2a	2b	2c	2d	2e	2f	2g	2dp

Display test mode can be used to verify connections after connecting the MAX6954 to 7-segment displays. Display test mode overrides, but does not alter, all control and digit registers and turns all segments on. Enable display test mode by writing 0x01 to register 0x07. If a segment does not light in display test mode this indicates a connection problem that should be investigated. Write 0x00 to register 0x07 to exit display test mode.

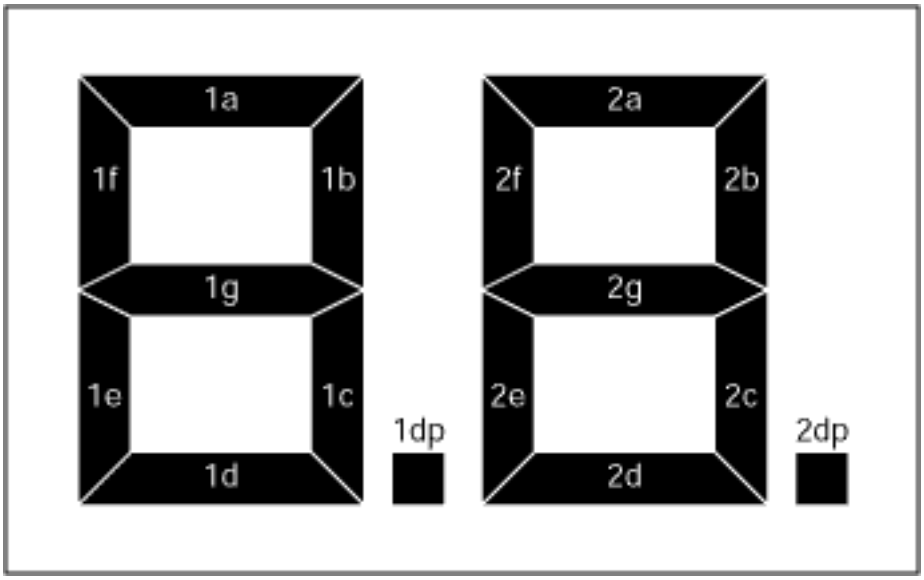

Figure 2. Segment labeling for 7-aegment displays.

After verification of the connections between the MAX6954 and the 7-segment displays the device must be configured for operation with 7-segment displays. Table 2 contains a list of the initial power-up states of important MAX6954 registers. When power is first applied to the MAX6954 the device is in shutdown mode, all digits are blanked, the 7-segment font map is selected and the device is set to scan the maximum number of digits. The default decode mode (0x01) and digit type (0x0C) register settings are correct for 7-segment applications.

Table 2. MAX6954 Initial Power-Up Register Status

REGISTER	POWER-UP CONDITION	ADDRESS (HEX)	REGISTER DATA							
			D7	D6	D5	D4	D3	D2	D1	D0
Decode Mode	7-segment font enabled	0x01	1	1	1	1	1	1	1	1
Global Intensity	1/16 (minimum intensity)	0x02	X	X	X	X	0	0	0	0
Scan Limit	Display sixteen 7-segment digits: 0, 1, 2, 3, 4, 5, 6, 7, 0a, 1a, 2a, 3a, 4a, 5a, 6a, 7a	0x03	X	X	X	X	X	1	1	1
Control Register	Shutdown enabled, blink disabled, blink speed is slow	0x04	0	0	X	X	0	0	0	0
Display Test	Normal operation (display test disabled)	0x07	X	X	X	X	X	X	X	0
Digit Type	Digits 0 through 7 are 7 segment digits	0x0C	0	0	0	0	0	0	0	0
Intensity10	1/16 (min on), digits 1 and 0	0x10	0	0	0	0	0	0	0	0
Intensity32	1/16 (min on), digits 3 and 2	0x11	0	0	0	0	0	0	0	0
Intensity54	1/16 (min on), digits 5 and 4	0x12	0	0	0	0	0	0	0	0
Intensity76	1/16 (min on), digits 7 and 6	0x13	0	0	0	0	0	0	0	0
Intensity10a	1/16 (min on), digits 1a and 0a	0x14	0	0	0	0	0	0	0	0
Intensity32a	1/16 (min on), digits 3a and 2a	0x15	0	0	0	0	0	0	0	0
Intensity54a	1/16 (min on), digits 5a and 4a	0x16	0	0	0	0	0	0	0	0
Intensity76a	1/16 (min on), digits 7a and 6a	0x17	0	0	0	0	0	0	0	0
Digit 0	Blank digit, both planes	0x60	0	0	1	0	0	0	0	0
Digit 1	Blank digit, both planes	0x61	0	0	1	0	0	0	0	0
Digit 2	Blank digit, both planes	0x62	0	0	1	0	0	0	0	0
Digit 3	Blank digit, both planes	0x63	0	0	1	0	0	0	0	0
Digit 4	Blank digit, both planes	0x64	0	0	1	0	0	0	0	0
Digit 5	Blank digit, both planes	0x65	0	0	1	0	0	0	0	0
Digit 6	Blank digit, both planes	0x66	0	0	1	0	0	0	0	0
Digit 7	Blank digit, both planes	0x67	0	0	1	0	0	0	0	0
Digit 0a	Blank digit, both planes	0x68	0	0	1	0	0	0	0	0
Digit 1a	Blank digit, both planes	0x69	0	0	1	0	0	0	0	0
Digit 2a	Blank digit, both planes	0x6A	0	0	1	0	0	0	0	0
Digit 3a	Blank digit, both planes	0x6B	0	0	1	0	0	0	0	0
Digit 4a	Blank digit, both planes	0x6C	0	0	1	0	0	0	0	0
Digit 5a	Blank digit, both planes	0x6D	0	0	1	0	0	0	0	0
Digit 6a	Blank digit, both planes	0x6E	0	0	1	0	0	0	0	0
Digit 7a	Blank digit, both planes	0x6F	0	0	1	0	0	0	0	0

The configuration register (0x01) is used to enter and exit shutdown, control the blink function, globally clear the digit data and to select between global or digit-by-digit control of intensity. The configuration register contains 7 bits (Table 3):

- S bit selects shutdown or normal operation (read/write).
- B bit selects the blink rate (read/write).
- E bit globally enables or disables the blink function (read/write).
- T bit resets the blink timing (data is not stored-transient bit).
- R bit globally clears the digit data for both planes P0 and P1 for ALL digits (data is not stored-transient bit).
- I bit selects between global or digit-by-digit control of intensity (read/write).

- P bit returns the current phase of the blink timing (read only-a write to this bit is ignored).

Table 3. Configuration Register Format

CONFIGURATION REGISTER DATA BIT	DATA BIT LABEL	STATE	FUNCTION
D7	P	0	P1 Blink Phase
D6	I	0	Intensity for all digits is controlled by one setting in the Global Intensity Register
		1	Intensity for digits is controlled by the individual settings in the Intensity10 through Intensity76a registers.
D5	R	0	Digit data for both planes P0 and P1 are unaffected
		1	Digit data for both planes P0 and P1 are cleared on the rising edge of active-low CS
D4	T	0	Blink timing counters are unaffected.
		1	Blink timing counters are reset on the rising edge of active-low CS.
D3	E	0	Blink function disabled
		1	Blink function enabled
D2	B	0	Slow Blinking. Segments blink on for 1s, off for 1s with fOSC = 4MHz.
		1	Fast Blinking. Segments blink on for 0.5s, off for 0.5s with fOSC = 4MHz.
D1	X	X	Don't care
D0	S	0	Shutdown
		1	Normal Operation

Enable the display driver with global intensity control and without blinking by writing 0x01 to register 0x04. The internal oscillator powers as the MAX6954 exits shutdown and the oscillator output is available at OSC_OUT. Notice that the 7-segment displays remain blank, as the power-up state of digit control registers 0x60 to 0x6F is 0x20 or no segments lit (see Table 2 and **Figure 3**).

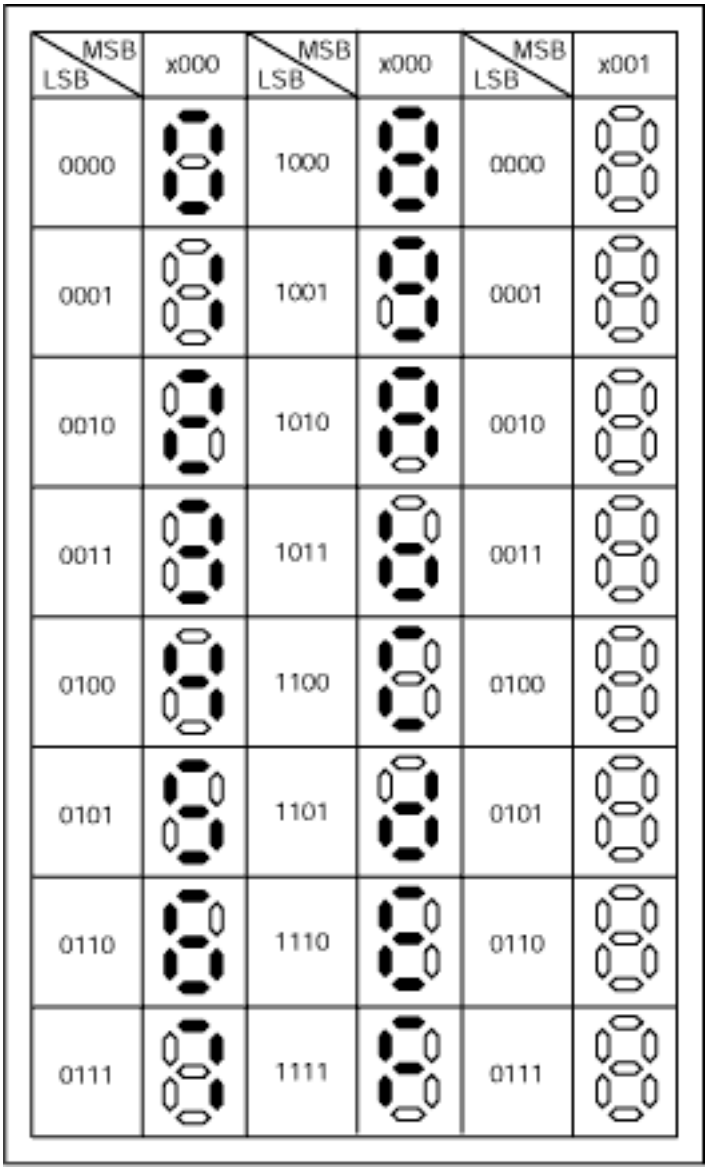

Figure 3. 7-segment display font map.

The MAX6954 includes a hexadecimal font map for 7-segment displays. Seven bits represent the hexadecimal font map; an 8th bit is used to select whether the decimal point (DP) is lit (Table 4). Digit registers are implemented with two planes, P0 and P1. Each digit is represented by 2 bytes of memory, 1 byte in plane P0 and the other in plane P1 (see Table 7). The digit registers are mapped so that a digit's data can be updated in plane P0 (registers 0x20 through 0x2F), plane P1 (registers 0x40 through 0x4F), or both planes simultaneously (registers 0x60 through 0x6F). The data in the digit registers does not control the digit segments directly for 7-segment displays. Instead, the register data is used to address a character generator that stores the data for the font (Figure 3). The lower 7 bits of the digit data (D6 to D0) select the character from the font. The most significant bit of the register data (D7) controls the DP segment of the digits; it is set to 1 to light DP, and to 0 to leave DP unlit.

Table 4. Digit Type Data Register Format

MODE	ADDRESS CODE (HEX)	REGISTER DATA							
		D7	D6	D5	D4	D3	D2	D1	D0
7-segment mode, writing digit data to use font map data with decimal place unlit	0x20 to 0x2F 0x40 to 0x4F 0x60 to 0x6F	0	Bits D6 to D0 select font character						
7-segment mode, writing digit data to use font map data with decimal place lit	0x20 to 0x2F 0x40 to 0x4F 0x60 to 0x6F	1	Bits D6 to D0 select font character						

If the blink function is disabled through the Blink Enable Bit E (Table 3) in the configuration register, then the digit register data in plane P0 is used to multiplex the display. The digit register data in P1 is not used. If the blink function is enabled, then the digit register data in both plane P0 and plane P1 are alternately used to multiplex the display. Blinking is achieved by multiplexing the LED display using data plane P0 and plane P1 on alternate phases of the blink clock.

As an example let's display the phone number for Maxim/Dallas Direct: 1 800 629 4642, using the MAX6954. We disabled the blink functionality when we programmed the configuration register, so data can be written to the 0x20 through 0x2F registers to control digit 0 through digit 7a, respectively. Using the font map in Figure 3 determine the code equivalent for each character:

Table 5. Call 800.629.4642 Example

REGISTER ADDRESS (HEX)	DIGIT	CHARACTER	FONT MAP EQUIVALENT CODE	
			DECIMAL	HEX
0x20	0	C	0000 1100	0x0C
0x28	0a	A	0000 1001	0x0A
0x21	1	1	0000 0001	0x01
0x29	1a	1	0000 0001	0x01
0x23	3	8	0000 1000	0x08
0x2B	3a	0	0000 0000	0x00
0x24	4	0	1000 0000	0x80
0x2C	4a	6	0000 0110	0x06
0x25	5	2	0000 0010	0x02
0x2D	5a	9	1000 1001	0x89
0x26	6	4	0000 0100	0x04
0x2E	6a	6	0000 0110	0x06
0x27	7	4	0000 0100	0x04
0x2F	7a	2	0000 0010	0x02

Adjust the intensity of the displays by writing to register 0x02, the global intensity control register. Intensity may be adjusted between 0x00 (minimum on, 1/16 current) and 0xFF (maximum on, 15/16 current). Digital control of display brightness can also be managed individually for each digit. For full details about adjusting digit intensity and other advanced features such as GPIO and key-scan, refer to the MAX6954 data sheet.

Table 6. Quick-Start Example Command Summary

REGISTER (HEX)	COMMAND (HEX)	FUNCTION
0x07	0x01	Enter display test mode
0x07	0x00	Exit display test mode
0x04	0x01	Exit shutdown mode, disable blinking and select global intensity control
0x20	0x0C	Write "C" to digit 0
0x28	0x0A	Write "A" to digit 0a
0x21	0x01	Write "1" to digit 1
0x29	0x01	Write "1" to digit 1a
0x23	0x08	Write "8" to digit 3
0x2B	0x00	Write "0" to digit 3a
0x24	0x80	Write "0." to digit 4
0x2C	0x06	Write "6" to digit 4a
0x25	0x02	Write "2" to digit 5
0x2D	0x89	Write "9." to digit 5a
0x26	0x04	Write "4" to digit 6
0x2E	0x06	Write "6" to digit 6a
0x27	0x04	Write "4" to digit 7
0x2F	0x02	Write "2" to digit 7a
0x02	0xFF	Set global intensity to full-scale

Table 7. Partial MAX6954/6955 Register Address Map

REGISTER	ADDRESS (COMMAND BYTE)								ADDRESS (HEX CODE)
	D15	D14	D13	D12	D11	D10	D9	D8	
Decode Mode	R/active-low W	0	0	0	0	0	0	1	0x01
Global Intensity	R/active-low W	0	0	0	0	0	1	0	0x02
Scan Limit	R/active-low W	0	0	0	0	0	1	1	0x03
Configuration	R/active-low W	0	0	0	0	1	0	0	0x04
Display Test	R/active-low W	0	0	0	0	1	1	1	0x07
Digit Type	R/active-low W	0	0	0	1	1	0	0	0x0C
Intensity 10	R/active-low W	0	0	1	0	0	0	0	0x10
Intensity 32	R/active-low W	0	0	1	0	0	0	1	0x11
Intensity 54	R/active-low W	0	0	1	0	0	1	0	0x12
Intensity 76	R/active-low W	0	0	1	0	0	1	1	0x13
Intensity 10a	R/active-low W	0	0	1	0	1	0	0	0x14
Intensity 32a	R/active-low W	0	0	1	0	1	0	1	0x15

Intensity 54a	R/active-low W	0	0	1	0	1	1	0	0x16
Intensity 76a	R/active-low W	0	0	1	0	1	1	1	0x17
Digit 0 Plane P0	R/active-low W	0	1	0	0	0	0	0	0x20
Digit 1 Plane P0	R/active-low W	0	1	0	0	0	0	1	0x21
Digit 2 Plane P0	R/active-low W	0	1	0	0	0	1	0	0x22
Digit 3 Plane P0	R/active-low W	0	1	0	0	0	1	1	0x23
Digit 4 Plane P0	R/active-low W	0	1	0	0	1	0	0	0x24
Digit 5 Plane P0	R/active-low W	0	1	0	0	1	0	1	0x25
Digit 6 Plane P0	R/active-low W	0	1	0	0	1	1	0	0x26
Digit 7 Plane P0	R/active-low W	0	1	0	0	1	1	1	0x27
Digit 0a Plane P0	R/active-low W	0	1	0	1	0	0	0	0x28
Digit 1a Plane P0	R/active-low W	0	1	0	1	0	0	1	0x29
Digit 2a Plane P0	R/active-low W	0	1	0	1	0	1	0	0x2A
Digit 3a Plane P0	R/active-low W	0	1	0	1	0	1	1	0x2B
Digit 4a Plane P0	R/active-low W	0	1	0	1	1	0	0	0x2C
Digit 5a Plane P0	R/active-low W	0	1	0	1	1	0	1	0x2D
Digit 6a Plane P0	R/active-low W	0	1	0	1	1	1	0	0x2E
Digit 7a Plane P0	R/active-low W	0	1	0	1	1	1	1	0x2F
Digit 0 Plane P1	R/active-low W	1	0	0	0	0	0	0	0x40
Digit 1 Plane P1	R/active-low W	1	0	0	0	0	0	1	0x41
Digit 2 Plane P1	R/active-low W	1	0	0	0	0	1	0	0x42
Digit 3 Plane P1	R/active-low W	1	0	0	0	0	1	1	0x43
Digit 4 Plane P1	R/active-low W	1	0	0	0	1	0	0	0x44
Digit 5 Plane P1	R/active-low W	1	0	0	0	1	0	1	0x45
Digit 6 Plane P1	R/active-low W	1	0	0	0	1	1	0	0x46
Digit 7 Plane P1	R/active-low W	1	0	0	0	1	1	1	0x47
Digit 0a Plane P1	R/active-low W	1	0	0	1	0	0	0	0x48
Digit 1a Plane P1	R/active-low W	1	0	0	1	0	0	1	0x49
Digit 2a Plane P1	R/active-low W	1	0	0	1	0	1	0	0x4A
Digit 3a Plane P1	R/active-low W	1	0	0	1	0	1	1	0x4B
Digit 4a Plane P1	R/active-low W	1	0	0	1	1	0	0	0x4C
Digit 5a Plane P1	R/active-low W	1	0	0	1	1	0	1	04D
Digit 6a Plane P1	R/active-low W	1	0	0	1	1	1	0	0x4E
Digit 7a Plane P1	R/active-low W	1	0	0	1	1	1	1	0x4F

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