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#### APPLICATION NOTE 3212

# Quick-Start: Driving 16-Segment Displays with the MAX6954

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*Abstract: This article is how-to guide, intended as a quick learning aid for engineers considering using the MAX6954 to drive 16-segment monochrome LEDs.*

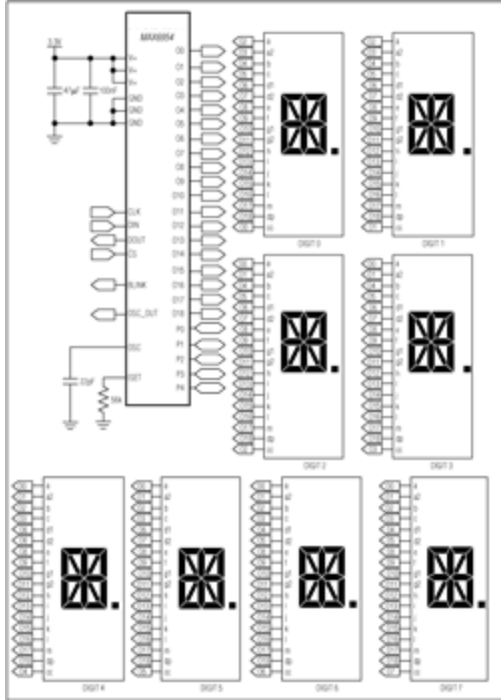
The MAX6954 is a versatile display driver, capable of controlling a mix of discrete, 7-segment, 14-segment, and 16-segment LED displays through a serial interface. This application note shows a typical application and configuration for driving eight mono-color, 16-segment LEDs.

See the [MAX6954](#) data sheet for additional information about MAX6954 features.

"[Quick-Start: Driving 7-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 7-segment and 14-segment applications, respectively.

A common application for the MAX6954 is driving up to eight 16-segment mono-color LEDs. This application note guides the user through the process of connecting the MAX6954 to 16-segment displays and configuring the internal registers to control the displays using the included 104-character 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 16-segment digits that is compatible with the MAX6954 multiplex scheme and the built in 104-character font map. The letters in Table 1 correspond to the segment labels shown in **Figure 2**. **Figure 1** illustrates an eight digit, 16-segment application circuit for the MAX6954.



[For Larger Image](#)

Figure 1. MAX6954 16-segment application circuit.



Figure 2. Segment labeling for 16-segment displays.

Table 1. Connection Scheme for Eight 16-Segment Digits

DIGIT	O0	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12	O13	O14	O15	O16	O17	O18
0	CC0		a1	a2	b	c	d1	d2	e	f	g1	g2	h	i	j	k	l	m	dp
1		CC1	a1	a2	b	c	d1	d2	e	f	g1	g2	h	i	j	k	l	m	dp
2	a1	a2	CC2		b	c	d1	d2	e	f	g1	g2	h	i	j	k	l	m	dp
3	a1	a2		CC3	b	c	d1	d2	e	f	g1	g2	h	i	j	k	l	m	dp
4	a1	a2	b	c	CC4		d1	d2	e	f	g1	g2	h	i	j	k	l	m	dp
5	a1	a2	b	c		CC5	d1	d2	e	f	g1	g2	h	i	j	k	l	m	dp
6	a1	a2	b	c	d1	d2	CC6		e	f	g1	g2	h	i	j	k	l	m	dp

7	a1	a2	b	c	d1	d2		CC7	e	f	g1	g2	h	i	j	k	l	m	dp
---	----	----	---	---	----	----	--	-----	---	---	----	----	---	---	---	---	---	---	----

Display test mode can be used to verify connections after connecting the MAX6954 to 16-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.

After verification of the connections between the MAX6954 and the 16-segment displays the device must be configured for operation with 16-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 16-segment font map is selected and the device is set to scan the maximum eight digits. The default decode mode (0x01) and digit type (0x0C) register settings are correct for 16-segment applications.

MSB LSB	x000	x001	x010	x011	x100	x101	x110	x111
0000	0	1	2	3	4	5	6	7
0001	8	9	A	B	C	D	E	F
0010	G	H	I	J	K	L	M	N
0011	O	P	Q	R	S	T	U	V
0100	W	X	Y	Z	[	]	^	_
0101	0	1	2	3	4	5	6	7
0110	8	9	A	B	C	D	E	F
0111	G	H	I	J	K	L	M	N
1000	O	P	Q	R	S	T	U	V
1001	W	X	Y	Z	[	]	^	_
1010	0	1	2	3	4	5	6	7
1011	8	9	A	B	C	D	E	F
1100	G	H	I	J	K	L	M	N
1101	O	P	Q	R	S	T	U	V
1110	W	X	Y	Z	[	]	^	_
1111	0	1	2	3	4	5	6	7

Figure 3. 16-Segment display font map.

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	16-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 eight 16-segment digits: 0, 1, 2, 3, 4, 5, 6, 7	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 16 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
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

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
		1	P0 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 Intensity76 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 $f_{OSC} = 4\text{MHz}$ .
		1	Fast Blinking. Segments blink on for 0.5s, off for 0.5s with $f_{OSC} = 4\text{MHz}$ .
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 16-segment displays remain blank, as the power-up state of digit control registers 0x60 to 0x67 is 0x20 or no segments lit (see Table 2 and **Figure 3**).

The MAX6954 includes a 104-character ASCII font map for 16-segment displays. The characters follow the standard ASCII font, with the addition of the following common symbols: £, €, ¥, °, μ, ±, ≠, and ⌘. Seven bits represent the 104-character 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 0x27), plane P1 (registers 0x40 through 0x47), or both planes simultaneously (registers 0x60 through 0x67). The data in the digit registers does not control the digit segments directly for 16-segment displays. Instead, the register data is used to address a character generator that stores the data for the 16-segment 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
16-segment mode, writing digit data to use font map data with decimal place unlit	0x20 to 0x27 0x40 to 0x47 0x60 to 0x67	0	Bits D6 to D0 select font character 0 to 127						
16-segment mode, writing digit data to use font map data with decimal place lit	0x20 to 0x27 0x40 to 0x47 0x60 to 0x67	1	Bits D6 to D0 select font character 0 to 127						

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 eight characters, "MAXIM-IC," using the MAX6954. We disabled the blink functionality when we programmed the configuration register, so data can be written to the 0x20 through 0x27 registers to control digit 0 through digit 7, respectively. Using the font map in Figure 3 determine the code equivalent for each character:

**Table 5. MAXIM-IC Example**

REGISTER ADDRESS (HEX)	DIGIT	CHARACTER	FONT MAP EQUIVALENT CODE	
			DECIMAL	HEX
0x20	0	M	0100 1101	0x4D
0x21	1	A	0100 0001	0x41
0x22	2	X	0101 1000	0x58
0x23	3	I	0100 1001	0x49
0x24	4	M	0100 1101	0x4D
0x25	5	-	0010 1101	0x2D
0x26	6	I	0100 1001	0x49
0x27	7	C	0100 0011	0x43

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	0x4D	Write "M" to digit 0
0x21	0x41	Write "A" to digit 1
0x22	0x58	Write "X" to digit 2
0x23	0x49	Write "I" to digit 3
0x24	0x4D	Write "M" to digit 4
0x25	0x2D	Write "-" to digit 5
0x26	0x49	Write "I." to digit 6
0x27	0x43	Write "C" to digit 7
0x02	0xFF	Set globalk intensity to full-scale

**Table 7. Partial MAX6954/MAX6955 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
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 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

### Related Parts

<a href="#">MAX6954</a>	4-Wire Interfaced, 2.7V to 5.5V LED Display Driver with I/O Expander and Key Scan	<a href="#">Free Samples</a>
<a href="#">MAX6955</a>	2-Wire Interfaced, 2.7V to 5.5V LED Display Driver with I/O Expander and Key Scan	<a href="#">Free Samples</a>

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