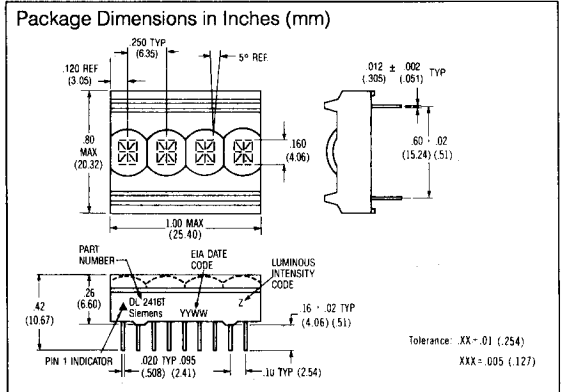
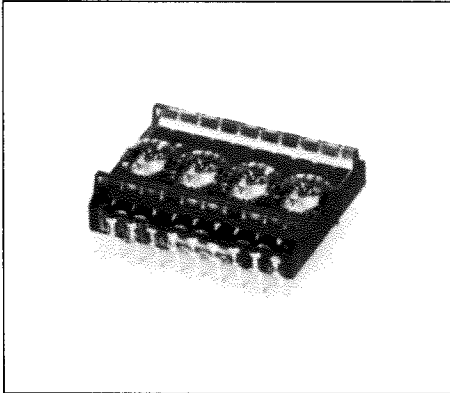


## .160" Red, 4-Character 16 Segment Plus Decimal Alphanumeric Intelligent Display® With Memory/Decoder/Driver



### FEATURES

- 0.16" x 0.125 Magnified Character
- Wide Viewing Angle, X Axis  $\pm 45^\circ$ , Y Axis  $\pm 55^\circ$
- Close Multi-line Spacing, 0.8" Centers
- Rugged Solid Plastic Encapsulated Package
- Fast Access Time, 110 ns @ 25°C
- Full Size for Stationery Equipment
- Built-In Memory
- Built-In Character Generator
- Built-In Multiplex and LED Drive Circuitry
- Direct Access to Each Digit Independently and Asynchronously
- Independent Cursor Function
- 17th Segment for Improved Punctuation Marks
- Memory Clear Function that Clears Character and Cursor Memory Simultaneously
- True Blanking for Intensity Dimming Applications
- Brightness Control for 100%, 85%, 70%, and 57% Brightness Levels
- End Stackable, 4 Character Package
- Intensity Coded for Display Uniformity
- Extended Operating Temperature Range:  $-40^\circ\text{C}$  to  $+85^\circ\text{C}$
- Superior ESD Immunity
- 100% Burned in and Tested
- Wave Solderable
- TTL Compatible over Operating Temperature Range

### DESCRIPTION

The DL2416T is a four digit display module with 16 bar segments plus a decimal and a built-in CMOS integrated circuit.

The integrated circuit contains memory, ASCII character generator, multiplexing circuitry and drivers. Data entry is asynchronous and can be random. A display system can be built using any number of DL2416s since each digit in any DL2416T can be addressed independently and will continue to display the character last stored until replaced by another.

System interconnection is also straightforward. The least significant two address bits ( $A_0, A_1$ ) are normally connected to the like named inputs of all DL2416Ts in the system. With two chip enables ( $CE_1$  and  $CE_2$ ), four DL2416Ts (16 characters) can easily be interconnected without a decoder.

Data lines are connected to all DL2416Ts directly and in parallel, as is the write line ( $WR$ ). The display will then behave as a write-only memory.

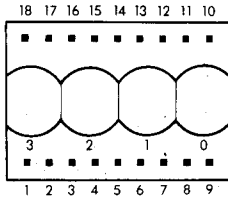
The DL2416T has several features superior to competitive devices. 100% pre-burned in processing assures users that the device will function in more stressful assembly and use environments. The full width character "J" gives better readability under adverse conditions, and the "true blanking" allow the designer to dim the display for more flexibility of display presentation. The  $\bar{C}LR$  clear function will clear the cursor RAM and the ASCII character RAM, simultaneously. Finally, a new brightness control feature allows programming the displays at 100%, 85%, 70%, and 57% brightness levels.

## DESCRIPTION (Continued)

All products are 100% burned-in and tested, then subjected to out-going AQL's of .25% for brightness matching, visual alignment and dimensions, .065% for electrical and functional.

See Appnote 14 for applications information.

### TOP VIEW



Pin	Function	Pin	Function
1	CE1 Chip Enable	10	Gnd
2	CE2 Chip Enable	11	D0 Data Input
3	CLR Clear	12	D1 Data Input
4	CUE Cursor Enable	13	D2 Data Input
5	CU Cursor Select	14	D3 Data Input
6	WR Write	15	D6 Data Input
7	A1 Digit Select	16	D5 Data Input
8	A0 Digit Select	17	D4 Data Input
9	V <sub>CC</sub>	18	BL Display Blank

## Maximum Ratings

Supply Voltage V <sub>CC</sub>	-0.5 V to +6.0 Vdc
Voltage, Any Pin Respect to GND	-0.5 V to (V <sub>CC</sub> + 0.5) Vdc
Operating Temperature	-40°C to +85°C
Storage Temperature	-40°C to +100°C
Relative Humidity (non condensing) @85°C	85%
Maximum Solder Temperature, 1.59 mm (0.063") below Seating Plane, t<5 sec	260°C

## Optical Characteristics

Spectral Peak Wavelength	660 nm typ.
Magnified digit size	.160" x .125"
Time Averaged Luminous Intensity (100% brightness, 8 segments/digit, V <sub>CC</sub> = 5 V)	0.5 mcd/digit min. 1.0 mcd/digit typ.
LED to LED Intensity Matching	1.8:1.0 max.
Device to Device Intensity Matching (one bin)	1.5:1.0 max.
Bin to Bin Intensity Matching	1.9:1.0 max.
Viewing Angle (off normal axis)	
Horizontal	± 45°
Vertical	± 55°

## DC CHARACTERISTICS

Parameter	-40°C			+25°C			+85°C			Units	Conditions
	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.		
I <sub>CC</sub> <sup>(1)</sup> 4 Digits on 10 segments/digit		100	130		85	115		70	100	mA	V <sub>CC</sub> = 5 V
I <sub>CC</sub> Cursor <sup>(1, 2)</sup>		140	185		120	165		100	145	mA	V <sub>CC</sub> = 5 V
I <sub>CC</sub> Blank <sup>(1)</sup>		2.0	5.0		1.5	4.0		1.0	2.7	mA	V <sub>CC</sub> = 5 V, $\overline{BL}$ = 0.8 V
I <sub>IL</sub> (all inputs)		80	180		60	160		45	90	μA	V <sub>IN</sub> = 0.8 V, V <sub>CC</sub> = 5.0 V
V <sub>IH</sub>	2.0			2.0			2.0			V	V <sub>CC</sub> = 5 V ± 0.5 V
V <sub>IL</sub>			0.8			0.8			0.8	V	V <sub>CC</sub> = 5 V ± 0.5 V

1. Measured at 5 sec.

2. 60 sec max duration.

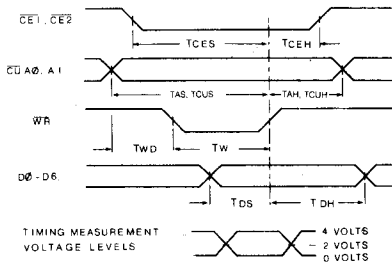
**AC CHARACTERISTICS** Guaranteed Minimum Timing Parameters @  $V_{cc}=4.5V \leq V_{cc} \leq 5.5V$

Parameter	Symbol	-40°C (ns)	+25°C (ns)	+85°C (ns)	Units
Address Set Up Time	$T_{AS}$	10	10	10	ns
Cursor Set Up Time	$T_{CUS}$	10	10	10	ns
Chip Enable Set Up Time	$T_{CES}$	0	0	0	ns
Clear Disable	$T_{CLRD}$	1	1	1	$\mu s$
Write Time	$T_W$	60	70	90	ns
Data Set Up Time	$T_{DS}$	20	30	50	ns
Chip Enable Hold Time	$T_{CEH}$	0	0	0	ns
Cursor Hold Time	$T_{CUH}$	20	30	40	ns
Address Hold Time	$T_{AH}$	20	30	40	ns
Data Hold Time	$T_{DH}$	20	30	40	ns
Clear Time	$T_{CLR}$	1	1	1	$\mu s$
Total Access Time <sup>(1)</sup>	$T_{ACC}$	90	110	140	ns

Notes: 1. Access time  $T_{ACC}=T_{AS}+T_W+T_{DH}$ .  
 2. Digit multiplex frequency may vary from 200Hz to 800 Hz.

3.  $T_{CLR}$  = Time to clear character RAM, cursor RAM, counter chain, and the display.  
 2.  $T_{CLRD}$  = Must be inactive before next write cycle.

**TIMING CHARACTERISTICS**  
**WRITE CYCLE WAVEFORMS**



**LOADING DATA**

Setting the chip enable ( $\overline{CE1}$ ,  $\overline{CE2}$ ) to their true state will enable data loading. The desired data code (D0-D6) and digit address ( $A_0$ ,  $A_1$ ) must be held stable during the write cycle for storing new data.

Data entry may be asynchronous and random. (Digit 0 is defined as right hand digit with  $A_1 = A_2 = 0$ .)

Clearing the entire internal four-digit memory can be accomplished by holding the clear (CLR) low for 1  $\mu s$  minimum. The clear function will clear both the ASCII RAM and the cursor RAM. Loading an illegal data code will display a blank.

**TYPICAL LOADING DATA STATE TABLE**

CONTROL				ADDRESS		DATA						DISPLAY DIGIT							
BL	CE1	CE2	CUE	CU	WR	CLR	A1	A0	D6	D5	D4	D3	D2	D1	D0	3	2	1	0
H	X	X	L	X	H	H	PREVIOUSLY LOADED DISPLAY									G	R	E	Y
H	X	X	L	X	X	H	X	X	X	X	X	X	X	X	X	G	R	E	Y
H	X	H	L	X	X	H	X	X	X	X	X	X	X	X	X	G	R	E	Y
H	L	L	L	H	L	H	L	L	H	L	L	H	L	H	G	R	E	E	
H	L	L	L	H	L	H	L	H	H	L	H	L	H	L	H	G	R	U	E
H	L	L	L	H	L	H	H	L	H	L	L	H	L	L	L	G	L	U	E
H	L	L	L	H	L	H	H	H	H	L	L	L	H	L	L	B	L	U	E
L	X	X	X	X	H	H	X	X	BLANK DISPLAY										
H	L	L	L	H	L	H	H	H	H L L L H H H H						G	L	U	E	
H	X	X	L	X	H	L	X	X	CLEARS CHARACTER DISPLAYS										
H	L	L	L	H	L	H	X	X	SEE CHARACTER CODE						SEE CHARACTER SET				

X = DON'T CARE

## LOADING CURSOR

Setting the chip enables ( $\overline{CE1}$ ,  $\overline{CE2}$ ) and cursor select ( $\overline{CU}$ ) to their true state will enable cursor loading. A write ( $\overline{WR}$ ) pulse will now store or remove a cursor into the digit location addressed by  $A_0$ ,  $A_1$ ; as defined in data entry. A cursor will be stored if  $D_0=1$ ; and will be removed if  $D_0=0$ . The cursor ( $\overline{CU}$ ) pulse width should not be less than the write ( $\overline{WR}$ ) pulse or erroneous data may appear in the display.

For those users not requiring the cursor, the cursor enable signal (CUE) may be tied low to disable the display of the cursor function. A flashing cursor can be realized by simply pulsing CUE. If the cursor has been loaded to any or all positions in the display, then CUE will control whether the cursor(s) or the characters appear. CUE does not affect the contents of cursor memory.

LOADING CURSOR STATE TABLE

CONTROL								ADDRESS		DATA								DISPLAY DIGIT			
BL	$\overline{CE1}$	$\overline{CE2}$	CUE	$\overline{CU}$	$\overline{WR}$	CLR		A1	A0	D6	D5	D4	D3	D2	D1	D0	3	2	1	0	
H	X	X	L	X	H	H											B	E	A	R	
H	X	X	H	X	H	H											B	E	A	R	
H	L	L	H	L	L	H		L	L	X	X	X	X	X	X		B	E	A	☒	
H	L	L	H	L	L	H		L	H	X	X	X	X	X	H		B	E	A	☒	
H	L	L	H	L	L	H		H	L	X	X	X	X	X	H		B	☒	☒	☒	
H	L	L	H	L	L	H		H	H	X	X	X	X	X	H		☒	☒	☒	☒	
H	L	L	H	L	L	H		H	L	X	X	X	X	X	L		☒	E	☒	☒	
H	X	X	L	X	H	H											B	E	A	R	
H	L	L	L	L	L	H		H	H	X	X	X	X	X	L		B	E	A	R	
H	X	X	H	X	H	H											B	E	☒	☒	

X = DON'T CARE

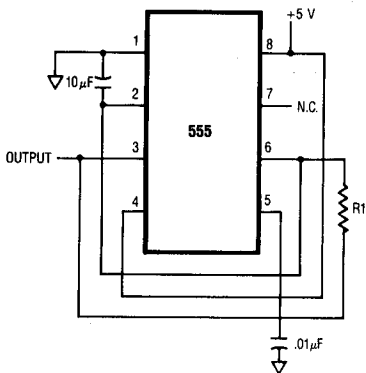
## DISPLAY BLANKING

Blanking the display may be accomplished by loading a blank or space into each digit of the display or by using the ( $\overline{BL}$ ) display blank input.

Setting the ( $\overline{BL}$ ) input low does not affect the contents of either data or cursor memory. A flashing display can be realized by pulsing ( $\overline{BL}$ ).

A flashing circuit can easily be constructed using a 555 astable multivibrator. Figure 1 illustrates a circuit in which varying  $R1$  (100K ~ 10K) will have a flash rate of 1 Hz ~ 10 Hz.

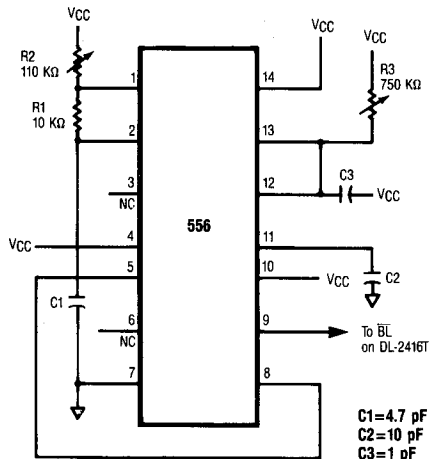
FIGURE 1. FLASHING CIRCUIT FOR DL 2416T USING A 555



The display can be dimmed by pulse width modulating the ( $\overline{BL}$ ) at a frequency sufficiently fast to not interfere with the internal clock. This clock frequency may vary from 200 Hz to 1.3 KHz. The dimming signal frequency should be 2.5 KHz or higher. Dimming the display also reduces power consumption.

An example of a simple dimming circuit using a 556 is illustrated in Figure 2. Adjusting potentiometer  $R2$  will dim the display through frequency modulation (2.5 KHz to 4.4 KHz). Adjusting potentiometer  $R3$  will dim the display by increasing the negative pulse width (10% to 50%).

FIGURE 2. DIMMING CIRCUIT FOR DL 2416T USING A 556

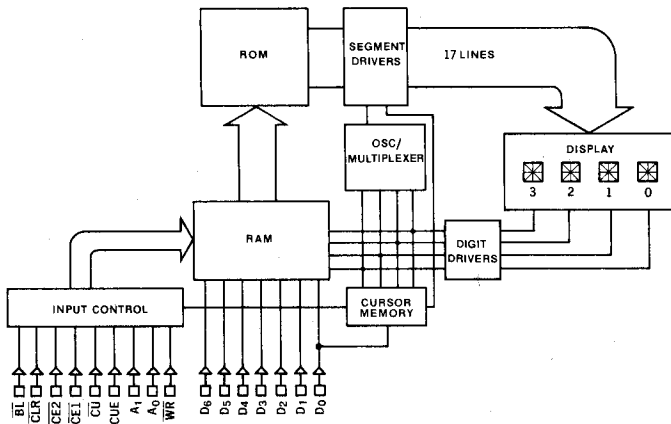


C1=4.7 pF  
C2=10 pF  
C3=1 pF

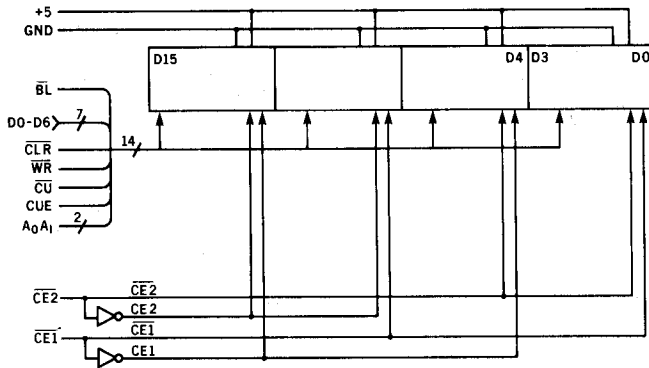
CHARACTER SET

D0	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
D1	L	L	H	H	L	L	H	H	L	L	H	H	L	L	H	H	L	H
D2	L	L	L	L	L	H	H	H	H	L	L	L	L	H	H	H	H	H
D3	L	L	L	L	L	L	L	L	L	H	H	H	H	H	H	H	H	H
D6/D5/D4/HEX	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F		
L H L	2	!	"	#	\$	%	&	'	<	>	*	+	,	-	.	/		
L H H	3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?	
H L L	4	a	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	
H L H	5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_	

All other input codes display "blank"



Internal Block Diagram



Typical Schematic for 16 Digit System

## DESIGN CONSIDERATIONS

For details on design and applications of the DL 2416T utilizing standard bus configurations in multiple display systems, or parallel I/O devices, such as the 8255 with an 8080 or memory mapped addressing on processors such as the 8080, Z80, 6502, 8748, or 6800 refer to Appnote 14, and 20, in the current Siemens Optoelectronic Data Book.

## ELECTRICAL AND MECHANICAL CONSIDERATIONS

### VOLTAGE TRANSIENT SUPPRESSION

It is highly recommended that the display and the components that interface with the display be powered by the same supply to avoid logic inputs higher than  $V_{CC}$ . Additionally, the LEDs may cause transients in the power supply line while they change display states. Common practice is to place .01  $\mu F$  capacitors close to the displays across  $V_{CC}$  and GND, one for each display, and one 10  $\mu F$  capacitor for every second display.

### ESD PROTECTION

The metal gate CMOS IC of the DL 2416T is extremely immune to ESD damage. However, users of these devices are encouraged to take all the standard precautions normal for CMOS components. These include properly grounding personnel, tools, tables, and transport carriers that come in contact with unshielded parts. Where these conditions are not, or cannot be met, keep the leads of the device shorted together or the parts in anti-static packaging.

### SOLDERING CONSIDERATIONS

The DL 2416T can be hand soldered with SN63 solder using a grounded iron set to 260°C.

Wave soldering is also possible following these conditions: Preheat that does not exceed 93°C on the solder side of the PC board or a package surface temperature of 85°C. Water soluble organic acid flux (except carboxylic acid) or resin-based RMA flux without alcohol can be used.

Wave temperature of 245°C  $\pm$  5°C with a dwell between 1.5 sec. to 3.0 sec. Exposure to the wave should not exceed temperatures above 260°C, for 5 seconds at 0.063" below the seating plane. The packages should not be immersed in the wave.

### POST SOLDER CLEANING PROCEDURES

The least offensive cleaning solution is hot D.I. water (60°C) for less than 15 minutes. Addition of mild saponifiers is acceptable. Do not use commercial dishwasher detergents.

For faster cleaning, solvents may be used. Care should be exercised in choosing these as some may chemically attack the nylon package. Maximum exposure should not exceed two minutes at elevated temperatures. Acceptable solvents are TF (trichlorotrifluoroethane), TA, 111 Trichloroethane, and unheated acetone.<sup>(1)</sup>

Unacceptable solvents contain alcohol, methanol, methylene chloride, ethanol, TP35, TCM, TMC, TMS+, TE, and TES. Since many commercial mixtures exist, you should contact your solvent vendor for chemical composition information. Some major solvent manufacturers are: Allied Chemical Corporation, Specialty Chemical Division, Morristown, NJ;

Baron-Blakeslee, Chicago, IL; Dow Chemical, Midland, MI; E.I. DuPont de Nemours & Co., Wilmington, DE.

For further information refer to Appnotes 18 and 19 in the current Siemens Optoelectronic Data Book.

An alternative to soldering and cleaning the display modules is to use sockets. Naturally, 18 pin DIP sockets .600" wide with .100" centers work well for single displays. Multiple display assemblies are best handled by longer SIP sockets or DIP sockets when available for uniform package alignment. Socket manufacturers are Aries Electronics, Inc., Frenchtown, NJ; Garry Manufacturing, New Brunswick, NJ; Robinson-Nugent, New Albany, IN; and Samtec Electronic Hardware, New Albany, IN.

For further information refer to Appnote 22 in the current Siemens Optoelectronic Data Book.

### OPTICAL CONSIDERATIONS

The .160" high characters of the DL 2416T allow readability up to eight feet. Proper filter selection will allow the user to build a display that can be utilized over this distance.

Filters allow the user to enhance the contrast ratio between a lit LED and the character background. This will maximize discrimination of different characters as perceived by the display user. The only limitation is cost. The cost/benefit ratio for filters can be maximized to the user's benefit by first considering the ambient lighting environment.

Incandescent (with almost no green) or fluorescent (with almost no red) lights do not have the flat spectral response of sunlight. Plastic band-pass filters are inexpensive and effective in optimizing contrast ratios. The DL 2416T is a standard red display and should be matched with a long wavelength pass filter in the 600 nm to 620 nm range. For display systems of multiple colors (using other Siemens' displays), neutral density grey filters offer the best compromise.

Additional contrast enhancement can be gained through shading the displays. Plastic band-pass filters with built-in louvers offer the "next step up" in contrast improvement. Plastic filters can be further improved with anti-reflective coatings to reduce glare. The trade-off is "fuzzy" characters. Mounting the filters close to the display reduces this effect. Care should be taken not to overheat the plastic filters by allowing for proper air flow.

Optimal filter enhancements for any condition can be gained through the use of circular polarized, anti-reflective, band-pass filters. The circular polarizing further enhances contrast by reducing the light that travels through the filter and reflects back off the display to less than 1%.

Several filter manufacturers supply quality filter materials. Some of them are: Panelgraphic Corporation, W. Caldwell, NJ; SGL Homalite, Wilmington, DE; 3M Company, Visual Products Division, St. Paul, MN; Polaroid Corporation, Polarizer Division, Cambridge, MA; Marks Polarized Corporation, Deer Park, NY; Hoya Optics, Inc., Fremont, CA.

One last note on mounting filters. Recessing display and bezel assemblies is an inexpensive way to provide a shading effect in overhead lighting situations. Several Bezel manufacturers are: R.M.F. Products, Batavia, IL; Nobex Components, Griffith Plastic Corp., Burlingame, CA; Photo Chemical Products of California, Santa Monica, CA; I.E.E.-Atlas, Van Nuys, CA.

Refer to Siemens Appnote 23 for further information.

<sup>(1)</sup>Some commercial names for acceptable compounds are: Basic TF, Arkhone P, Genesolve D, Blaco-tron TF, Freon TA, Genesolve DA, and Blaco-tron TA.