TYPES SN54143, SN54144, SN74143, SN74144
4-BIT COUNTER/LATCH, SEVEN-SEGMENT LED/LAMP DRIVERS

NOVEMBER 1971—REVISED DECEMBER 1983

- **Choice of Driver Outputs:**

  SN54143 and SN74143 have 15 mA Constant-Current Outputs for Driving Common-Anode LED's such as TIL302 or TIL303 without Series Resistors

  SN54144 and SN74144 Drive High-Current Lamps, Numitrons†, or LED's from Saturated Open-Collector Outputs

- **Universal Logic Capabilities**

  Ripple Blanking of Extraneous Zeros
  Latch Outputs Can Drive Logic Processors Simultaneously

  Decimal Point Driver Is Included

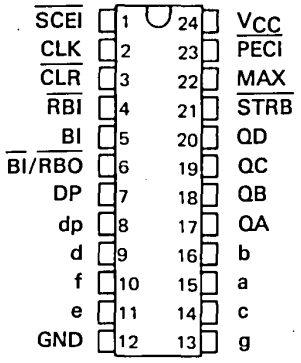
- **Synchronous BCD Counter Capability Includes:**

  Cascadable to N-Bits

  Look-Ahead-Enable Techniques Minimize Speed Degradation When Cascaded for Large-Word Display

  Direct Clear Input

SN54143, SN54144 . . . J OR W PACKAGE
SN74143, SN74144 . . . J OR N PACKAGE
(TOP VIEW)



description

These TTL MSI circuits contain the equivalent of 86 gates on a single chip. Logic inputs and outputs are completely TTL compatible. The buffered inputs are implemented with relatively large resistors in series with the bases of the input transistors to lower drive-current requirements to one-half of that required for a standard Series 54/74 TTL input. The serial-count-enable, actually two internal emitters, is rated as one standard Series 54/74 load. The logic outputs, except $\overline{RBO}$, have active pull-ups.

The SN54143 and SN74143 driver outputs are designed specifically to maintain a relatively constant on-level sink current of approximately 15 milliamperes from output "a" through "g" and seven milliamperes from output "dp" over a voltage range from one to five volts. Any number of LED's in series may be driven as long as the output voltage rating is not exceeded.

The SN54144 and SN74144 have high-sink-current saturated outputs for driving indicators having voltage ratings up to 15 volts or requiring up to 25 milliamperes drive. The SN54144 sinks 20 milliamperes and the SN74144 sinks 25 milliamperes at an on-level voltage of 0.6 volts across their respective operating temperature ranges.

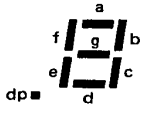
All inputs are diode-clamped to minimize transmission-line effects, thereby simplifying system design. Maximum clock frequency is typically 18 megahertz and power dissipation is typically 280 milliwatts. The SN54143 and SN54144 are characterized for operation over the full military temperature range of −55°C to 125°C; the SN74143 and SN74144 are characterized for operation from 0°C to 70°C.

† Trademark of RCA

description (continued)

Functions of the inputs and outputs of these devices are as follows:

FUNCTION	PIN NO.	DESCRIPTION
CLEAR INPUT	3	When low, resets and holds counter at 0. Must be high for normal counting.
CLOCK INPUT	2	Each positive-going transition will increment the counter provided that the circuit is in the normal counting mode (serial and parallel count enable inputs low, clear input high).
PARALLEL COUNT ENABLE INPUT (PCEI)	23	Must be low for normal counting mode. When high, counter will be inhibited. Logic level must not be changed when the clock is low.
SERIAL COUNT ENABLE INPUT (SCEI)	1	Must be low for normal counting mode, also must be low to enable maximum count output to go low. When high, counter will be inhibited and maximum count output will be driven high. Logic level must not be changed when the clock is low.
MAXIMUM COUNT OUTPUT	22	Will go low when the counter is at 9 and serial count enable input is low. Will return high when the counter changes to 0 and will remain high during counts 1 through 8. Will remain high (inhibited) as long as serial count enable input is high.
LATCH STROBE INPUT	21	When low, data in latches follow the data in the counter. When high, the data in the latches are held constant, and the counter may be operated independently.
LATCH OUTPUTS (Q_A, Q_B, Q_C, Q_D)	17, 18, 19, 20	The BCD data that drives the decoder can be stored in the 4-bit latch and is available at these outputs for driving other logic and/or processors. The binary weights of the outputs are: $Q_A = 1$, $Q_B = 2$, $Q_C = 4$, $Q_D = 8$.
DECIMAL POINT INPUT	7	Must be high to display decimal point. The decimal point is not displayed when this input is low or when the display is blanked.
BLANKING INPUT ($\overline{BI}$)	5	When high, will blank (turn off) the entire display and force $\overline{RBO}$ low. Must be low for normal display. May be pulsed to implement intensity control of the display.
RIPPLE-BLANKING INPUT ($\overline{RBI}$)	4	When the data in the latches is BCD 0, a low input will blank the entire display and force the $\overline{RBO}$ low. This input has no effect if the data in the latches is other than 0.
RIPPLE-BLANKING OUTPUT ($\overline{RBO}$)	6	Supplies ripple blanking information for the ripple blanking input of the next decade. Provides a low if $\overline{BI}$ is high, or if $\overline{RBI}$ is low and the data in the latches in BCD 0; otherwise, this output is high. This pin has a resistive pull-up circuit suitable for performing a wire-AND function with any open-collector output. Whenever this pin is low the entire display will be blanked; therefore, this pin may be used as an active-low blanking input.
LED/LAMP DRIVER OUTPUTS (a, b, c, d, e, f, g, dp)	15, 16, 14, 9 11, 10, 13, 8	Outputs for driving seven-segment LED's or lamps and their decimal points. See segment identification and resultant displays on following page.



SEGMENT IDENTIFICATION

NUMERICAL DESIGNATIONS—RESULTANT DISPLAYS

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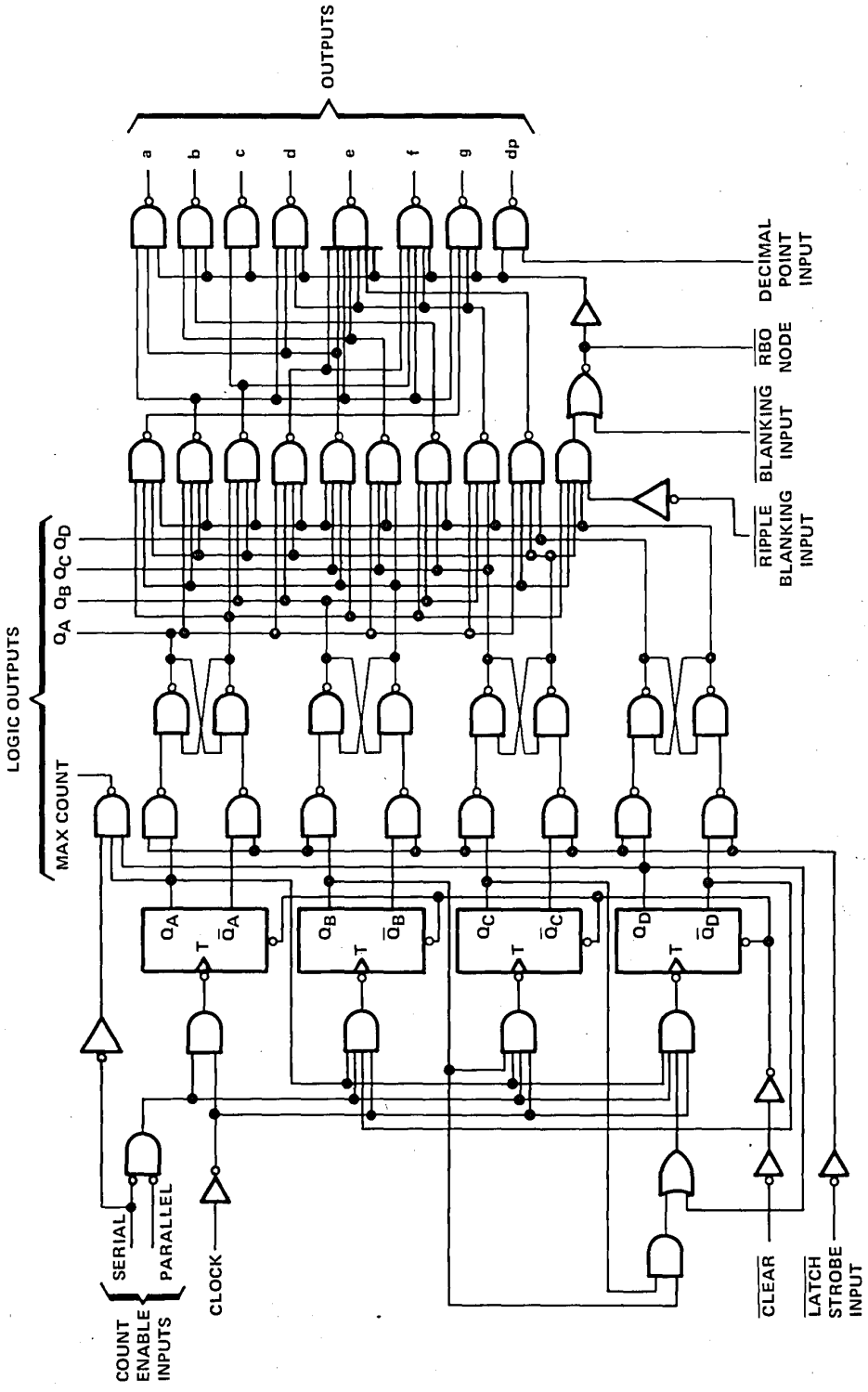
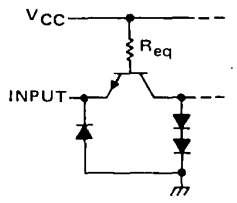
logic diagram



schematics of inputs and outputs

'143, '144

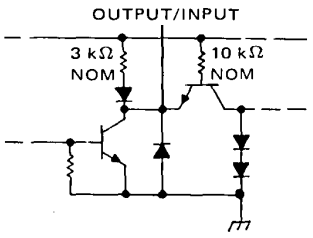
EQUIVALENT OF EACH INPUT EXCEPT $\overline{BI}/\overline{RBO}$



SCEI: R_{eq} = 4 kΩ NOM
Other inputs: R_{eq} = 8 kΩ NOM

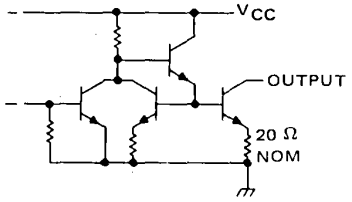
'143, '144

EQUIVALENT OF $\overline{BI}/\overline{RBO}$



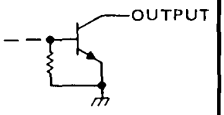
'143

TYPICAL OF ALL OUTPUTS EXCEPT $\overline{BI}/\overline{RBO}$



'144

TYPICAL OF ALL OUTPUTS EXCEPT $\overline{BI}/\overline{RBO}$



absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Supply voltage, V_{CC} (see Note 1) . . . . . 7 V
Input voltage . . . . . 5.5 V
Off-state voltage at outputs "a" thru "g" and "dp", '144 . . . . . 15 V
Off-state current at outputs "a" thru "g" and "dp", '143 . . . . . 250 μA
Continuous total power dissipation at (or below) 70°C free-air temperature (see Note 2) . . . . . 1.4 W
Operating free-air temperature range: SN54' Circuits . . . . . −55°C to 125°C
SN74' Circuits . . . . . 0°C to 70°C
Storage temperature range . . . . . −65°C to 150°C

NOTES: 1. Voltage values are with respect to network ground terminal.
2. For the SN54143 and SN54144 in the N and W packages, this rating applies at (or below) 80°C free-air temperature. For operation above this temperature, derate linearly at the rate of 11.7 mW/°C for the W package and 14.7 mW/°C for the N package. No derating is required for these devices in the J package.

recommended operating conditions

		SN54143, SN54144			SN74143, SN74144			UNIT
		MIN	NOM	MAX	MIN	NOM	MAX	
Supply voltage, V_{CC}		4.5	5	5.5	4.75	5	5.25	V
On-state voltage at outputs a thru g and dp ('143 only)		1		5	1		5	V
High-level output current, I_{OH}	Q_A, Q_B, Q_C, Q_D			−240			−240	μA
	Maximum count			−560			−560	
	$\overline{RBO}$			−120			−120	
Low-level output current, I_{OL}	Q_A, Q_B, Q_C, Q_D, $\overline{RBO}$			4.8			4.8	mA
	Maximum count			11.2			11.2	
Clock pulse width, $t_{w(clock)}$	High logic level	25			25			ns
	Low logic level	55			55			
Clear pulse width, $t_{w(clear)}$		25			25			ns
Setup time, t_{su}	Serial and parallel carry	30↑			30↑			ns
	Clear inactive state	60↑			60↑			
Operating free-air temperature, T_A		−55		125	0		70	°C

↑The arrow indicates that the rising edge of the clock pulse is used for reference.

TEXAS INSTRUMENTS
POST OFFICE BOX 225012 • DALLAS, TEXAS 75265

electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER			TEST CONDITIONS†	SN54143, SN74143			SN54144, SN74144			UNIT
				MIN	TYP‡	MAX	MIN	TYP‡	MAX	
V_{IH}	High-level input voltage			2			2			V
V_{IL}	Low-level input voltage					0.8			0.8	V
V_{IK}	Input clamp voltage		V_{CC} = MIN, I_I = −12 mA			−1.5			−1.5	V
V_{OH}	High-level output voltage	$\overline{RBO}$	V_{CC} = MIN, V_{IH} = 2 V, V_{IL} = 0.8 V, I_{OH} = MAX	2.4			2.4			V
		Q_A, Q_B, Q_C, Q_D								
		Maximum count								
V_{OL}	Low-level output voltage	Q_A, Q_B, Q_C, Q_D, $\overline{RBO}$	V_{CC} = MIN, V_{IH} = 2 V, V_{IL} = 0.8 V, I_{OL} = MAX			0.4			0.4	V
		Maximum count								
$V_{O(off)}$	Off-state output voltage	Outputs a thru g, dp	V_{CC} = MAX, I_{OH} = 250 μA	7			15			V
$V_{O(on)}$	On-State output voltage	Outputs a thru g, dp	V_{CC} = MIN, See Note 3						0.6	V
$I_{O(on)}$	On-state output current	Outputs a thru g	V_{CC} = MIN, V_O = 1 V	9	15					mA
			V_{CC} = 5 V, V_O = 2 V		15					
			V_{CC} = MAX, V_O = 5 V		15	22				
		Output dp	V_{CC} = MIN, V_O = 1 V	4.5	7					
			V_{CC} = 5 V, V_O = 2 V		7					
			V_{CC} = MAX, V_O = 5 V		7	12				
I_I	Input current at maximum input voltage		V_{CC} = MAX, V_I = 5.5 V			1			1	mA
I_{IH}	High-level input current	Serial carry	V_{CC} = MAX, V_I = 2.4 V			40			40	μA
		$\overline{RBO}$ node		−0.12	−0.5		−0.12	−0.5		mA
		Other inputs				20			20	μA
I_{IL}	Low-level input current	Serial carry	V_{CC} = MAX, V_I = 0.4 V, See Note 4			−1.6			−1.6	mA
		$\overline{RBO}$ node			−1.5	−2.4		−1.5	−2.4	
		Other inputs				−0.8			−0.8	
I_{OS}	Short-circuit output current	Q_A, Q_B, Q_C, Q_D	V_{CC} = MAX	−9		-27.5	−9		−27.5	mA
		Maximum count		−15		−55	−15		−55	
I_{CC}	Supply current		V_{CC} = MAX, See Note 5		56	93		56	93	mA

† For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions for the applicable type.
‡ All typical values are at V_{CC} = 5 V, T_A = 25°C.

NOTES: 3. For SN54144, I_{OL} = 20 mA; for SN74144, I_{OL} = 25 mA.
4. I_{IL} at $\overline{RBO}$ node is tested with $\overline{BI}$ grounded and RBI at 4.5 V.
5. I_{CC} is measured after the following conditions are established:
a) $\overline{Strobe}$ = $\overline{RBI}$ = DP = 4.5 V
b) Parallel count enable = serial count enable = $\overline{BI}$ = GND
c) Clear (⊓) then clock until all outputs are on (8)
d) For '143, outputs "a" through "g" and "dp" = 2.5 V, all other outputs open. For '144, all outputs are open.

switching characteristics, V_{CC} = 5 V, T_A = 25°C

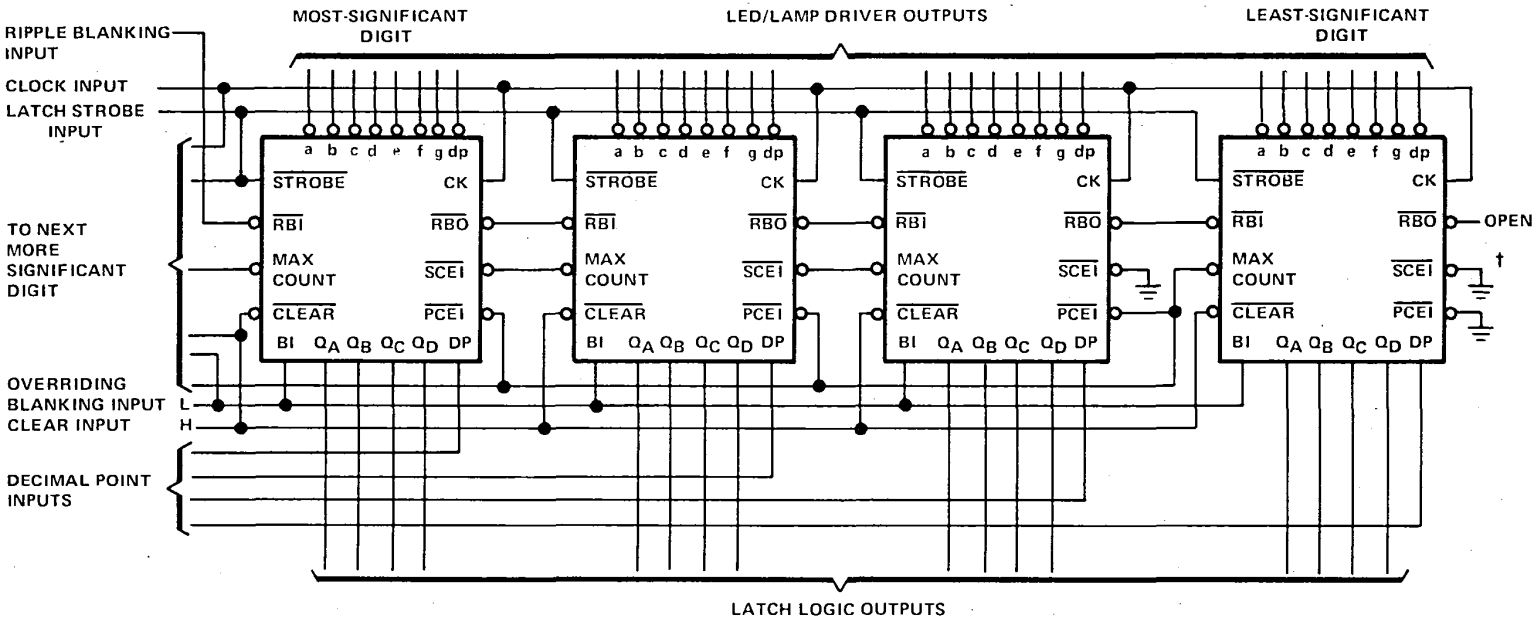
PARAMETER§	FROM (INPUT)	TO (OUTPUT)	TEST CONDITIONS	MIN	TYP	MAX	UNIT
f_{max}				12	18		MHz
t_{PLH}	Serial look-ahead	Maximum count	C_L = 15 pF, R_L = 560 Ω, See Note 6		12	20	ns
t_{PHL}					23	35	
t_{PLH}	Clock	Maximum count			26	40	ns
t_{PHL}					29	45	
t_{PLH}	Clock	Q_A, Q_B, Q_C, Q_D	C_L = 15 pF, R_L = 1.2 kΩ, See Note 6		28	45	ns
t_{PHL}					38	60	
t_{PHL}	$\overline{Clear}$	Q_A, Q_B, Q_C, Q_D			57	90	ns

§ f_{max} = Maximum clock frequency, t_{PLH} = Propagation delay time, low-to-high-level output, t_{PHL} = Propagation delay time, high-to-low-level output
NOTE 6: See General Information Section for load circuits and voltage waveforms.

TYPICAL APPLICATION DATA

This application demonstrates how the drivers may be cascaded for N-bit display applications. It features:

- Synchronous, look-ahead counting
- Ripple blanking of leading zeros; blanking of trailing zeros (not illustrated) can also be implemented
- Overriding blanking for total suppression or intensity modulation of display
- Direct parallel clear
- Latch strobe permits counter to acquire next display while viewing current display



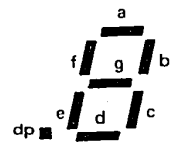
†The serial count-enable input of the least-significant digit is normally grounded; however, it may be used as a count-enable control for the entire counter (high to disable, low to count) provided the logic level on this pin is not changed while the clock line is low or false counting may result.

TEXAS INSTRUMENTS
POST OFFICE BOX 225012 • DALLAS, TEXAS 75265

FUNCTION TABLE

FUNCTION	CLOCK PULSE	INPUTS							OUTPUTS													TYPICAL DISPLAY	NOTES
		$\overline{CLEAR}$	LATCH $\overline{STROBE}$	$\overline{RBI}$	$\overline{BI}$	DECIMAL INPUT	SERIAL CARRY	PARALLEL CARRY	$\overline{RBI}/\overline{RBO}$	MAXIMUM COUNT OUTPUT	LATCH Q_D	Q_C	Q_B	Q_A	LED/LAMP DRIVERS a	b	c	d	e	f	g	dp		
Clear/Ripple Blank		L	L	L	X	X	X	X	L	H	L	L	L	L	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	None	A, E
Blank		H	L	X	H	X	X	X	L	H	L	L	L	L	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	None	A, D, E
Decimal	0	H	L	H	L	H	L	L	H	H	L	L	L	L	ON	ON	ON	ON	ON	ON	OFF	ON	0.	B
	1	H	L	H	L	L	L	L	H	H	L	L	L	H	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF	1	B
	2	H	L	H	L	L	L	L	H	H	L	L	H	L	ON	ON	OFF	ON	ON	OFF	ON	OFF	2	B
	3	H	L	H	L	L	L	L	H	H	L	L	H	H	ON	ON	ON	ON	OFF	OFF	ON	OFF	3	B
	4	H	L	H	L	L	L	L	H	H	L	H	L	L	OFF	ON	ON	OFF	OFF	ON	ON	OFF	4	B
	5	H	L	H	L	L	L	L	H	H	L	H	L	H	ON	OFF	ON	ON	OFF	ON	ON	OFF	5	B
	6	H	L	H	L	L	L	L	H	H	L	H	H	L	ON	OFF	ON	ON	ON	ON	ON	OFF	6	B
	7	H	L	H	L	L	L	L	H	H	L	H	H	H	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	7	B
	8	H	L	H	L	L	L	L	H	H	H	L	L	L	ON	ON	ON	ON	ON	ON	ON	OFF	8	B
	9	H	L	H	L	L	L	L	H	L	H	L	L	H	ON	ON	ON	ON	OFF	ON	ON	OFF	9	B
	0	H	L	H	L	L	L	L	H	H	L	L	L	L	ON	ON	ON	ON	ON	ON	OFF	OFF	0	B, C
	1	H	L	H	L	L	L	L	H	H	L	L	L	H	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF	1	B
	2	H	L	H	L	L	L	L	H	H	L	L	H	L	ON	ON	OFF	ON	ON	OFF	ON	OFF	2	B
	3	H	L	H	L	L	L	L	H	H	L	L	H	H	ON	ON	ON	ON	OFF	OFF	ON	OFF	3	B
	4	H	L	H	L	L	L	L	H	H	L	H	L	L	OFF	ON	ON	OFF	OFF	ON	ON	OFF	4	B
	5	H	H	H	L	L	L	L	H	H	L	H	L	H	ON	OFF	ON	ON	OFF	ON	ON	OFF	5	B
Latch	6	H	H	H	L	L	L	L	H	H	L	H	L	H	ON	OFF	ON	ON	OFF	ON	ON	OFF	6	B
Latch	7	H	H	H	L	L	L	L	H	H	L	H	L	H	ON	OFF	ON	ON	OFF	ON	ON	OFF	7	B
	8	H	L	H	L	L	L	L	H	H	H	L	L	L	ON	ON	ON	ON	ON	ON	ON	OFF	8	B
	9	H	L	H	L	L	L	L	H	L	H	L	L	H	ON	ON	ON	ON	OFF	ON	ON	OFF	9	B
Ripple Blank	0	H	L	L	X	L	L	L	L	H	L	L	L	L	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	None	A, B, E

NOTES:
A. $\overline{RBI}/\overline{RBO}$ is wire-AND logic serving as ripple blanking input ($\overline{RBI}$) and/or ripple blanking output ($\overline{RBO}$).
B. The blanking input ($\overline{BI}$) must be low when functions DECIMAL/0 through 20/RIPPLE BLANK are desired.
C. The ripple-blanking input ($\overline{RBI}$) must be open or high to display a zero during the decimal 0 input.
D. When a high logic level is applied directly to the blanking input ($\overline{BI}$) all segment outputs are off regardless of any other input condition.
E. When the ripple-blanking input ($\overline{RBI}$) and outputs Q_A through Q_D are at a low logic level, all segment outputs are off and the ripple-blanking output ($\overline{RBO}$) goes to a low logic level (response condition).



SEGMENT IDENTIFICATION