

# NLSF595

## Serial (SPI) Tri-Color LED Driver

The NLSF595 is advanced CMOS shift register with open drain outputs fabricated with 0.6  $\mu\text{m}$  silicon gate CMOS technology. This device is used in conjunction with a microcontroller, with only one dedicated line. All pins have Overvoltage Protection that allows voltages above  $V_{CC}$  up to 7.0 V to be present on the pins without damage or disruption of operation of the part, regardless of the operating voltage. This device may be used between 2.0 and 5.5 volts, the output driver level may be independent of supply voltage: 0–7.0 volts.

### Features

- Parallel Outputs are Open Drain Capable of Sinking > 12 mA
  - ◆ Output Withstands up to +7.0 Regardless of  $V_{CC}$
- Standard Serial (SPI) Interface, Data, Clock, Enable (Low)
- All Inputs CMOS Level Compatible
- Frees up I/O around a Microcontroller
- Only One Pin Dedicated to this Device (Latch Enable)
- Output Enable may be Permanently Pulled Low
- High Speed Clocking,  $F_{max}$  > 25 MHz (Shift Clock)
- Eight Bits Parallel Output
- Double Buffered Outputs, so Register may Fill without Affecting Output
- STD CMOS Serial Output, may be used to Cascade more than One Device
- Each Part Controls Two Tri-Color LEDs
- Two Devices can Control 5 Tri-Color LEDs
- Low Leakage:  $I_{CC} = 2.0 \mu\text{A}$  (Max) at  $T_A = 25^\circ\text{C}$
- Latchup Performance Exceeds 100 mA
- QFN-16/TSSOP-16 Packages
- ESD Performance:
  - ◆ Human Body Model; > 2000 V
  - ◆ Machine Model; > 200 V
- Functionally Similar to the Popular 74VHC595
- These Devices are Pb-Free and are RoHS Compliant



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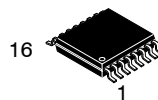
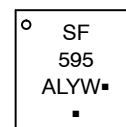
<http://onsemi.com>

### MARKING DIAGRAMS



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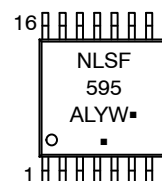
QFN-16  
MN SUFFIX  
CASE 485G



16

1

TSSOP-16  
DT SUFFIX  
CASE 948F



A = Assembly Location  
L = Wafer Lot  
Y = Year  
W = Work Week  
■ = Pb-Free Package

(Note: Microdot may be in either location)

### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 12 of this data sheet.

# NLSF595

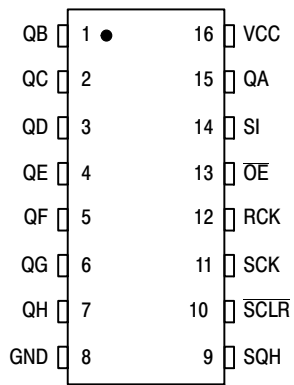


Figure 1. Pin Assignment (TSSOP-16)

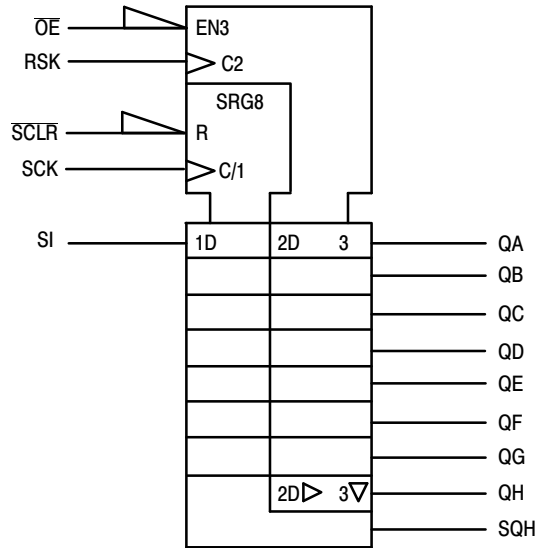


Figure 2. IEC Logic Symbol

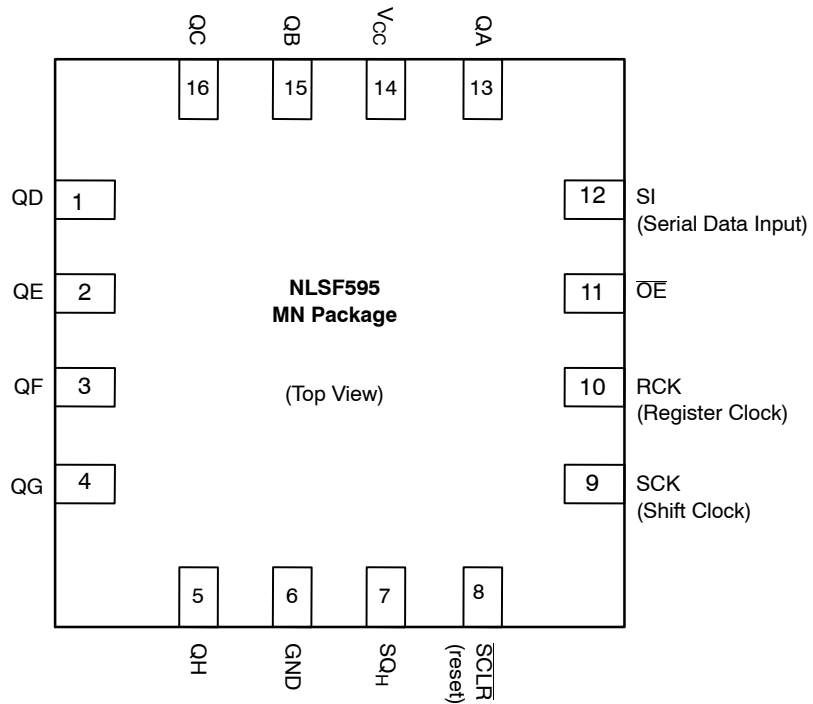


Figure 3. Pin Assignment (QFN-16)

# NLSF595

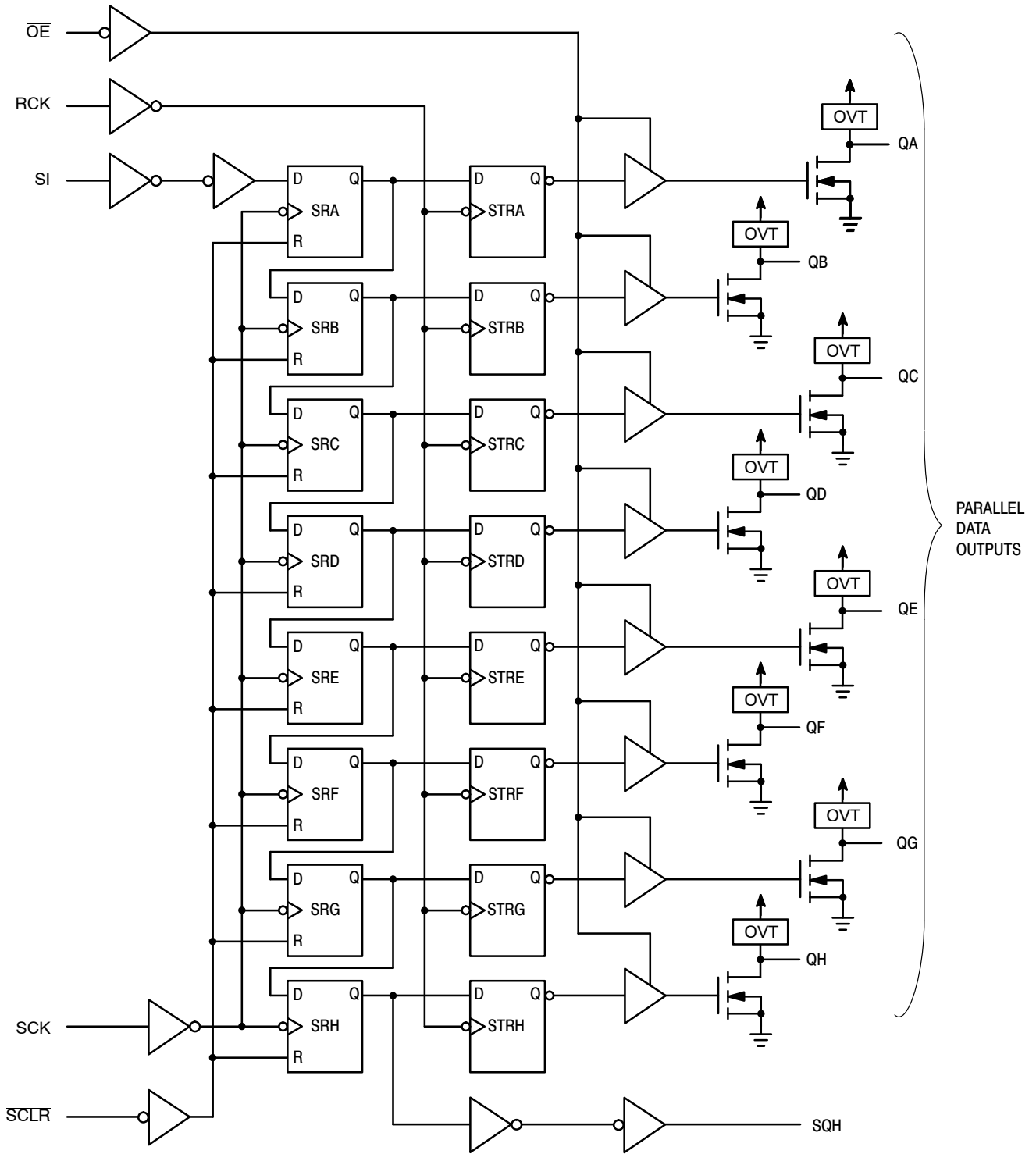


Figure 4. Expanded Logic Diagram

# NLSF595

## MAXIMUM RATINGS

Symbol	Parameter	Value	Units
V <sub>CC</sub>	Positive DC Supply Voltage	-0.5 to +7.0	V
V <sub>IN</sub>	Digital Input Voltage	-0.5 to +7.0	V
V <sub>OUT</sub>	DC Output Voltage	-0.5 to V <sub>CC</sub> +7.0	V
I <sub>IK</sub>	Input Diode Current	-20	mA
I <sub>OK</sub>	Output Diode Current	±50	mA
I <sub>OUT</sub>	DC Output Current, per Pin	+50	mA
I <sub>CC</sub>	DC Supply Current, V <sub>CC</sub> and GND Pins	±75	mA
P <sub>D</sub>	Power Dissipation in Still Air	450	mW
T <sub>STG</sub>	Storage Temperature Range	-65 to +150	°C
I <sub>LATCHUP</sub>	Latchup Performance Above V <sub>CC</sub> and Below GND at 125°C (Note 1)	±300	mA
θ <sub>JA</sub>	Thermal Resistance, Junction-to-Ambient	128	°C/W

Maximum ratings are those values beyond which device damage can occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability may be affected.

1. Tested to EIA/JESD78

## RECOMMENDED OPERATING CONDITIONS

Symbol	Characteristics	Min	Max	Units
V <sub>CC</sub>	DC Supply Voltage	2.0	5.5	V
V <sub>IN</sub>	DC Input Voltage	0	5.5	V
V <sub>OUT</sub>	DC Output Voltage	0	V <sub>CC</sub>	V
T <sub>A</sub>	Operating Temperature Range, all Package Types	-55	125	°C
t <sub>r</sub> , t <sub>f</sub>	Input Rise or Fall Time V <sub>CC</sub> = 3.3 V ± 0.3 V V <sub>CC</sub> = 5.0 V ± 0.5 V	0	50 15	ns/V

## FUNCTION TABLE

Operation	Inputs					Resulting Function			
	Reset (SCLR)	Serial Input (SI)	Shift Clock (SCK)	Reg Clock (RCK)	Output Enable (OE)	Shift Register Contents	Storage Register Contents	Serial Output (SQH)	Parallel Outputs (QA - QH)
Clear shift register	L	X	X	L, H, ↓	L	L	U	L	U
Shift data into shift register	H	D	↑	L, H, ↓	L	D→SR <sub>A</sub> ; SR <sub>N</sub> →SR <sub>N+1</sub>	U	SR <sub>G</sub> →SR <sub>H</sub>	U
Registers remains unchanged	H	X	L, H, ↓	X	L	U	**	U	**
Transfer shift register contents to storage register	H	X	L, H, ↓	↑	L	U	SR <sub>N</sub> →STR <sub>N</sub>	*	SR <sub>N</sub>
Storage register remains unchanged	X	X	X	L, H, ↓	L	*	U	*	U
Enable parallel outputs	X	X	X	X	L	*	**	*	Enabled
Force outputs into high impedance state	X	X	X	X	H	*	**	*	Z

SR = shift register contents

D = data (L, H) logic level

↓ = High-to-Low

\* = depends on Reset and Shift Clock inputs

STR = storage register contents

U = remains unchanged

↑ = Low-to-High

\*\* = depends on Register Clock input

# NLSF595

## DC ELECTRICAL CHARACTERISTICS

Symbol	Parameter	Test Conditions	V <sub>CC</sub> (V)	T <sub>A</sub> = 25°C			T <sub>A</sub> ≤ 85°C		T <sub>A</sub> ≤ 125°C		Units
				Min	Typ	Max	Min	Max	Min	Max	
V <sub>IH</sub>	Minimum High-Level Input Voltage		2.0 3.0 4.5 5.5	1.5 2.1 3.15 3.85			1.5 2.1 3.15 3.85		1.5 2.1 3.15 3.85	V	
V <sub>IL</sub>	Maximum Low-Level Input Voltage		2.0 3.0 4.5 5.5			0.59 0.9 1.35 1.65		0.59 0.9 1.35 1.65		0.59 0.9 1.35 1.65	V
V <sub>OH</sub>	Minimum High-Level Serial Output Only Output Voltage V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> I <sub>OH</sub> = -50 μA	2.0 3.0 4.5	1.9 2.9 4.4	2.0 3.0 4.5		1.9 2.9 4.4		1.9 2.9 4.4		V
		V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> I <sub>OH</sub> = -4 mA I <sub>OH</sub> = -8 mA	3.0 4.5	2.58 3.94			2.48 3.80		2.34 3.66		
V <sub>OL</sub>	Maximum Low-Level Output Voltage V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OL</sub> = 50 μA	2.0 3.0 4.5		0.0 0.0 0.0	0.1 0.1 0.1		0.1 0.1 0.1		0.1 0.1 0.1	V
		I <sub>OL</sub> = 4 mA I <sub>OL</sub> = 8 mA	3.0 4.5			0.36 0.36		0.44 0.44		0.52 0.52	
V <sub>OL2</sub>	Maximum Low-Level Output Voltage with Max. Load V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OL</sub> = 20 mA I <sub>OL</sub> = 25 mA	3.0 4.5		0.8 0.5	1.0 0.6		1.1 0.7		1.25 0.8	V
I <sub>IN</sub>	Maximum Input Leakage Current	V <sub>IN</sub> = 5.5 V or GND	0 to 5.5			±0.1		±1.0		±1.0	μA
I <sub>CC</sub>	Maximum Quiescent Supply Current	V <sub>IN</sub> = V <sub>CC</sub> or GND	5.5			4.0		40.0		40.0	μA
I <sub>OZ</sub>	Three-State Output Off-State Current QA-QH	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> V <sub>OUT</sub> = V <sub>CC</sub> or GND	5.5			±0.25		±2.5		±2.5	μA
I <sub>LKG</sub>	Active (2) State Off Output Leakage Current QA-QH	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> V <sub>OUT</sub> = V <sub>CC</sub> or GND	5.5			±0.25		±2.5		±2.5	μA
I <sub>OFF</sub>	Power Off Output Leakage All Outputs	V <sub>IN</sub> = 0 or 5.5 V V <sub>OUT</sub> = 5.5 V	0			±0.25		±2.5		±2.5	μA

# NLSF595

## AC ELECTRICAL CHARACTERISTICS (Input $t_r = t_f = 3.0$ ns)

Symbol	Parameter	Test Conditions	$T_A = 25^\circ\text{C}$			$T_A \leq 85^\circ\text{C}$		$T_A \leq 125^\circ\text{C}$		Units
			Min	Typ	Max	Min	Max	Min	Max	
$f_{\max}$	Maximum Clock Frequency (50% Duty Cycle)	$V_{CC} = 3.3 \pm 0.3$ V	80	150		70		70		MHz
		$V_{CC} = 5.0 \pm 0.5$ V	135	185		115		115		
$t_{PLH}$ , $t_{PHL}$	Propagation Delay, SCK to SQH	$V_{CC} = 3.3 \pm 0.3$ V $C_L = 15$ pF $C_L = 50$ pF		8.8 11.3	13.0 16.5	1.0 1.0	15.0 18.5	1.0 1.0	15.0 18.5	ns
		$V_{CC} = 5.0 \pm 0.5$ V $C_L = 15$ pF $C_L = 50$ pF		6.2 7.7	8.2 10.2	1.0 1.0	9.4 11.4	1.0 1.0	9.4 11.4	
$t_{PHL}$	Propagation Delay, SCLR to SQH	$V_{CC} = 3.3 \pm 0.3$ V $C_L = 15$ pF $C_L = 50$ pF		8.4 10.9	12.8 16.3	1.0 1.0	13.7 17.2	1.0 1.0	13.7 17.2	ns
		$V_{CC} = 5.0 \pm 0.5$ V $C_L = 15$ pF $C_L = 50$ pF		5.9 7.4	8.0 10.0	1.0 1.0	9.1 11.1	1.0 1.0	9.1 11.1	
$t_{PLZ}$	Output Disable Time RCK to QA-QH Output Enable Time RCK to QA-QH	$V_{CC} = 3.3 \pm 0.3$ V $C_L = 15$ pF $C_L = 50$ pF		7.7 10.2	11.9 15.4	1.0 1.0	13.5 17.0	1.0 1.0	13.5 17.0	ns
		$V_{CC} = 5.0 \pm 0.5$ V $C_L = 15$ pF $C_L = 50$ pF		5.4 6.9	7.4 9.4	1.0 1.0	8.5 10.5	1.0 1.0	8.5 10.5	
$t_{PZL}$	Output Disable Time RCK to QA-QH Output Enable Time RCK to QA-QH	$V_{CC} = 3.3 \pm 0.3$ V $C_L = 15$ pF $C_L = 50$ pF		7.7 10.2	11.9 15.4	1.0 1.0	13.5 17.0	1.0 1.0	13.5 17.0	ns
		$V_{CC} = 5.0 \pm 0.5$ V $C_L = 15$ pF $C_L = 50$ pF		5.4 6.9	7.4 9.4	1.0 1.0	8.5 10.5	1.0 1.0	8.5 10.5	
$t_{PZL}$	Output Enable Time, OE to QA-QH	$V_{CC} = 3.3 \pm 0.3$ V $R_L = 1$ k $\Omega$ $C_L = 15$ pF $C_L = 50$ pF		7.5 9.0	11.5 15.0	1.0 1.0	13.5 17.0	1.0 1.0	13.5 17.0	ns
		$V_{CC} = 5.0 \pm 0.5$ V $R_L = 1$ k $\Omega$ $C_L = 15$ pF $C_L = 50$ pF		4.8 8.3	8.6 10.6	1.0 1.0	10.0 12.0	1.0 1.0	10.0 12.0	
$t_{PLZ}$	Output Disable Time, OE to QA-QH	$V_{CC} = 3.3 \pm 0.3$ V $R_L = 1$ k $\Omega$ $C_L = 50$ pF		12.1	15.7	1.0	16.2	1.0	16.2	ns
		$V_{CC} = 5.0 \pm 0.5$ V $R_L = 1$ k $\Omega$ $C_L = 50$ pF		7.6	10.3	1.0	11.0	1.0	11.0	
$C_{IN}$	Input Capacitance			4	10		10		10	pF
$C_{OUT}$	Three-State Output Capacitance (Output in High-Impedance State), QA-QH			6			10		10	pF

$C_{PD}$	Power Dissipation Capacitance (Note 2)	Typical @ 25°C, $V_{CC} = 5.0$ V		pF
		87		

2.  $C_{PD}$  is defined as the value of the internal equivalent capacitance which is calculated from the operating current consumption without load. Average operating current can be obtained by the equation:  $I_{CC(OPR)} = C_{PD} \cdot V_{CC} \cdot f_{in} + I_{CC}$ .  $C_{PD}$  is used to determine the no-load dynamic power consumption;  $P_D = C_{PD} \cdot V_{CC}^2 \cdot f_{in} + I_{CC} \cdot V_{CC}$ .

## NOISE CHARACTERISTICS (Input $t_r = t_f = 3.0$ ns, $C_L = 50$ pF, $V_{CC} = 5.0$ V)

Symbol	Characteristic	$T_A = 25^\circ\text{C}$		Units
		Typ	Max	
$V_{OLP}$	Quiet Output Maximum Dynamic $V_{OL}$	0.8	1.0	V
$V_{OLV}$	Quiet Output Minimum Dynamic $V_{OL}$	-0.8	-1.0	V
$V_{IHD}$	Minimum High Level Dynamic Input Voltage		3.5	V
$V_{ILD}$	Maximum Low Level Dynamic Input Voltage		1.5	V

# NLSF595

## TIMING REQUIREMENTS (Input $t_r = t_f = 3.0\text{ns}$ )

Symbol	Parameter	V <sub>CC</sub> V	T <sub>A</sub> = 25°C		T <sub>A</sub> = - 40 to 85°C	T <sub>A</sub> = - 55 to 125°C	Units
			Typ	Limit	Limit	Limit	
t <sub>su</sub>	Setup Time, SI to SCK	3.3 5.0		3.5 3.0	3.5 3.0	3.5 3.0	ns
t <sub>su(H)</sub>	Setup Time, SCK to RCK	3.3 5.0		8.0 5.0	8.5 5.0	8.5 5.0	ns
t <sub>su(L)</sub>	Setup Time, $\overline{\text{SCLR}}$ to RCK	3.3 5.0		8.0 5.0	9.0 5.0	9.0 5.0	ns
t <sub>h</sub>	Hold Time, SI to SCK	3.3 5.0		1.5 2.0	1.5 2.0	1.5 2.0	ns
t <sub>h(L)</sub>	Hold Time, $\overline{\text{SCLR}}$ to RCK	3.3 5.0		0 0	0 0	1.0 1.0	ns
t <sub>rec</sub>	Recovery Time, $\overline{\text{SCLR}}$ to SCK	3.3 5.0		3.0 2.5	3.0 2.5	3.0 2.5	ns
t <sub>w</sub>	Pulse Width, SCK or RCK	3.3 5.0		5.0 5.0	5.0 5.0	5.0 5.0	ns
t <sub>w(L)</sub>	Pulse Width, $\overline{\text{SCLR}}$	3.3 5.0		5.0 5.0	5.0 5.0	5.0 5.0	ns

# NLSF595

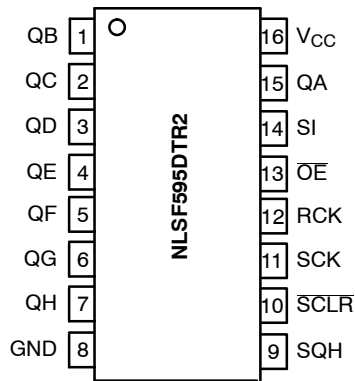
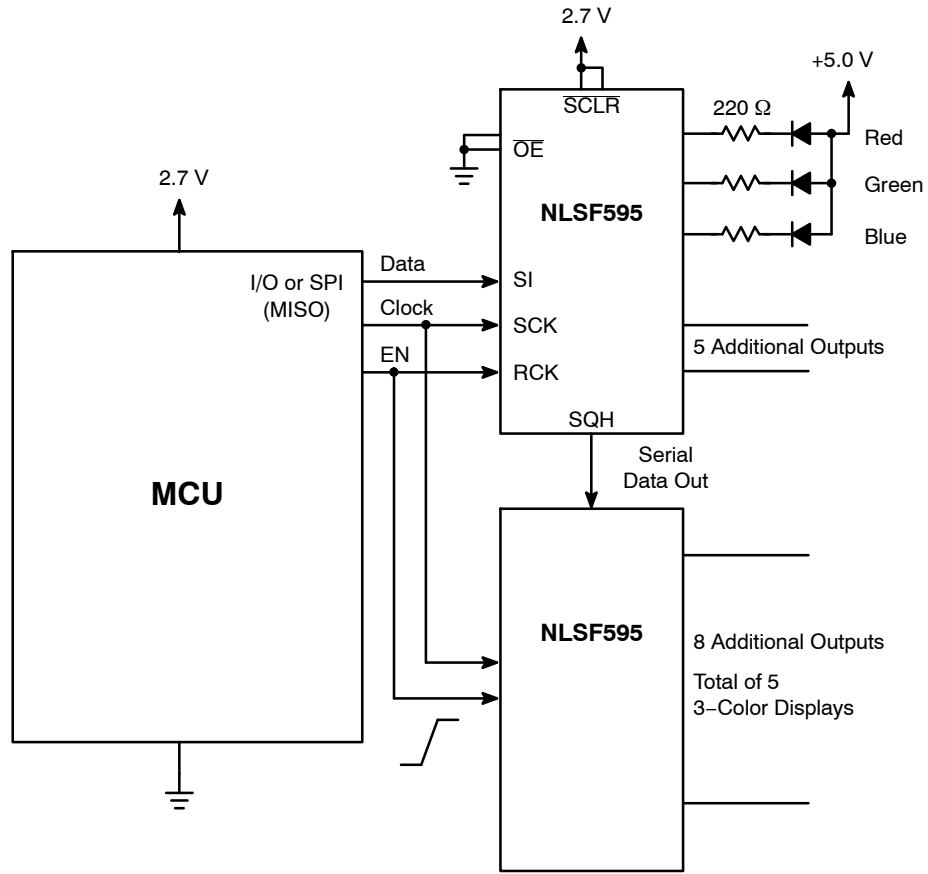


Figure 5. NLSF595 Shown Driving 5 3-Color LEDs



# NLSF595

## SWITCHING WAVEFORMS

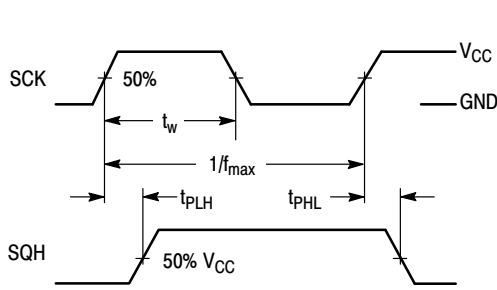


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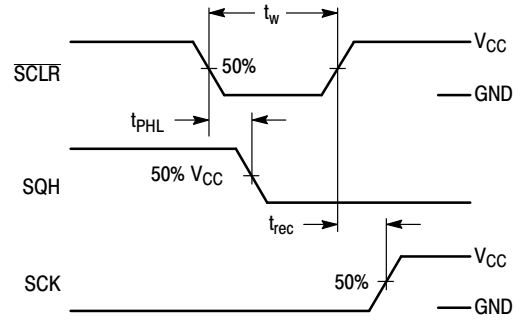


Figure 7.

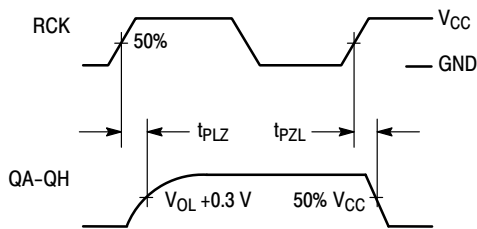


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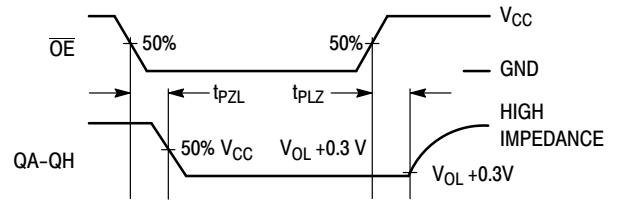


Figure 9.

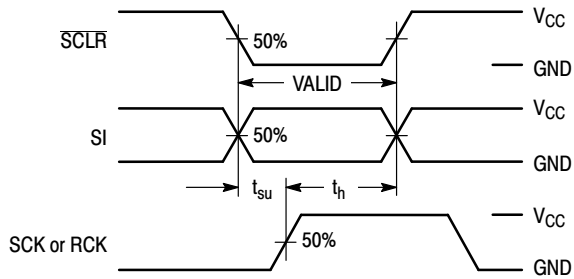


Figure 10.

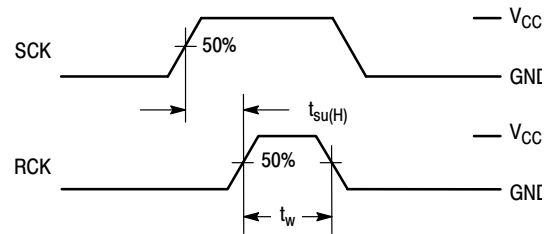
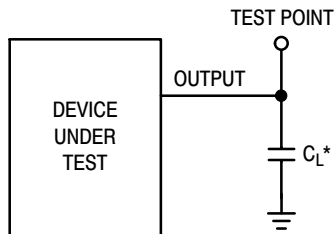


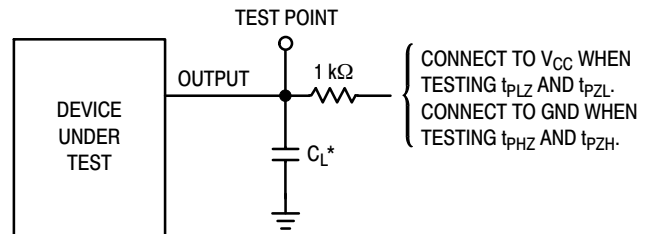
Figure 11.

## TEST CIRCUITS



\*Includes all probe and jig capacitance

Figure 12.



\*Includes all probe and jig capacitance

Figure 13.

# NLSF595

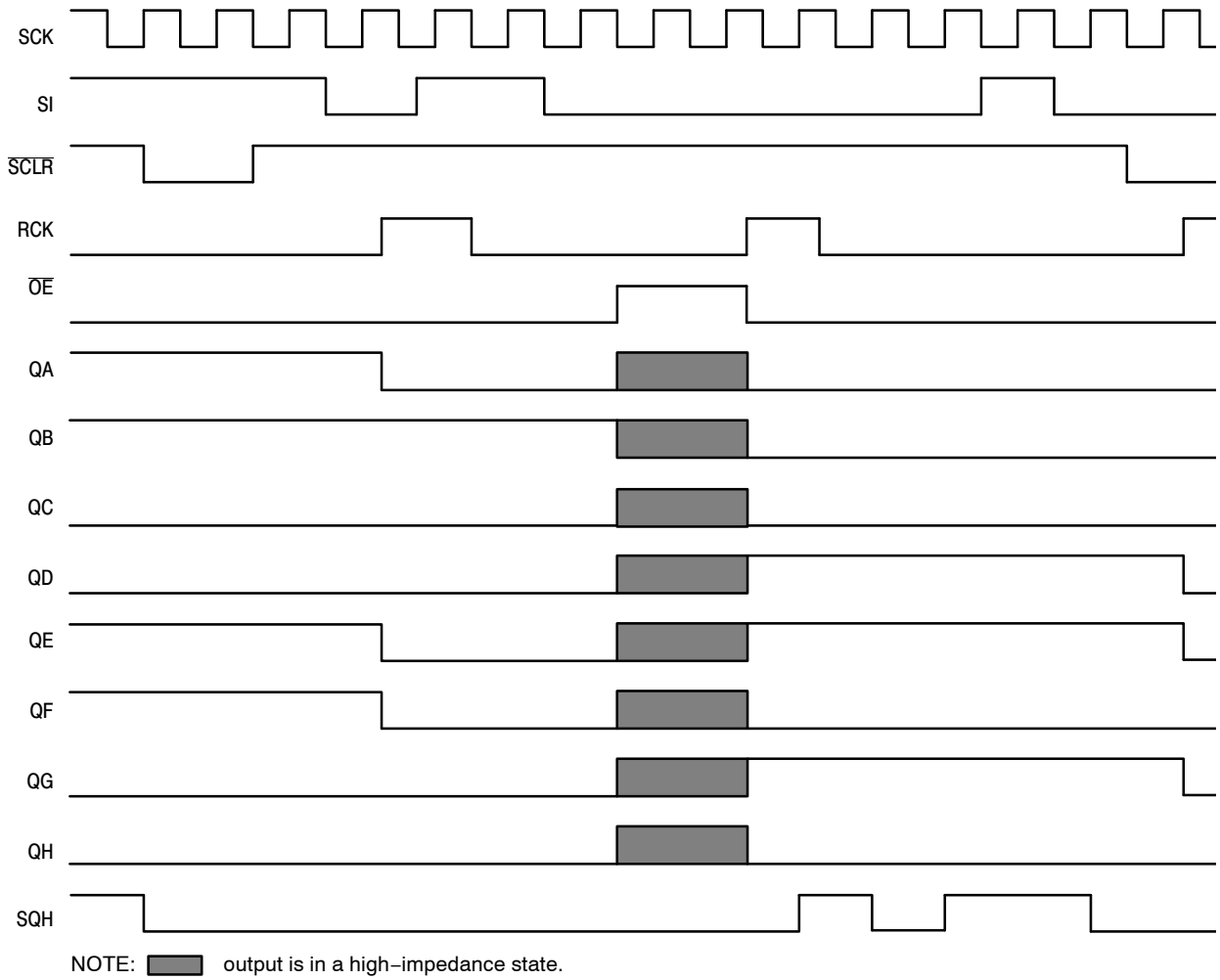


Figure 14. Timing Diagram

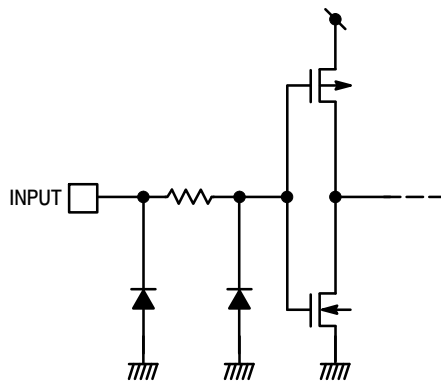


Figure 15. Input Equivalent Circuit

# NLSF595

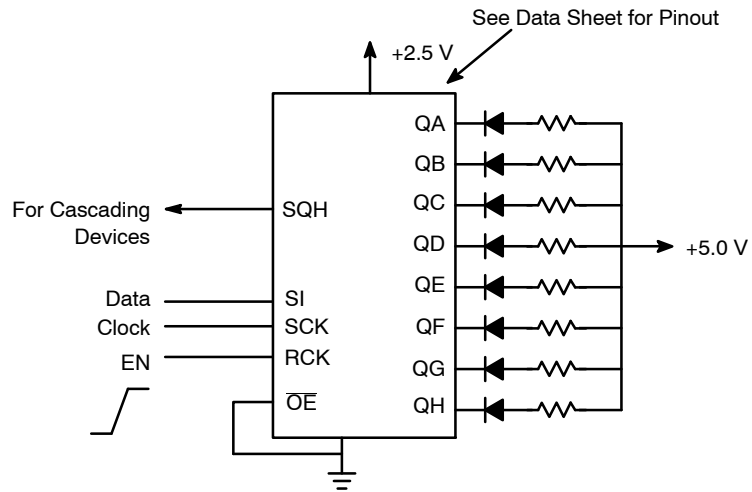
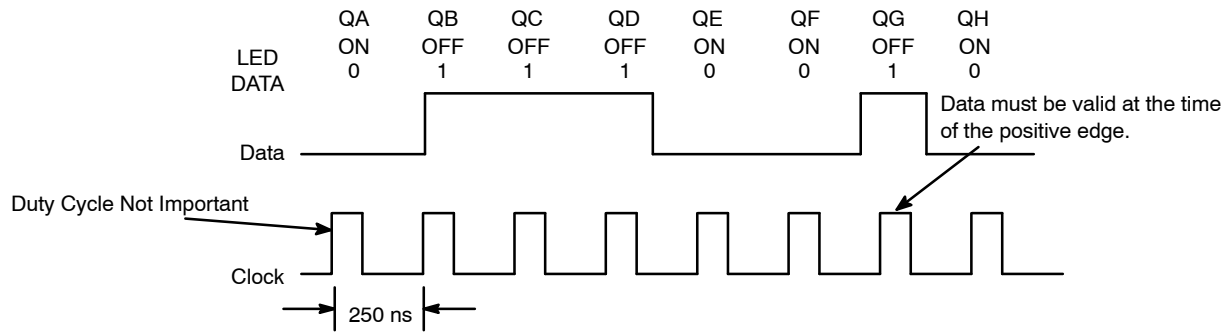


Figure 16. NLSF595 Example

# NLSF595

## ORDERING INFORMATION

Device Order Number	Device Nomenclature					Package	Shipping <sup>†</sup>
	Circuit Indicator	Technology	Device Function	Package Suffix	Tape & Reel Suffix		
NLSF595MNR2G	NL	SF	595	MN	R2	QFN (Pb-Free)	13-inch/3000 Unit
NLSF595DTR2G	NL	SF	595	DT	R2	TSSOP* (Pb-Free)	13-inch/2500 Unit

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

\*This package is inherently Pb-Free.

# MECHANICAL CASE OUTLINE

## PACKAGE DIMENSIONS

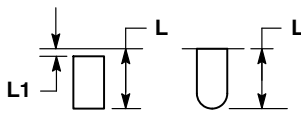
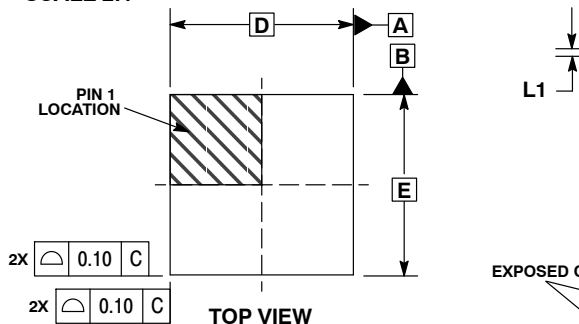
ON Semiconductor®



**QFN16 3x3, 0.5P**  
CASE 485G-01  
ISSUE F

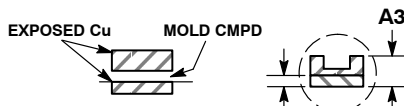
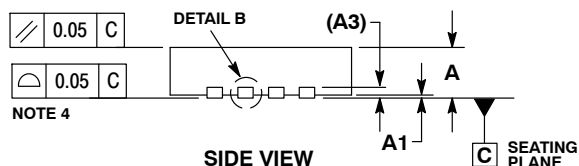
DATE 22 JUN 2011

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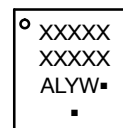


- NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
  2. CONTROLLING DIMENSION: MILLIMETERS.
  3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.25 AND 0.30 MM FROM TERMINAL.
  4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

MILLIMETERS			
DIM	MIN	NOM	MAX
A	0.80	0.90	1.00
A1	0.00	0.03	0.05
A3	0.20 REF		
b	0.18	0.24	0.30
D	3.00 BSC		
E	1.65	1.75	1.85
E2	3.00 BSC		
e	0.50 BSC		
K	0.18 TYP		
L	0.30	0.40	0.50
L1	0.00	0.08	0.15



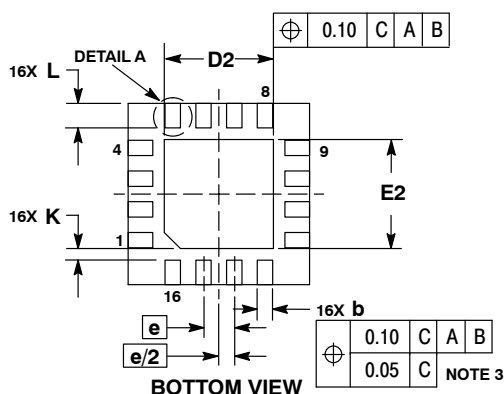
### GENERIC MARKING DIAGRAM\*



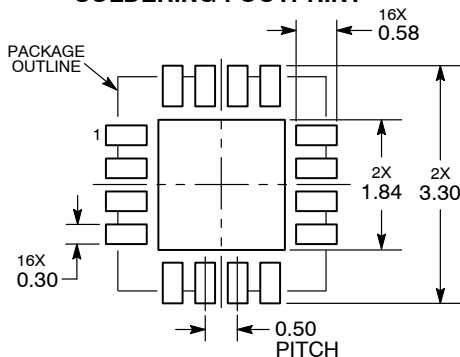
- XXXXX = Specific Device Code
- A = Assembly Location
- L = Wafer Lot
- Y = Year
- W = Work Week
- = Pb-Free Package

(Note: Microdot may be in either location)

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "■", may or may not be present.



### RECOMMENDED SOLDERING FOOTPRINT\*



DIMENSIONS: MILLIMETERS

\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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<b>DESCRIPTION:</b>	<b>QFN16, 3X3 MM, 0.5 PITCH</b>	<b>PAGE 1 OF 1</b>

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# MECHANICAL CASE OUTLINE

## PACKAGE DIMENSIONS

ON Semiconductor®



TSSOP-16  
CASE 948F-01  
ISSUE B

DATE 19 OCT 2006



NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A DOES NOT INCLUDE MOLD FLASH. PROTRUSIONS OR GATE BURRS. MOLD FLASH OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 (0.010) PER SIDE.
5. DIMENSION K DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08 (0.003) TOTAL IN EXCESS OF THE K DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. TERMINAL NUMBERS ARE SHOWN FOR REFERENCE ONLY.
7. DIMENSION A AND B ARE TO BE DETERMINED AT DATUM PLANE -W-.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.90	5.10	0.193	0.200
B	4.30	4.50	0.169	0.177
C	---	1.20	---	0.047
D	0.05	0.15	0.002	0.006
F	0.50	0.75	0.020	0.030
G	0.65 BSC		0.026 BSC	
H	0.18	0.28	0.007	0.011
J	0.09	0.20	0.004	0.008
J1	0.09	0.16	0.004	0.006
K	0.19	0.30	0.007	0.012
K1	0.19	0.25	0.007	0.010
L	6.40 BSC		0.252 BSC	
M	0°	8°	0°	8°

SOLDERING FOOTPRINT



GENERIC MARKING DIAGRAM\*



- XXXX = Specific Device Code
- A = Assembly Location
- L = Wafer Lot
- Y = Year
- W = Work Week
- G or ■ = Pb-Free Package

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "■", may or may not be present.

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