

# NPIC6C595-Q100

Power logic 8-bit shift register; open-drain outputs

Rev. 2 — 9 June 2020

Product data sheet

## 1. General description

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The NPIC6C595-Q100 is an 8-bit serial-in/serial or parallel-out shift register with a storage register and open-drain outputs. Both the shift and storage register have separate clocks. The device features a serial input (DS) and a serial output (Q7S) to enable cascading and an asynchronous reset input (MR). A LOW on MR resets both the shift register and storage register. Data is shifted on the LOW-to-HIGH transitions of the SHCP input. The data in the shift register is transferred to the storage register on a LOW-to-HIGH transition of the STCP input and to the Q7S output on a LOW-to-HIGH transition of the SHCP input. If both clocks are connected together, the shift register is always one clock pulse ahead of the storage register. Data in the storage register drives the gate of the output extended-drain NMOS transistor whenever the output enable input ( $\overline{OE}$ ) is LOW. A HIGH on  $\overline{OE}$  causes the outputs to assume a high-impedance OFF-state. Operation of the  $\overline{OE}$  input does not affect the state of the registers. The open-drain outputs are 33 V/100 mA continuous current extended-drain NMOS transistors designed for use in systems that require moderate load power such as LEDs.

Integrated voltage clamps in the outputs provide protection against inductive transients making the device suitable for power driver applications such as relay, solenoids and other low-current or medium-voltage loads.

This product has been qualified to the Automotive Electronics Council (AEC) standard Q100 (Grade 1) and is suitable for use in automotive applications.

## 2. Features and benefits

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- Automotive product qualification in accordance with AEC-Q100 (Grade 1)
  - Specified from -40 °C to +125 °C
- Low  $R_{DSon}$
- Eight Power EDNMOS transistor outputs of 100 mA continuous current
- 250 mA current limit capability
- Output clamping voltage 33 V
- 30 mJ avalanche energy capability
- All registers cleared with single input
- Low power consumption
- ESD protection:
  - HBM AEC-Q100-002 revision D exceeds 2500 V
  - CDM AEC-Q100-011 revision B exceeds 1000 V
- DHVQFN package with Side-Wettable Flanks enabling Automatic Optical Inspection (AOI) of solder joints

## 3. Applications

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- LED sign
- Graphic status panel
- Fault status indicator

### 4. Ordering information

Table 1. Ordering information

Type number	Package			Version
	Temperature range	Name	Description	
NPIC6C595D-Q100	-40 °C to +125 °C	SO16	plastic small outline package; 16 leads; body width 3.9 mm	SOT109-1
NPIC6C595PW-Q100	-40 °C to +125 °C	TSSOP16	plastic thin shrink small outline package; 16 leads; body width 4.4 mm	SOT403-1
NPIC6C595BQ-Q100	-40 °C to +125 °C	DHVQFN16	plastic dual in-line compatible thermal enhanced very thin quad flat package; no leads; 16 terminals; body 2.5 × 3.5 × 0.85 mm	SOT763-1

### 5. Functional diagram

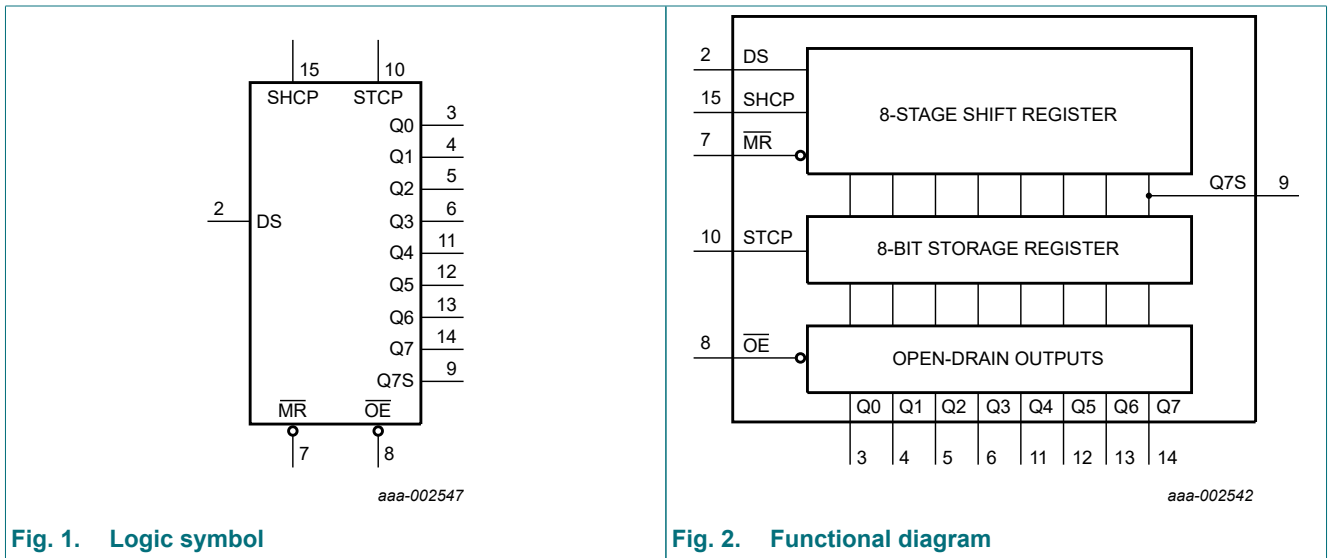


Fig. 1. Logic symbol

Fig. 2. Functional diagram

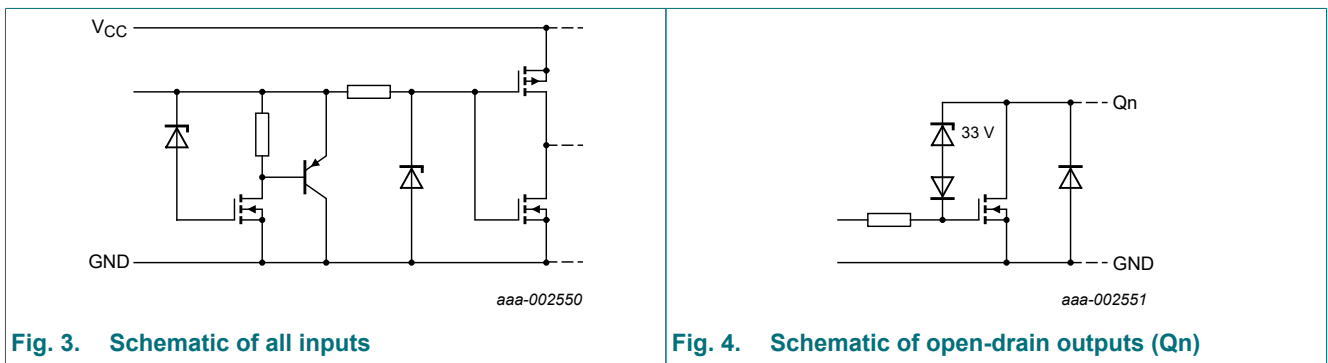


Fig. 3. Schematic of all inputs

Fig. 4. Schematic of open-drain outputs (Qn)

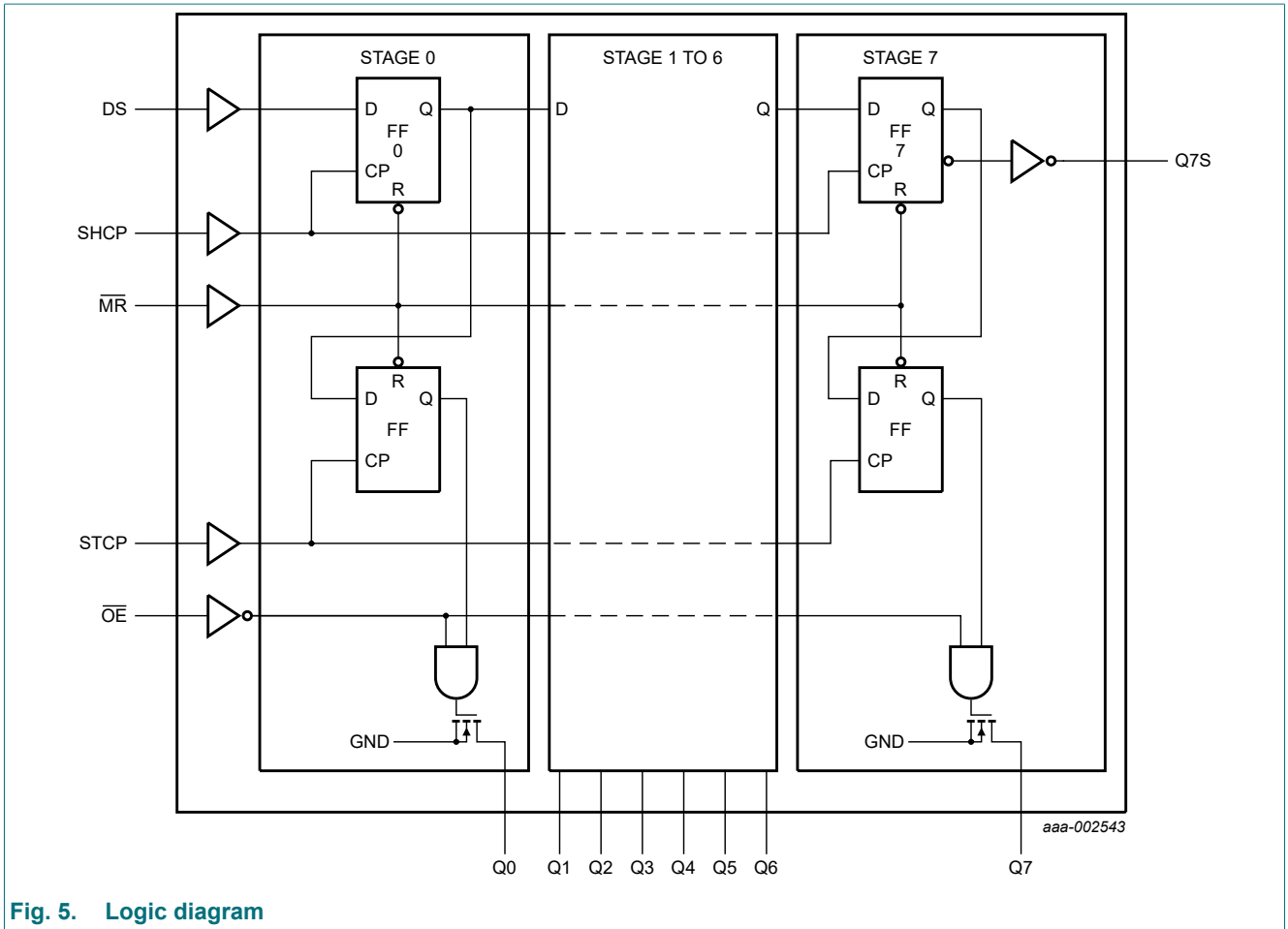


Fig. 5. Logic diagram

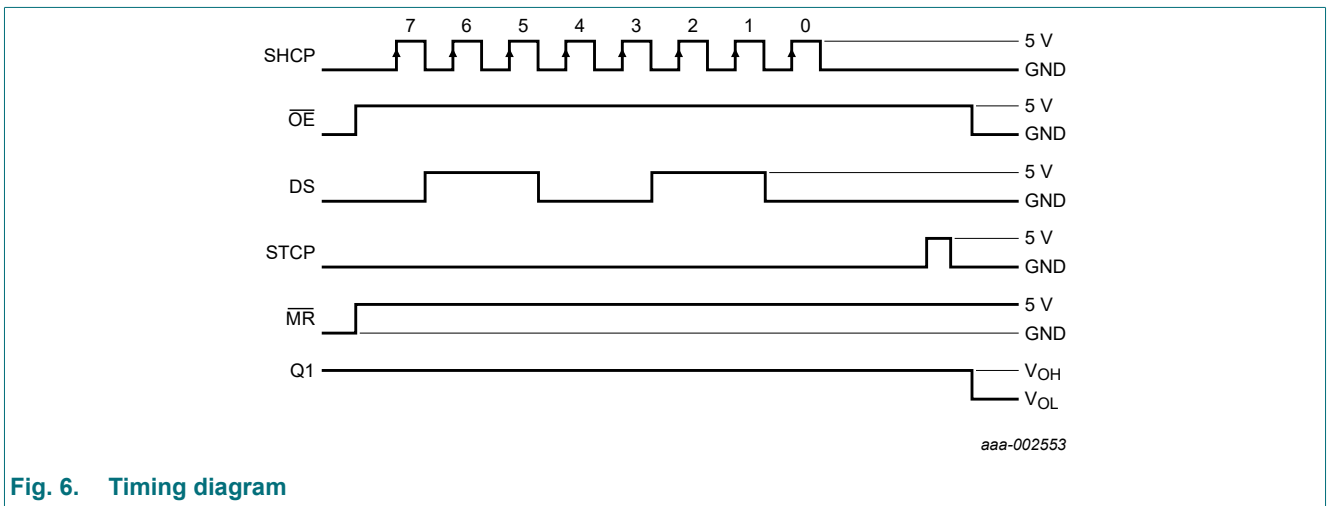
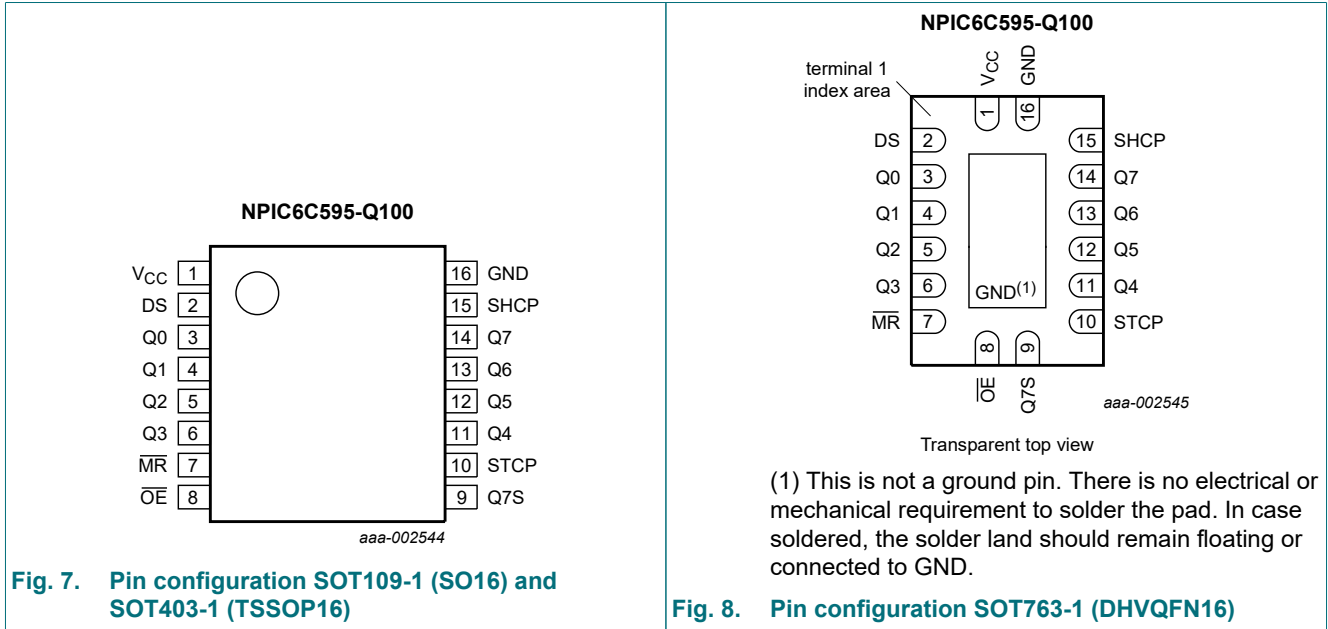


Fig. 6. Timing diagram

## 6. Pinning information

### 6.1. Pinning



### 6.2. Pin description

Table 2. Pin description

Symbol	Pin	Description
V <sub>CC</sub>	1	supply voltage
DS	2	serial data input
Q0, Q1, Q2, Q3, Q4, Q5, Q6, Q7	3, 4, 5, 6, 11, 12, 13, 14	parallel data output (open-drain)
MR	7	master reset (active LOW)
OE	8	output enable input (active LOW)
Q7S	9	serial data output
STCP	10	storage register clock input
SHCP	15	shift register clock input
GND	16	ground (0 V)

## 7. Limiting values

**Table 3. Limiting values**

In accordance with the Absolute Maximum Rating System (IEC 60134). Voltages are referenced to GND (ground = 0 V).

Symbol	Parameter	Conditions	Min	Max	Unit
$V_{CC}$	supply voltage		-0.5	+7.0	V
$V_I$	input voltage		-0.3	+7.0	V
$V_{DS}$	drain-source voltage	power EDNMOS drain-source voltage [1]	-	+33	V
$I_{d(SD)}$	source-drain diode current	continuous	-	250	mA
		pulsed [2]	-	500	mA
$I_D$	drain current	$T_{amb} = 25\text{ °C}$			
		continuous; each output; all outputs on	-	100	mA
		pulsed; each output; all outputs on [2]	-	250	mA
$I_{DM}$	peak drain current	single output; $T_{amb} = 25\text{ °C}$ [2]	-	250	mA
$E_{AS}$	non-repetitive avalanche energy	single pulse; see Fig. 9 [3]	-	30	mJ
$I_{AL}$	avalanche current	see Fig. 9 [3]	-	200	mA
$T_{stg}$	storage temperature		-65	+150	°C
$P_{tot}$	total power dissipation	$T_{amb} = 25\text{ °C}$ [4]			
		SO16	-	800	mW
		TSSOP16	-	725	mW
		DHVQFN16	-	1825	mW
		$T_{amb} = 125\text{ °C}$ [4]			
		SO16	-	160	mW
		TSSOP16	-	145	mW
		DHVQFN16	-	365	mW

[1] Each power EDNMOS source is internally connected to GND.

[2] Pulse duration  $\leq 100\ \mu\text{s}$  and duty cycle  $\leq 2\%$ .

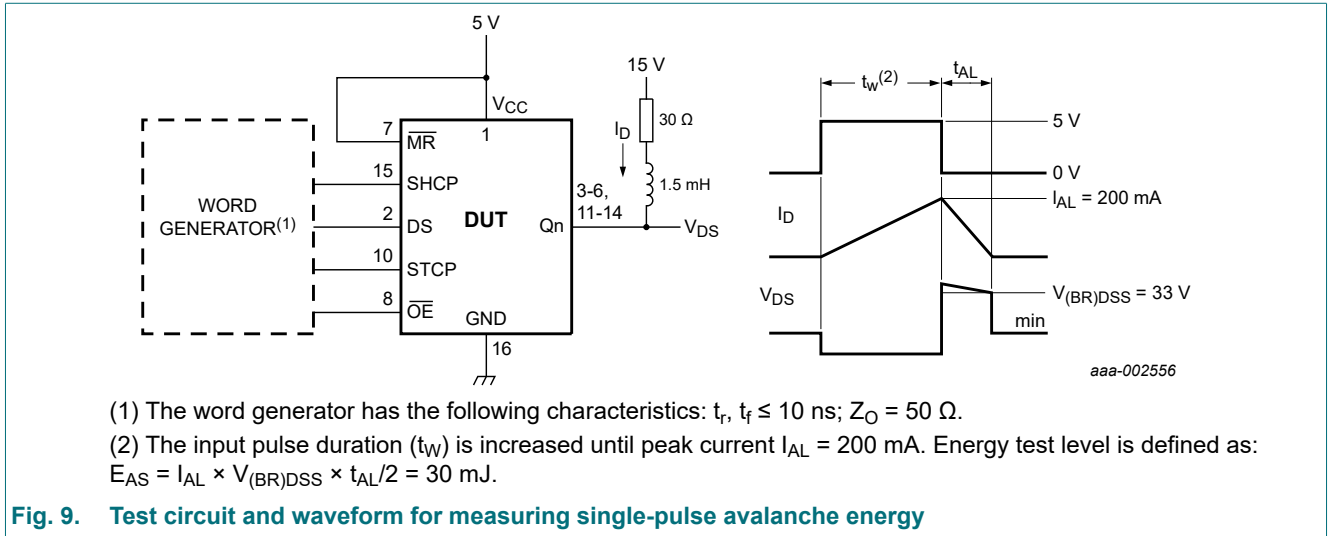
[3]  $V_{DS} = 15\text{ V}$ ; starting junction temperature ( $T_j$ ) =  $25\text{ °C}$ ;  $L = 1.5\text{ H}$ ; avalanche current ( $I_{AL}$ ) =  $200\text{ mA}$ .

[4] For SOT109-1 (SO16) package:  $P_{tot}$  derates linearly with  $12.4\text{ mW/K}$  above  $110\text{ °C}$ .

For SOT403-1 (TSSOP16) package:  $P_{tot}$  derates linearly with  $8.5\text{ mW/K}$  above  $91\text{ °C}$ .

For SOT763-1 (DHVQFN16) package:  $P_{tot}$  derates linearly with  $11.2\text{ mW/K}$  above  $106\text{ °C}$ .

7.1. Test circuit and waveform



8. Recommended operating conditions

Table 4. Recommended operating conditions

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{CC}$	supply voltage		4.5	-	5.5	V
$V_I$	input voltage		0	-	5.5	V
$I_D$	drain current	pulsed drain output current; $V_{CC} = 5 \text{ V}$ ; [1] [2] $T_{amb} = 25 \text{ }^\circ\text{C}$ ; all outputs on	-	-	250	mA
$T_{amb}$	ambient temperature		-40	-	+125	$^\circ\text{C}$

[1] Pulse duration  $\leq 100 \mu\text{s}$  and duty cycle  $\leq 2 \%$ .  
 [2] This technique should limit  $T_j - T_{amb}$  to  $10 \text{ }^\circ\text{C}$  maximum.

## 9. Static characteristics

**Table 5. Static characteristics**

At recommended operating conditions. Voltages are referenced to GND (ground = 0 V).

Symbol	Parameter	Conditions	V <sub>CC</sub> = 5.0 V; T <sub>amb</sub> = 25 °C			Unit
			Min	Typ	Max	
V <sub>IH</sub>	HIGH-level input voltage	V <sub>CC</sub> = 4.5 V to 5.5 V	0.85V <sub>CC</sub>	-	-	V
V <sub>IL</sub>	LOW-level input voltage	V <sub>CC</sub> = 4.5 V to 5.5 V	-	-	0.15V <sub>CC</sub>	V
V <sub>OH</sub>	HIGH-level output voltage	serial data output Q7S; V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub>				
		I <sub>O</sub> = -20 µA; V <sub>CC</sub> = 4.5 V	4.4	4.49	-	V
		I <sub>O</sub> = -4 mA; V <sub>CC</sub> = 4.5 V	4.0	4.2	-	V
V <sub>OL</sub>	LOW-level output voltage	serial data output Q7S; V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub>				
		I <sub>O</sub> = 20 µA; V <sub>CC</sub> = 4.5 V	-	0.005	0.1	V
		I <sub>O</sub> = 4 mA; V <sub>CC</sub> = 4.5 V	-	0.3	0.5	V
I <sub>IH</sub>	HIGH-level input current	V <sub>CC</sub> = 5.5 V; V <sub>I</sub> = V <sub>CC</sub>	-	-	1	µA
I <sub>IL</sub>	LOW-level input current	V <sub>CC</sub> = 5.5 V; V <sub>I</sub> = 0 V	-	-	-1	µA
V <sub>(BR)DSS</sub>	drain-source breakdown voltage	I <sub>D</sub> = 1 mA	33	37	-	V
V <sub>SD</sub>	source-drain voltage	diode forward voltage; I <sub>F</sub> = 100 mA	-	0.85	1.2	V
I <sub>CC</sub>	supply current	logic supply current; V <sub>CC</sub> = 5.5 V; V <sub>I</sub> = V <sub>CC</sub> or GND				
		all outputs off	-	0.004	200	µA
		all outputs on	-	0.006	500	µA
		all outputs off; SHCP = 5 MHz; C <sub>L</sub> = 30 pF; see Fig. 14 and Fig. 16	-	0.75	5	mA
I <sub>O(nom)</sub>	nominal output current	V <sub>DS</sub> = 0.5 V; T <sub>amb</sub> = 85 °C; I <sub>out</sub> = I <sub>D</sub> [1] [2] [3]	-	140	-	mA
I <sub>DSX</sub>	drain cut-off current	V <sub>CC</sub> = 5.5 V; V <sub>DS</sub> = 30 V	-	0.002	0.2	µA
		V <sub>CC</sub> = 5.5 V; V <sub>DS</sub> = 30 V; T <sub>amb</sub> = 125 °C	-	0.15	0.3	µA
R <sub>DSon</sub>	drain-source on-state resistance	see Fig. 17 and Fig. 18 [1] [2]				
		V <sub>CC</sub> = 4.5 V; I <sub>D</sub> = 50 mA	-	3.0	9	Ω
		V <sub>CC</sub> = 4.5 V; I <sub>D</sub> = 50 mA; T <sub>amb</sub> = 125 °C		5.4	12	Ω
		V <sub>CC</sub> = 4.5 V; I <sub>D</sub> = 100 mA	-	3.1	10	Ω

[1] This technique should limit T<sub>j</sub> - T<sub>amb</sub> to 10 °C maximum.

[2] These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

[3] Nominal output current is defined for a consistent comparison between devices from different sources. It is the current that produces a voltage drop of 0.5 V at T<sub>amb</sub> = 85 °C.

## 10. Dynamic characteristics

**Table 6. Dynamic characteristics**

Voltages are referenced to GND (ground = 0 V); For test circuit see Fig. 14.

Symbol	Parameter	Conditions	V <sub>CC</sub> = 5.0 V; T <sub>amb</sub> = 25 °C			Unit
			Min	Typ	Max	
t <sub>PLH</sub>	LOW to HIGH propagation delay	$\overline{OE}$ to Qn; I <sub>D</sub> = 75 mA; see Fig. 10 and Fig. 19	-	97	-	ns
t <sub>PHL</sub>	HIGH to LOW propagation delay	$\overline{OE}$ to Qn; I <sub>D</sub> = 75 mA; see Fig. 10 and Fig. 19	-	9	-	ns
t <sub>r</sub>	rise time	$\overline{OE}$ to Qn; I <sub>D</sub> = 75 mA; see Fig. 10 and Fig. 19	-	60	-	ns
t <sub>f</sub>	fall time	$\overline{OE}$ to Qn; I <sub>D</sub> = 75 mA; see Fig. 10 and Fig. 19	-	18	-	ns
t <sub>pd</sub>	propagation delay	SHCP to Q7S; I <sub>D</sub> = 75 mA; see Fig. 11 [1]	-	5	-	ns
f <sub>max</sub>	maximum frequency	SHCP; I <sub>D</sub> = 75 mA; see Fig. 11 [2]	-	-	10	MHz
t <sub>rr</sub>	reverse recovery time	I <sub>F</sub> = 100 mA; dI/dt = 10 A/μs; see Fig. 13 [3] [4]	-	120	-	ns
t <sub>a</sub>	reverse recovery current rise time	I <sub>F</sub> = 100 mA; dI/dt = 10 A/μs; see Fig. 13 [3] [4]	-	100	-	ns
t <sub>su</sub>	set-up time	DS to SHCP; see Fig. 12	20	-	-	ns
t <sub>h</sub>	hold time	DS to SHCP; see Fig. 12	20	-	-	ns
t <sub>W</sub>	pulse width		40	-	-	ns

[1] t<sub>pd</sub> is the same as t<sub>PLH</sub> and t<sub>PHL</sub>.

[2] This is the maximum serial clock frequency assuming cascaded operation where serial data is passed from one stage to a second stage. The clock period allows for SHCP → Q7S propagation delay and setup time plus some timing margin.

[3] This technique should limit T<sub>j</sub> - T<sub>amb</sub> to 10 °C maximum.

[4] These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.



10.1. Waveforms and test circuit

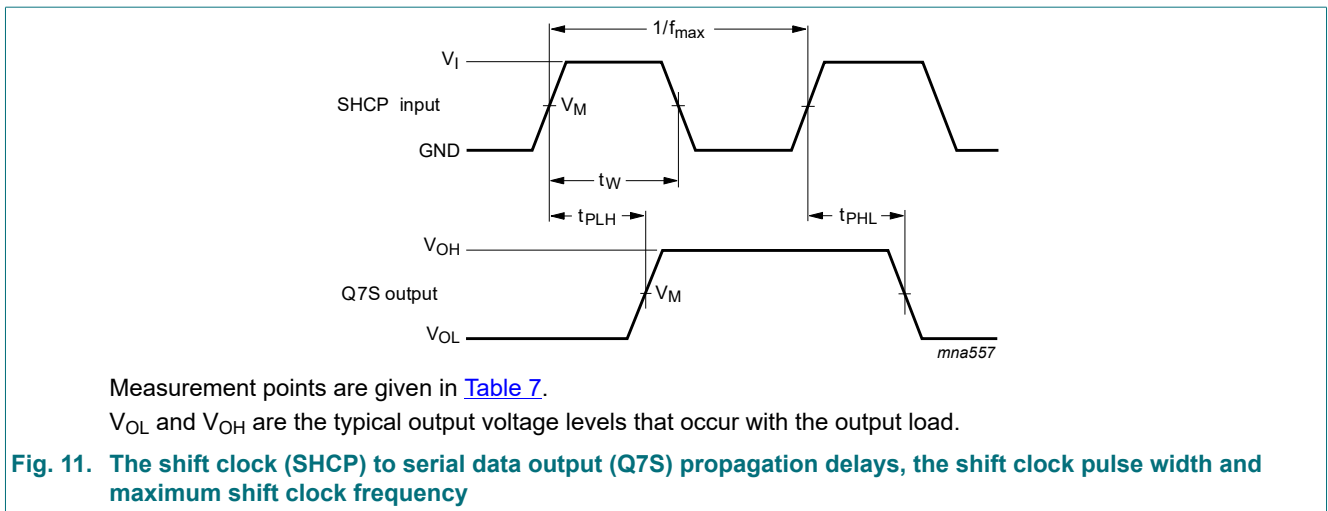
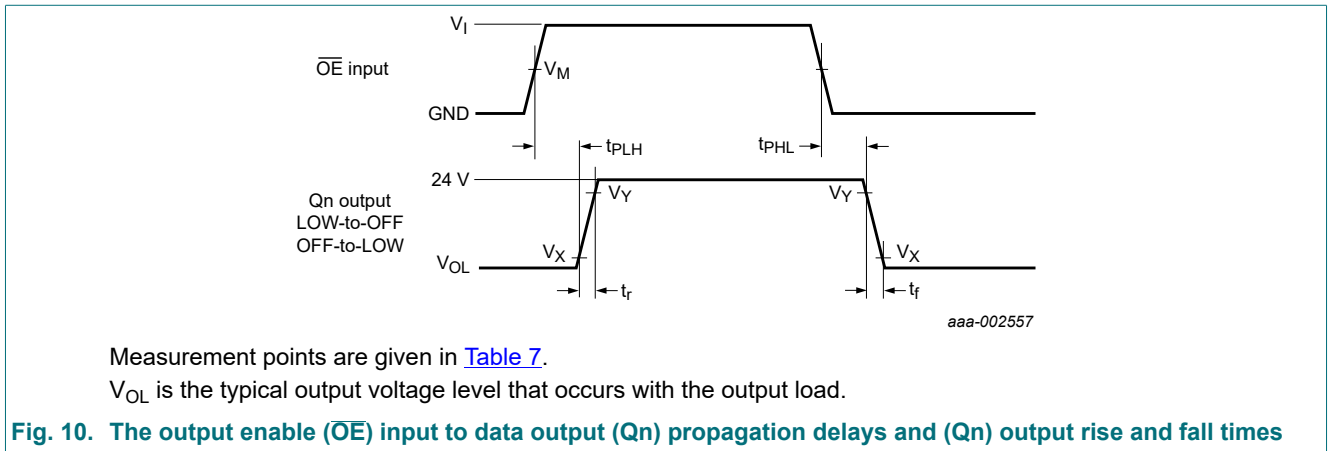
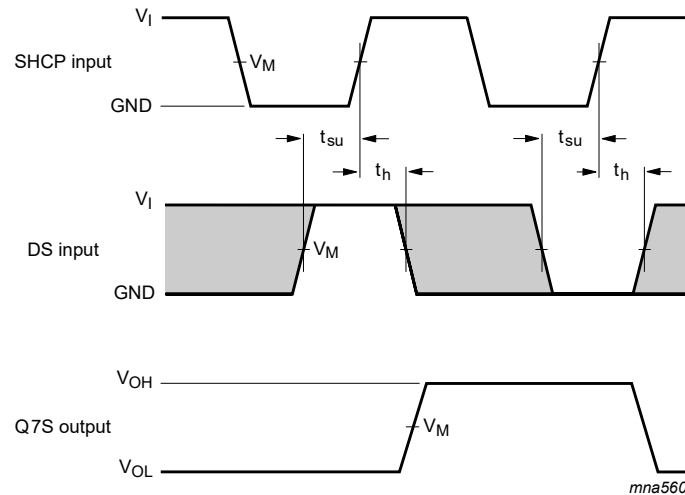


Table 7. Measurement points

Supply voltage	Input	Output		
$V_{CC}$	$V_M$	$V_M$	$V_X$	$V_Y$
5 V	$0.5V_{CC}$	$0.5V_{DS}$	$0.1V_{DS}$	$0.9V_{DS}$



Measurement points are given in [Table 8](#).

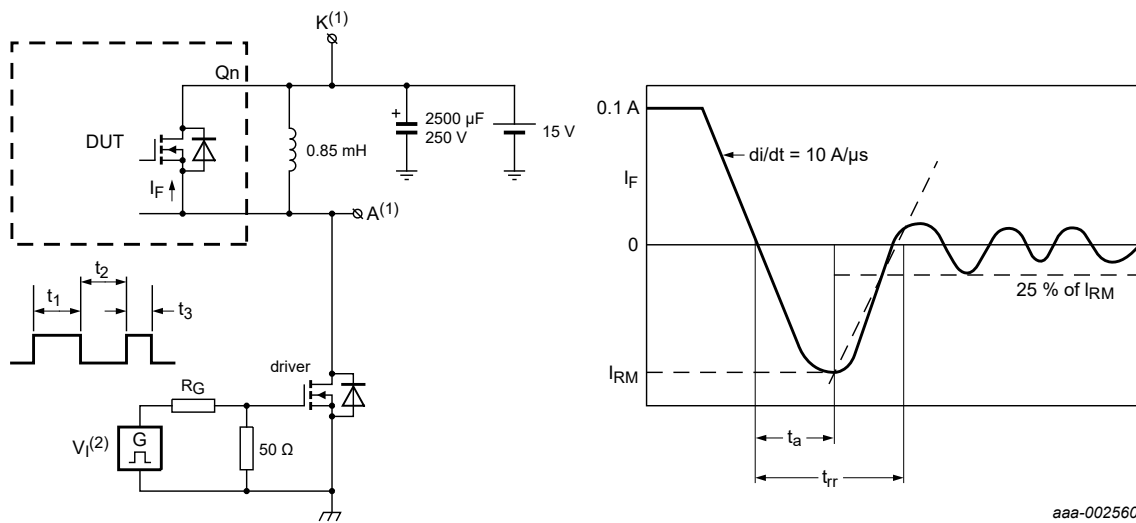
The shaded areas indicate when the input is permitted to change for predictable output performance.

$V_{OL}$  and  $V_{OH}$  are the typical output voltage levels that occur with the output load.

**Fig. 12. The data set-up and hold times for the serial data input (DS)**

**Table 8. Measurement points**

Supply voltage	Input	Output
$V_{CC}$	$V_M$	$V_M$
5 V	$0.5V_{CC}$	$0.5V_{CC}$



(1) The open-drain Qn terminal under test is connected to test point K. All other terminals are connected together and connected to test point A.

(2) The  $V_1$  amplitude and  $R_G$  are adjusted for  $di/dt = 10 \text{ A}/\mu\text{s}$ . A  $V_1$  double-pulse train is used to set  $I_F = 0.1 \text{ A}$ , where  $t_1 = 10 \mu\text{s}$ ,  $t_2 = 7 \mu\text{s}$  and  $t_3 = 3 \mu\text{s}$ .

**Fig. 13. Test circuit and waveform for measuring reverse recovery current**

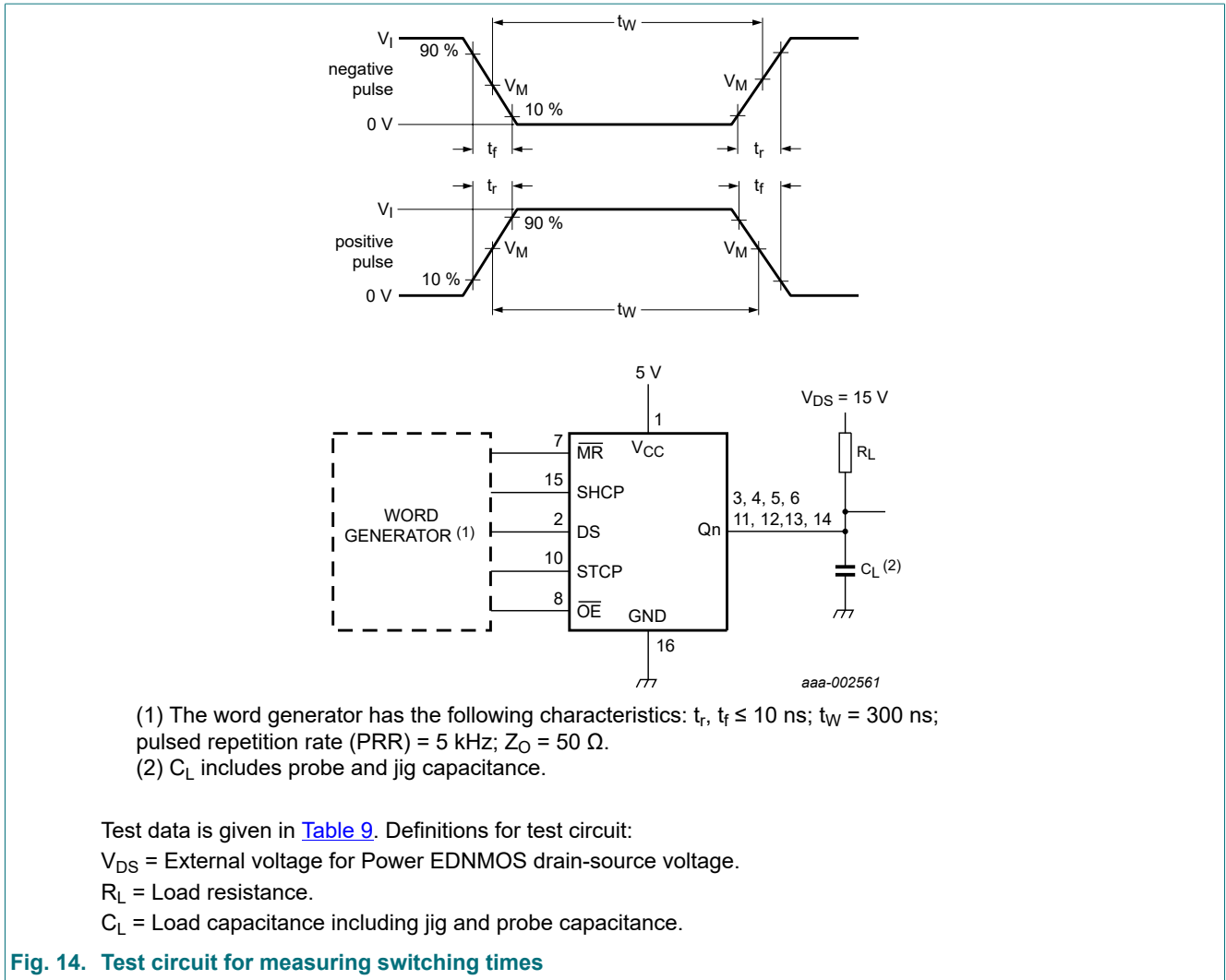


Table 9. Test data

Supply voltage	Input			Load	
	$V_I$	$t_r, t_f$	$V_M$	$C_L$	$R_L$
5 V	5 V	$\leq 10$ ns	50 %	30 pF	200 $\Omega$

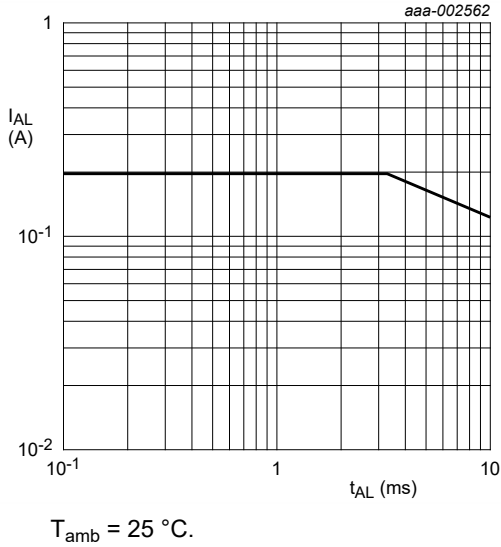


Fig. 15. Avalanche current (peak) versus time duration of avalanche

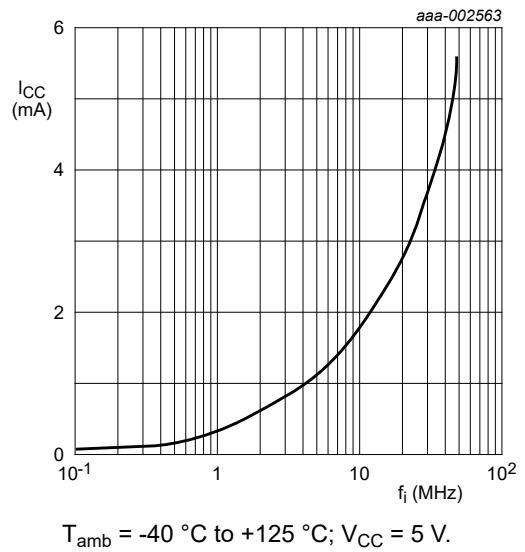


Fig. 16. Supply current versus frequency

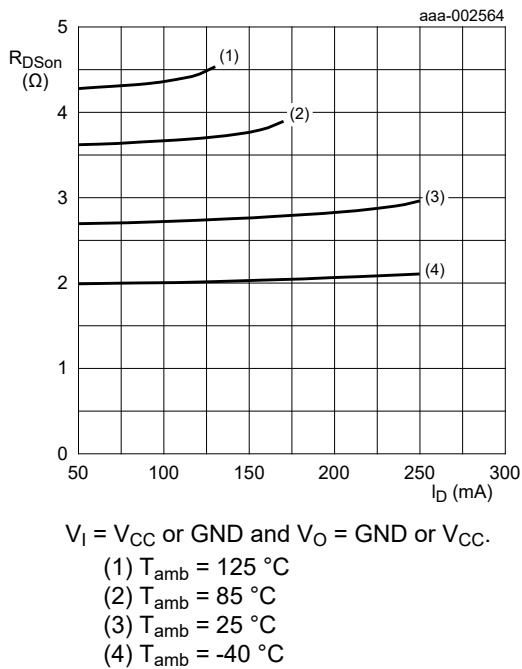


Fig. 17. Drain-source on-state resistance versus drain current

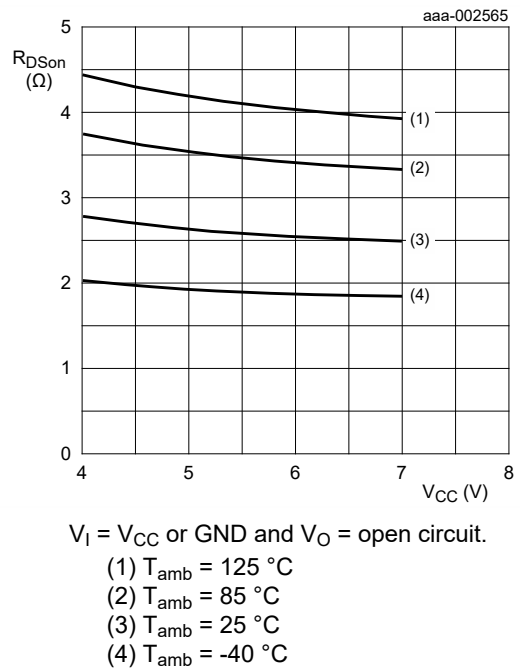
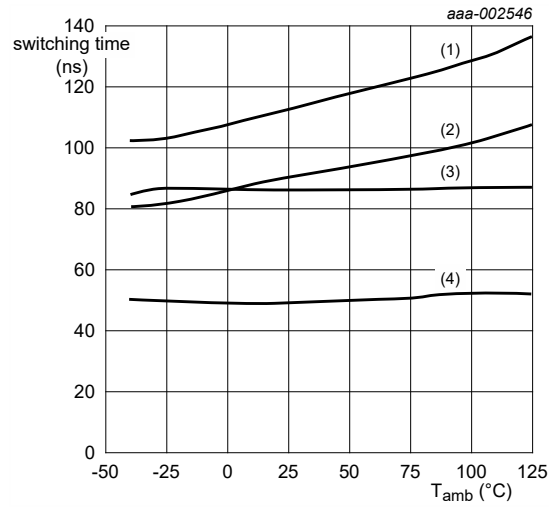


Fig. 18. Static drain-source on-state resistance versus supply voltage



I<sub>D</sub> = 75 mA, this technique should limit T<sub>j</sub> - T<sub>amb</sub> to 10 °C maximum.

- (1) t<sub>PLH</sub>.
- (2) t<sub>r</sub>.
- (3) t<sub>f</sub>.
- (4) t<sub>PHL</sub>.

Fig. 19. Switching time versus temperature

### 11. Package outline

SO16: plastic small outline package; 16 leads; body width 3.9 mm

SOT109-1



Fig. 20. Package outline SOT109-1 (SO16)

TSSOP16: plastic thin shrink small outline package; 16 leads; body width 4.4 mm

SOT403-1



Fig. 21. Package outline SOT403-1 (TSSOP16)

DHVQFN16: plastic dual in-line compatible thermal enhanced very thin quad flat package; no leads; 16 terminals; body 2.5 x 3.5 x 0.85 mm

SOT763-1



Fig. 22. Package outline SOT763-1 (DHVQFN16)



## 12. Abbreviations

Table 10. Abbreviations

Acronym	Description
CDM	Charged Device Model
DUT	Device Under Test
EDNMOS	Extended Drain Negative Metal Oxide Semiconductor
ESD	ElectroStatic Discharge
HBM	Human Body Model

## 13. Revision history

Table 11. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
NPIC6C595_Q100 v.2	20200609	Product data sheet	-	NPIC6C595_Q100 v.1
Modifications:	<ul style="list-style-type: none"> <li>The format of this data sheet has been redesigned to comply with the identity guidelines of Nexperia.</li> <li>Legal texts have been adapted to the new company name where appropriate.</li> <li><a href="#">Section 2</a> updated.</li> <li><a href="#">Fig. 5</a> updated; Latch changed to Flip Flop</li> <li><a href="#">Table 3</a>: Derating values for <math>P_{tot}</math> total power dissipation updated.</li> </ul>			
NPIC6C595_Q100 v.1	20120712	Product data sheet	-	-

## 14. Legal information

### Data sheet status

Document status [1][2]	Product status [3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

- [1] Please consult the most recently issued document before initiating or completing a design.
- [2] The term 'short data sheet' is explained in section "Definitions".
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