NPIC6C596-Q100

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

Rev. 2 — 4 July 2013 **Product data sheet**

1. General description

The NPIC6C596-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 $\overline{\text{MR}}$ input. A LOW on $\overline{\text{MR}}$ 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. If both clocks are connected together, the shift register is always one clock pulse ahead of the storage register. To provide additional hold time in cascaded applications, the serial output QS7 is clocked out on the falling edge of SHCP. Data in the storage register drives the gate of the output extended-drain NMOS (EDNMOS) transistor whenever the output enable input ($\overline{\text{OE}}$) is LOW. A HIGH on $\overline{\text{OE}}$ causes the outputs to assume a high-impedance OFF-state. Operation of the $\overline{\text{OE}}$ 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 relays, 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

- 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
- Enhanced cascading for multiple stages
- 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

nexperia

3. Applications

- LED sign
- Graphic status panel
- Fault status indicator

4. Ordering information

Table 1. Ordering information

Type number	Package			
	Temperature range	Name	Description	Version
NPIC6C596D-Q100	–40 °C to +125 °C	SO16	plastic small outline package; 16 leads; body width 3.9 mm	SOT109-1
NPIC6C596PW-Q100	–40 °C to +125 °C	TSSOP16	plastic thin shrink small outline package; 16 leads; body width 4.4 mm	SOT403-1
NPIC6C596BQ-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

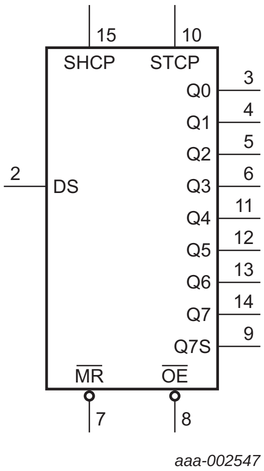


Fig 1. Logic symbol

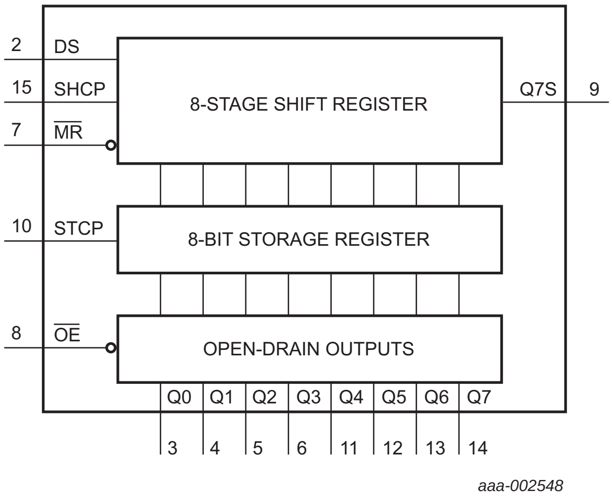


Fig 2. Functional diagram

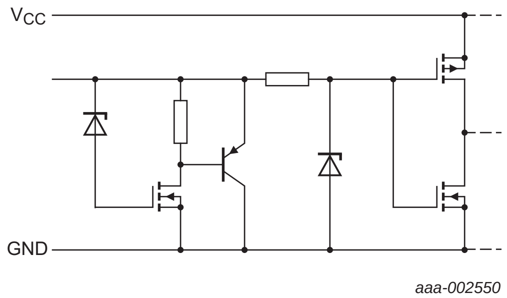


Fig 3. Schematic of all inputs

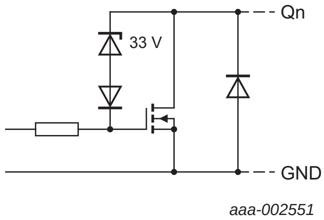


Fig 4. Schematic of open-drain outputs (Qn)

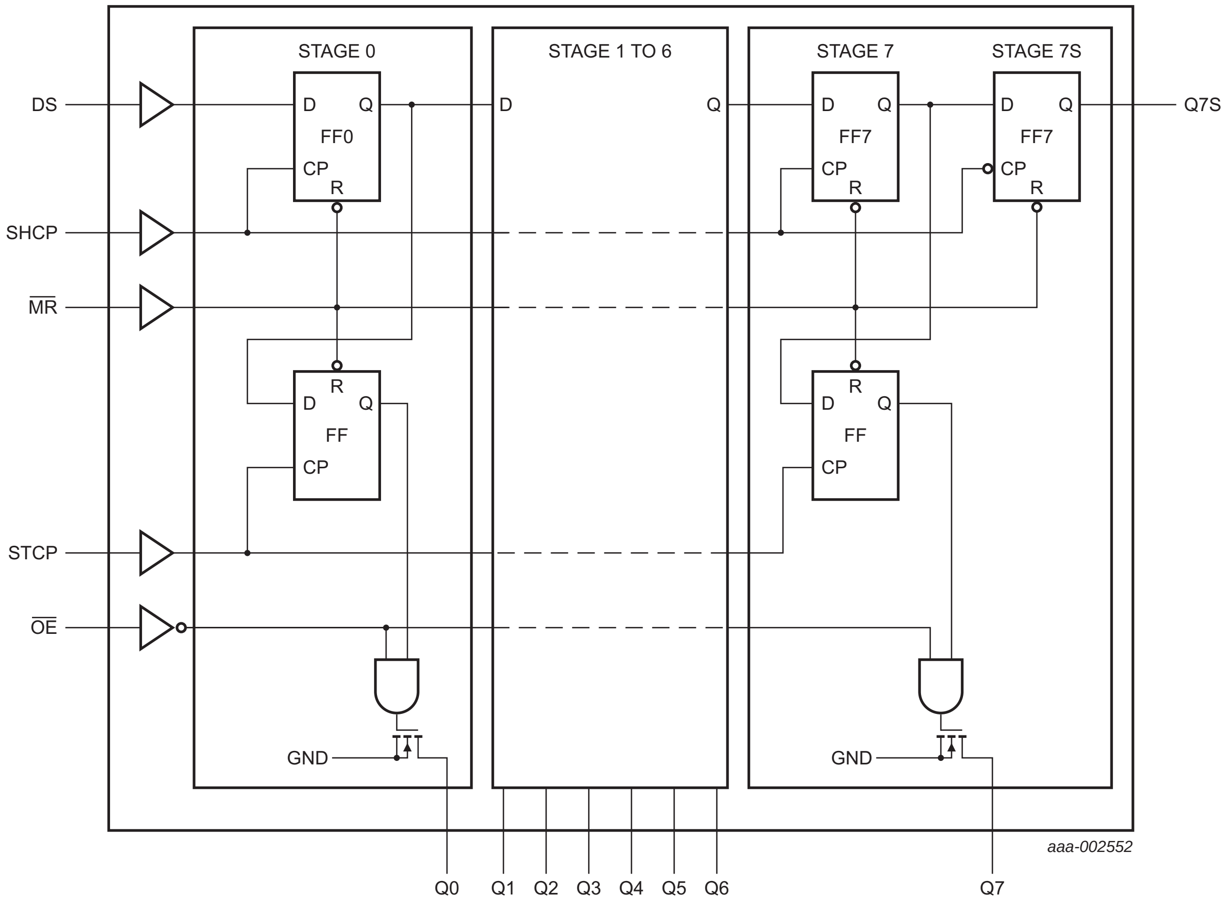


Fig 5. Logic diagram

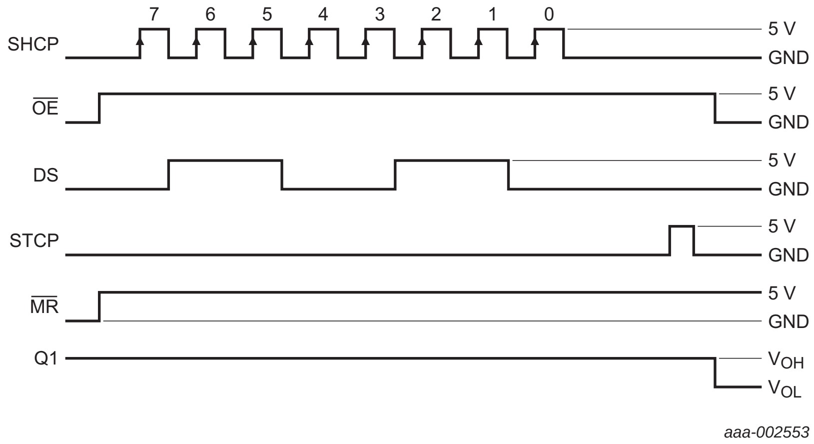


Fig 6. Timing diagram

6. Pinning information

6.1 Pinning

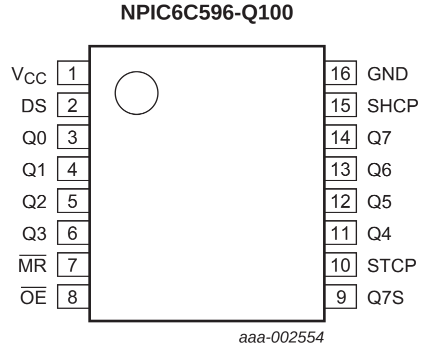
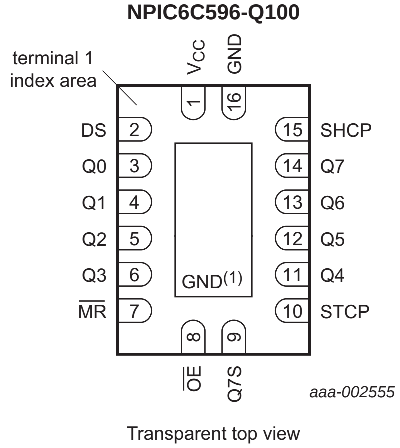


Fig 7. Pin configuration SO16 and TSSOP16



(1) This is not a supply pin. The substrate is attached to this pad using conductive die attach material. There is no electrical or mechanical requirement to solder this pad. However, if it is soldered, the solder land should remain floating or be connected to GND.

Fig 8. Pin configuration DHVQFN16

6.2 Pin description

Table 2. Pin description

Symbol	Pin	Description
V_{CC}	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)
$\overline{MR}$	7	master reset (active LOW)
$\overline{OE}$	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 °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 °C	[2]	-	250	mA
E_{AS}	non-repetitive avalanche energy	single pulse; see Figure 9	[3]	-	30	mJ
I_{AL}	avalanche current	see Figure 9	[3]	-	200	mA
T_{stg}	storage temperature			–65	+150	°C
P_{tot}	total power dissipation	T_{amb} = 25 °C	[4]			
		SO16		-	800	mW
		TSSOP16		-	725	mW
		DHVQFN16		-	1825	mW
		T_{amb} = 125 °C	[4]			
		SO16		-	160	mW
		TSSOP16		-	145	mW
		DHVQFN16		-	365	mW

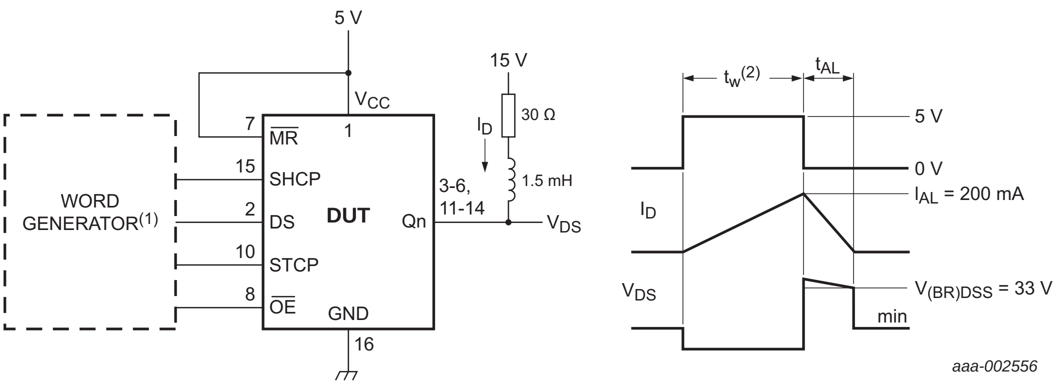
[1] Each power EDNMOS source is internally connected to GND.

[2] Pulse duration ≤ 100 μs and duty cycle ≤ 2 %.

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

[4] For SO16 packages: above 25 °C the value of P_{tot} derates linearly with 6.4 mW/°C.
For TSSOP16 packages: above 25 °C the value of P_{tot} derates linearly with 5.8 mW/°C.
For DHVQFN16 packages: above 25 °C the value of P_{tot} derates linearly with 14.6 mW/°C.

7.1 Test circuit and waveform



(1) The word generator has the following characteristics: t_r, $t_f \leq 10$ ns; $Z_O = 50\ \Omega$.

(2) The input pulse duration (t_W) is increased until peak current I_{AL} = 200 mA. Energy test level is defined as: $E_{AS} = I_{AL} \times V_{(BR)DSS} \times t_{AL}/2 = 30$ mJ.

Fig 9. Test circuit and waveform for measuring single-pulse avalanche energy

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 V; T_{amb} = 25 °C; all outputs on	[1][2]	-	-	250	mA
T_{amb}	ambient temperature			–40	-	+125	°C

[1] Pulse duration ≤ 100 μs and duty cycle ≤ 2 %.

[2] Technique should limit $T_j - T_{amb}$ to 10 °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_{CC} = 5.0 V; T_{amb} = 25 °C			Unit
			Min	Typ	Max	
V_{IH}	HIGH-level input voltage	V_{CC} = 4.5 V to 5.5 V	0.85V_{CC}	-	-	V
V_{IL}	LOW-level input voltage	V_{CC} = 4.5 V to 5.5 V	-	-	0.15V_{CC}	V
V_{OH}	HIGH-level output voltage	serial data output Q7S; V_I = V_{IH} or V_{IL}				
		I_O = –20 μA; V_{CC} = 4.5 V	4.4	4.49	-	V
		I_O = –4 mA; V_{CC} = 4.5 V	4.0	4.2	-	V

Table 5. Static characteristics *...continued*

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

Symbol	Parameter	Conditions		V_{CC} = 5.0 V; T_{amb} = 25 °C			Unit
				Min	Typ	Max	
V_{OL}	LOW-level output voltage	serial data output Q7S; $V_I = V_{IH}$ or V_{IL}					
		I_O = 20 μA; V_{CC} = 4.5 V		-	0.005	0.1	V
		I_O = 4 mA; V_{CC} = 4.5 V		-	0.3	0.5	V
I_{IH}	HIGH-level input current	V_{CC} = 5.5 V; $V_I = V_{CC}$		-	-	1	μA
I_{IL}	LOW-level input current	V_{CC} = 5.5 V; V_I = 0 V		−1	-	-	μA
$V_{(BR)DSS}$	drain-source breakdown voltage	I_D = 1 mA		33	37	-	V
V_{SD}	source-drain voltage	diode forward voltage; I_F = 100 mA		-	0.85	1.2	V
I_{CC}	supply current	logic supply current; V_{CC} = 5.5 V; $V_I = V_{CC}$ or GND					
		all outputs off		-	0.004	200	μA
		all outputs on	[1]	-	0.006	500	μA
		all outputs off; SHCP = 5 MHz;C_L = 30 pF; see Figure 14 and Figure 16		-	0.75	5	mA
$I_{O(nom)}$	nominal output current	V_{DS} = 0.5 V; T_{amb} = 85 °C; $I_{out} = I_D$	[2][3][4]	-	140	-	mA
I_{DSX}	drain cut-off current	V_{CC} = 5.5 V; V_{DS} = 30 V		-	0.002	0.2	μA
		V_{CC} = 5.5 V; V_{DS} = 30 V; T_{amb} = 125 °C		-	0.15	0.3	μA
R_{DSon}	drain-source on-state resistance	see Figure 17 and Figure 18	[2][3]				
		V_{CC} = 4.5 V; I_D = 50 mA		-	3.0	9	Ω
		V_{CC} = 4.5 V; I_D = 50 mA; T_{amb} = 125 °C			5.4	12	Ω
		V_{CC} = 4.5 V; I_D = 100 mA		-	3.1	10	Ω

[1] Output currents below 250 mA current limit.

[2] Technique should limit $T_j - T_{amb}$ to 10 °C maximum.

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

[4] 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_{amb} = 85 °C.

10. Dynamic characteristics

Table 6. Dynamic characteristics
Voltages are referenced to GND (ground = 0 V); For test circuit see Figure 14.

Symbol	Parameter	Conditions		V_{CC} = 5.0 V; T_{amb} = 25 °C			Unit
				Min	Typ	Max	
t_{PLH}	LOW to HIGH propagation delay	$\overline{OE}$ to Qn; I_D = 75 mA; see Figure 10 and Figure 19		-	97	-	ns
t_{PHL}	HIGH to LOW propagation delay	$\overline{OE}$ to Qn; I_D = 75 mA; see Figure 10 and Figure 19		-	9	-	ns
t_r	rise time	$\overline{OE}$ to Qn; I_D = 75 mA; see Figure 10 and Figure 19		-	60	-	ns
t_f	fall time	$\overline{OE}$ to Qn; I_D = 75 mA; see Figure 10 and Figure 19		-	18	-	ns
t_{pd}	propagation delay	SHCP to Q7S; I_D = 75 mA; see Figure 11	[1]	-	5	-	ns
f_{max}	maximum frequency	SHCP; I_D = 75 mA; see Figure 11	[2]	-	-	10	MHz
t_{rr}	reverse recovery time	I_F = 100 mA; dI/dt = 10 A/µs; see Figure 13	[3][4]	-	120	-	ns
t_a	reverse recovery current rise time	I_F = 100 mA; dI/dt = 10 A/µs; see Figure 13	[3][4]	-	100	-	ns
t_{su}	set-up time	DS to SHCP; see Figure 12		15	-	-	ns
t_h	hold time	DS to SHCP; see Figure 12		15	-	-	ns
t_W	pulse width			40	-	-	ns

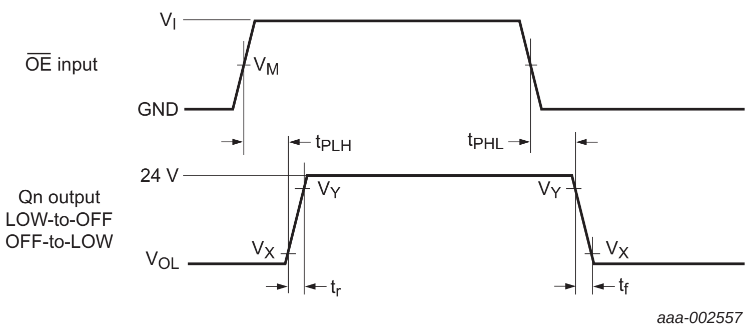
[1] t_{pd} is the same as t_{PLH} and t_{PHL}.

[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] Technique should limit $T_j - T_{amb}$ to 10 °C maximum.

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

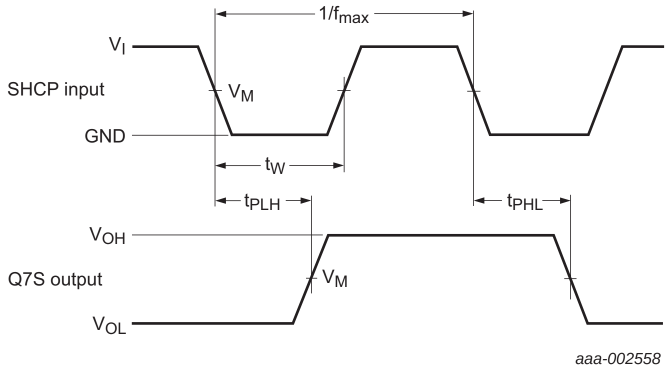
10.1 Test circuits and waveforms



Measurement points are given in Table 7.

V_{OL} is the typical output voltage level that occurs with the output load.

Fig 10. The output enable ($\overline{OE}$) input to data output (Qn) propagation delays and (Qn) output rise and fall times



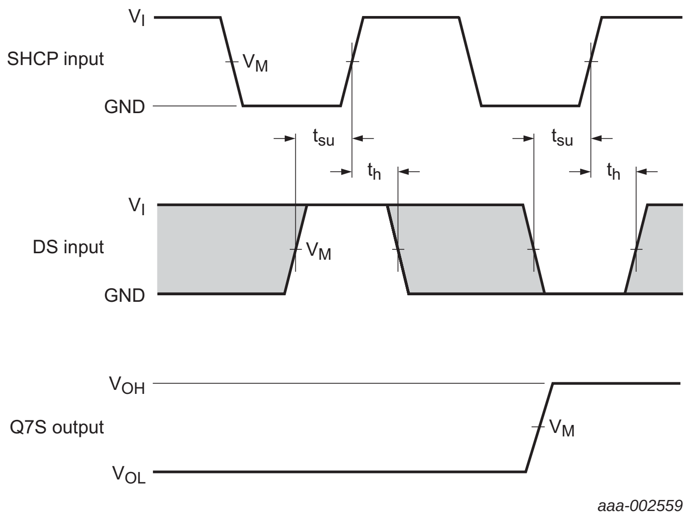
Measurement points are given in Table 7.

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

Fig 11. The shift clock (SHCP) to serial data output (Q7S) propagation delays with the minimum shift clock pulse width and maximum shift clock frequency

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.

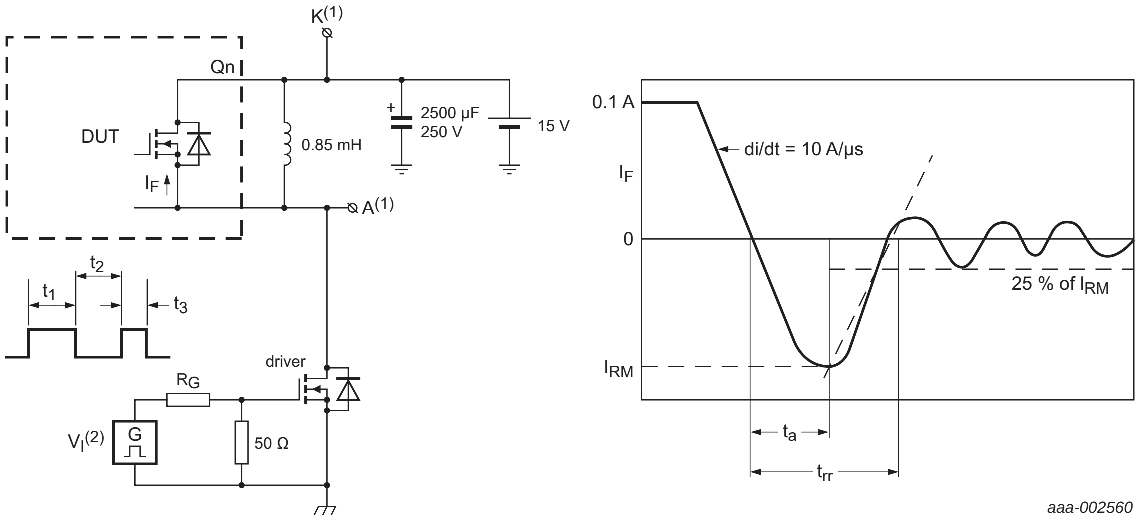
The shaded areas indicate when the input is permitted to change for predictable output performance.

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

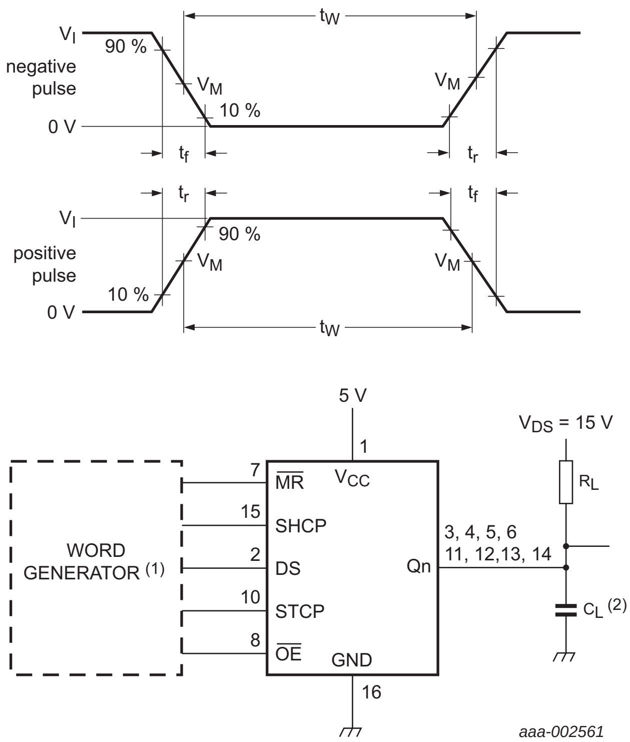
Supply voltage	Input	Output
V_{CC}	V_M	V_M
5 V	$0.5V_{CC}$	$0.5V_{CC}$



(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_I amplitude and R_G are adjusted for dI/dt = 10 A/µs. A V_I double-pulse train is used to set I_F = 0.1 A, where t_1 = 10 µs, t_2 = 7 µs and t_3 = 3 µs.

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



(1) The word generator has the following characteristics: t_r, $t_f \leq 10$ ns; $t_W = 300$ ns; pulsed repetition rate (PRR) = 5 kHz; $Z_O = 50\ \Omega$.

(2) C_L includes probe and jig capacitance.

Test data is given in Table 9. Definitions for test circuit:

V_{DS} = External voltage for Power EDNMOS drain-source voltage.

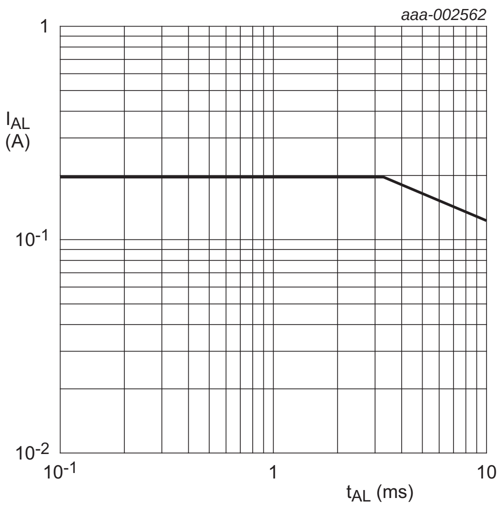
R_L = Load resistance.

C_L = Load capacitance including jig and probe capacitance.

Fig 14. Test circuit for measuring switching times

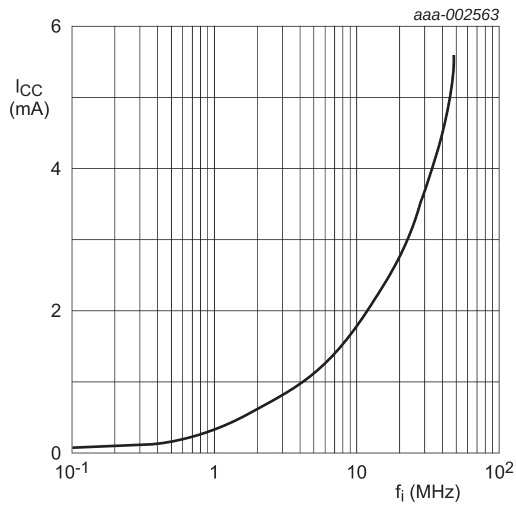
Table 9. Test data

Supply voltage	Input			Load	
	V_I	t_r, t_f	V_M	C_L	R_L
5 V	5 V	≤ 10 ns	50 %	30 pF	200 Ω



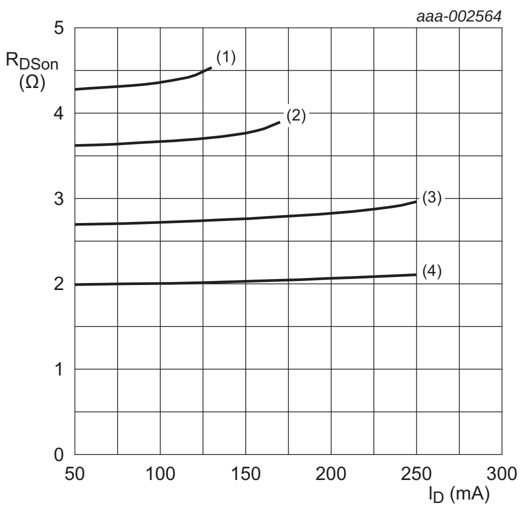
T_{amb} = 25 °C.

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



T_{amb} = −40 °C to 125 °C; V_{CC} = 5 V.

Fig 16. Supply current versus frequency



V_I = V_{CC} or GND and V_O = GND or V_{CC}.

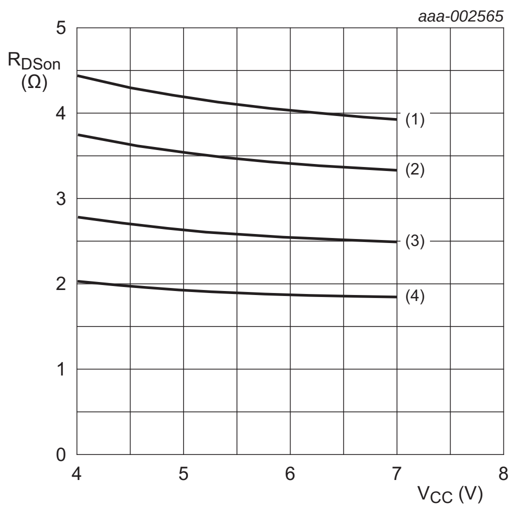
(1) T_{amb} = 125 °C

(2) T_{amb} = 85 °C

(3) T_{amb} = 25 °C

(4) T_{amb} = −40 °C

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



V_I = V_{CC} or GND and V_O = open circuit.

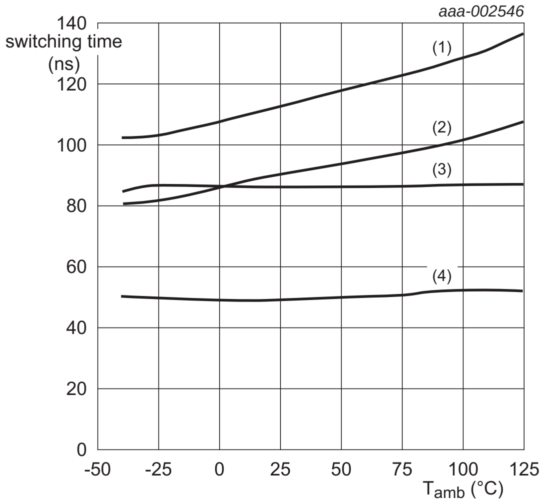
(1) T_{amb} = 125 °C

(2) T_{amb} = 85 °C

(3) T_{amb} = 25 °C

(4) T_{amb} = −40 °C

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



Technique should limit $T_J - T_C$ to 10 °C maximum.

(1) t_{PLH}.

(2) t_r.

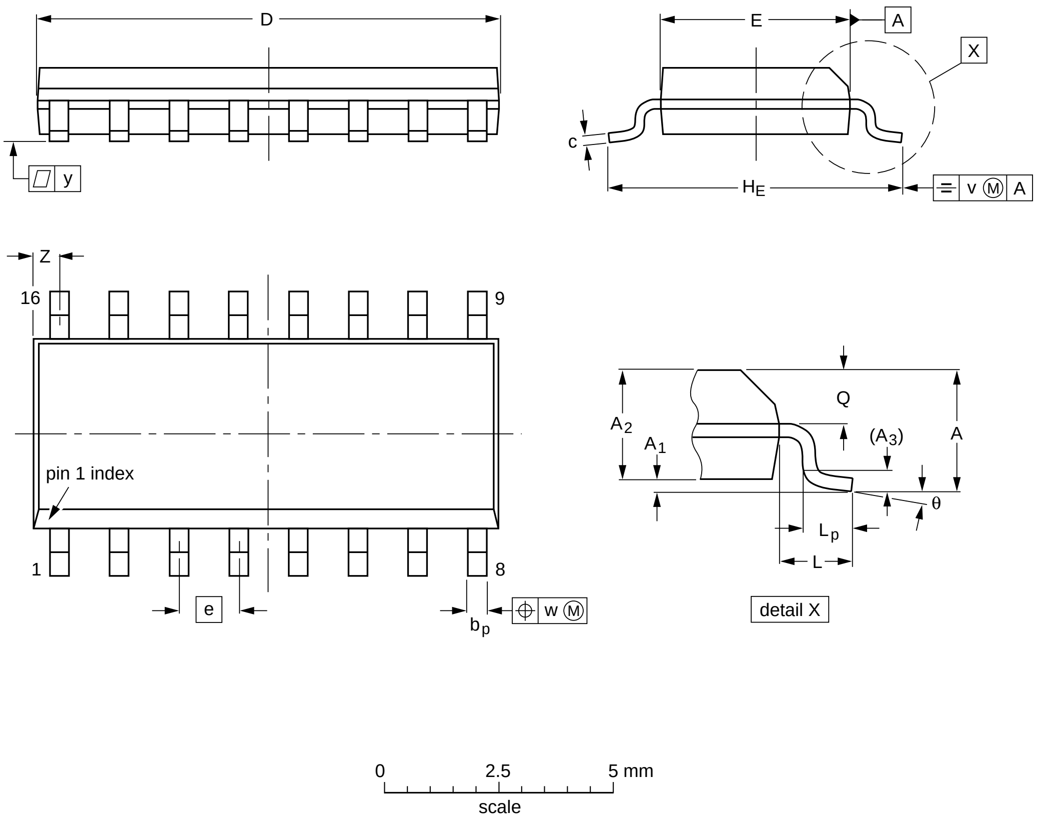
(3) t_f.

(4) t_{PHL}.

Fig 19. Switching time versus case temperature

11. Package outline

SO16: plastic small outline package; 16 leads; body width 3.9 mm **SOT109-1**



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	D(1)	E(1)	e	H_E	L	L_p	Q	v	w	y	Z(1)	θ
mm	1.75	0.25 0.10	1.45 1.25	0.25	0.49 0.36	0.25 0.19	10.0 9.8	4.0 3.8	1.27	6.2 5.8	1.05	1.0 0.4	0.7 0.6	0.25	0.25	0.1	0.7 0.3	8° 0°
inches	0.069	0.010 0.004	0.057 0.049	0.01	0.019 0.014	0.0100 0.0075	0.39 0.38	0.16 0.15	0.05	0.244 0.228	0.041	0.039 0.016	0.028 0.020	0.01	0.01	0.004	0.028 0.012	

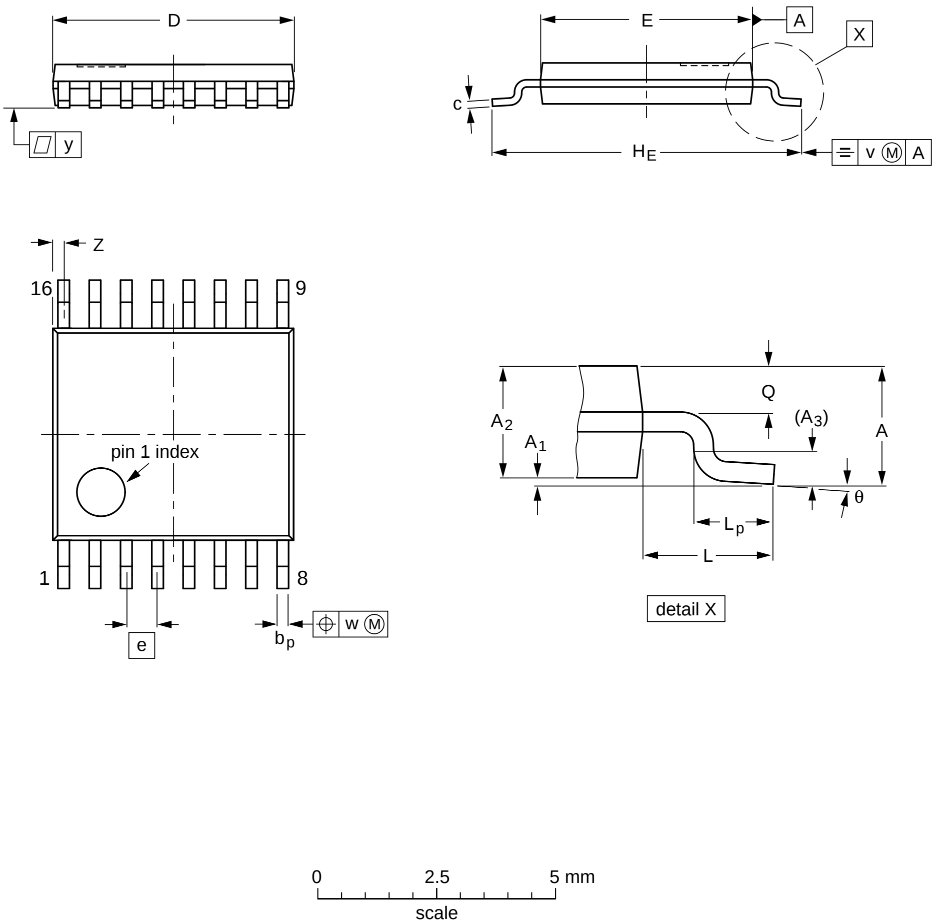
Note

1. Plastic or metal protrusions of 0.15 mm (0.006 inch) maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT109-1	076E07	MS-012				~~99-12-27~~ 03-02-19

Fig 20. Package outline SOT109-1 (SO16)

TSSOP16: plastic thin shrink small outline package; 16 leads; body width 4.4 mm **SOT403-1**



DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	D (1)	E (2)	e	H_E	L	L_p	Q	v	w	y	Z (1)	θ
mm	1.1	0.15 0.05	0.95 0.80	0.25	0.30 0.19	0.2 0.1	5.1 4.9	4.5 4.3	0.65	6.6 6.2	1	0.75 0.50	0.4 0.3	0.2	0.13	0.1	0.40 0.06	8^o 0^o

Notes

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
2. Plastic interlead protrusions of 0.25 mm maximum per side are not included.

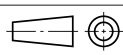
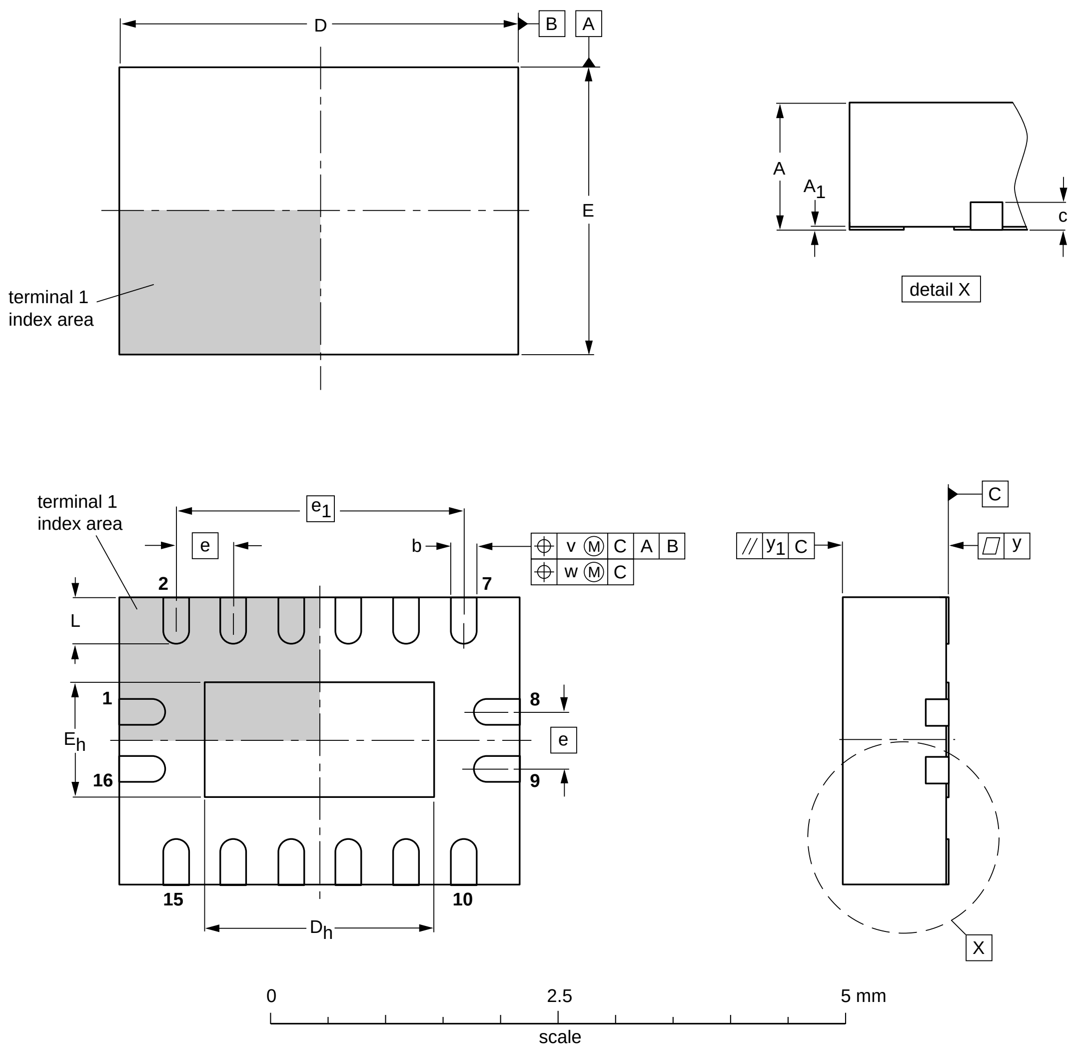
OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT403-1		MO-153				~~99-12-27~~ 03-02-18

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**



DIMENSIONS (mm are the original dimensions)

UNIT	A(1) max.	A_1	b	c	D(1)	D_h	E(1)	E_h	e	e_1	L	v	w	y	y_1
mm	1	0.05 0.00	0.30 0.18	0.2	3.6 3.4	2.15 1.85	2.6 2.4	1.15 0.85	0.5	2.5	0.5 0.3	0.1	0.05	0.05	0.1

Note

1. Plastic or metal protrusions of 0.075 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT763-1	- - -	MO-241	- - -			~~02-10-17~~ 03-01-27

Fig 22. Package outline SOT763-1 (DHVQFN16)

12. Abbreviations

Table 10. Abbreviations

Acronym	Description
CDM	Charged Device Model
CMOS	Complementary Metal Oxide Semiconductor
DUT	Device Under Test
EDNMOS	Extended Drain Negative Metal Oxide Semiconductor
ESD	ElectroStatic Discharge
HBM	Human Body Model
TTL	Transistor-Transistor Logic

13. Revision history

Table 11. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
NPIC6C596_Q100 v.2	20130704	Product data sheet	-	NPIC6C596_Q100 v.1
Modifications:	• Figure 5 corrected (errata).			
NPIC6C596_Q100 v.1	20120712	Product data sheet	-	-

14. Legal information

14.1 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".

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL http://www.nexperia.com.

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