

DATA SHEET

74LVC574A

Octal D-type flip-flop with 5 V
tolerant inputs/outputs; positive
edge-trigger (3-state)

Product specification
Supersedes data of 1998 Jul 29

2003 Jun 20

Octal D-type flip-flop with 5 V tolerant inputs/outputs; positive edge-trigger (3-state)

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FEATURES

- 5 V tolerant inputs and outputs, for interfacing with 5 V logic
- Supply voltage range from 1.2 to 3.6 V
- Inputs accept voltages up to 5.5 V
- CMOS low power consumption
- Direct interface with TTL levels
- High impedance when $V_{CC} = 0$ V
- 8-bit positive edge-triggered register
- Independent register and 3-state buffer operation
- Flow-through pin-out architecture
- Complies with JEDEC standard no. 8-1A
- ESD protection:
HBM EIA/JESD22-A114-A exceeds 2000 V
MM EIA/JESD22-A115-A exceeds 200 V.
- Specified from -40 to $+85$ °C and -40 to $+125$ °C.

DESCRIPTION

The 74LVC574A is a high-performance, low-power, low-voltage, Si-gate CMOS device, superior to most advanced CMOS compatible TTL families.

Inputs can be driven from either 3.3 or 5 V devices. In 3-state operation, outputs can handle 5 V. This feature allows the use of these devices as translators in a mixed 3.3 and 5 V environment.

The 74LVC574A is an octal D-type flip-flop featuring separate D-type inputs for each flip-flop and 3-state outputs for bus-oriented applications. A clock (CP) and an Output Enable (\overline{OE}) input are common to all flip-flops.

The eight flip-flops will store the state of their individual D-inputs that meet the set-up and hold times requirements on the LOW-to-HIGH CP transition.

When \overline{OE} is LOW, the contents of the eight flip-flops is available at the outputs. When \overline{OE} is HIGH, the outputs go to the high impedance off-state. Operation of the \overline{OE} input does not affect the state of the flip-flops.

The 74LVC574A is functionally identical to the 74LVC374A, but has a different pin arrangement.

QUICK REFERENCE DATA

GND = 0 V; $T_{amb} = 25$ °C; $t_r = t_f \leq 2.5$ ns.

SYMBOL	PARAMETER	CONDITIONS	TYPICAL	UNIT
t_{PHL}/t_{PLH}	propagation delay CP to Qn	$C_L = 50$ pF; $V_{CC} = 3.3$ V	3.2	ns
f_{max}	maximum clock frequency		150	MHz
C_I	input capacitance		5.0	pF
C_{PD}	power dissipation capacitance per flip-flop	notes 1 and 2	15	pF

Notes

1. C_{PD} is used to determine the dynamic power dissipation (P_D in μ W).

$P_D = C_{PD} \times V_{CC}^2 \times f_i \times N + \Sigma(C_L \times V_{CC}^2 \times f_o)$ where:

f_i = input frequency in MHz;

f_o = output frequency in MHz;

C_L = output load capacitance in pF;

V_{CC} = supply voltage in Volts;

N = total load switching outputs;

$\Sigma(C_L \times V_{CC}^2 \times f_o)$ = sum of the outputs.

2. The condition is $V_I = \text{GND to } V_{CC}$.

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FUNCTION TABLE

See note 1.

OPERATING MODE	INPUT			INTERNAL FLIP-FLOP	OUTPUT
	\overline{OE}	CP	Dn		Qn
Load and read register	L	↑	l	L	L
	L	↑	h	H	H
Load register and disable outputs	H	↑	l	L	Z
	H	↑	h	H	Z

Note

1. H = HIGH voltage level;
h = HIGH voltage level one set-up time prior to the LOW-to-HIGH CP transition;
L = LOW voltage level;
l = LOW voltage level one set-up time prior to the LOW-to-HIGH CP transition;
↑ = LOW-to-HIGH clock transition;
Z = high-impedance OFF-state.

ORDERING INFORMATION

TYPE NUMBER	PACKAGE				
	TEMPERATURE RANGE	PINS	PACKAGE	MATERIAL	CODE
74LVC574AD	−40 to +125 °C	20	SO20	plastic	SOT163-1
74LVC574ADB	−40 to +125 °C	20	SSOP20	plastic	SOT339-1
74LVC574APW	−40 to +125 °C	20	TSSOP20	plastic	SOT360-1
74LVC574ABQ	−40 to +125 °C	20	DHVQFN20	plastic	SOT764-1

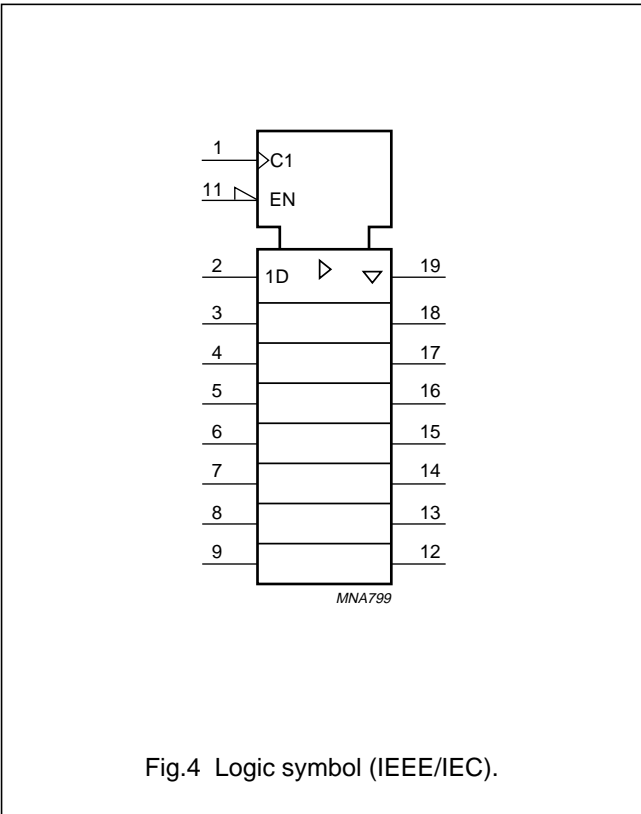
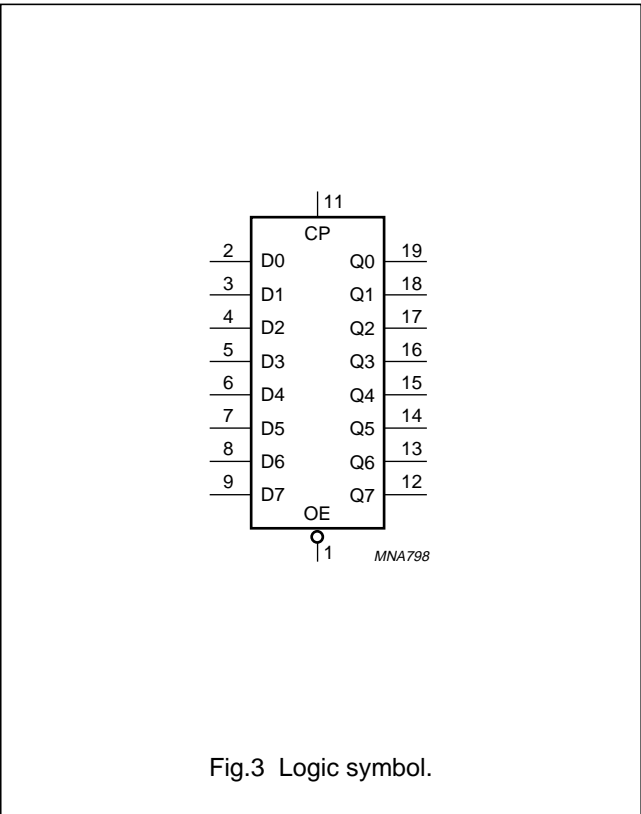
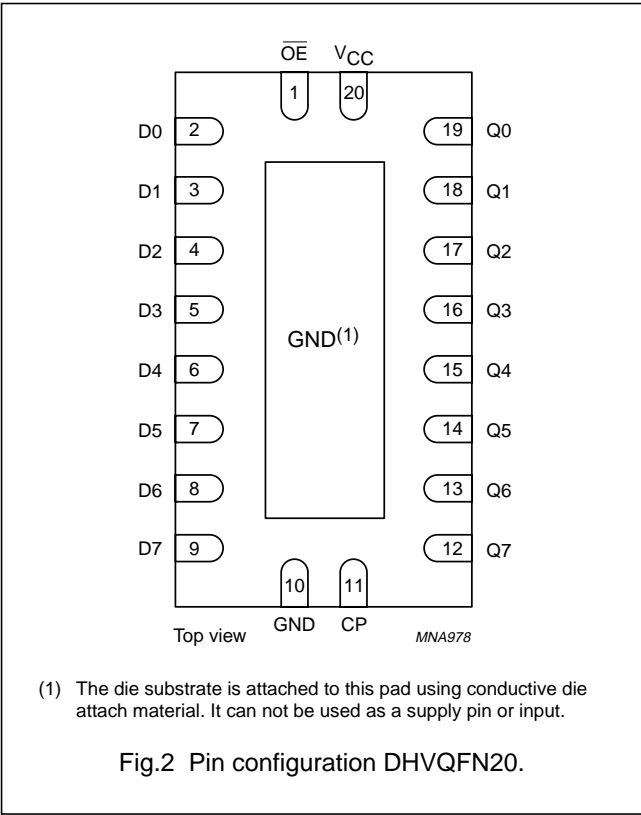
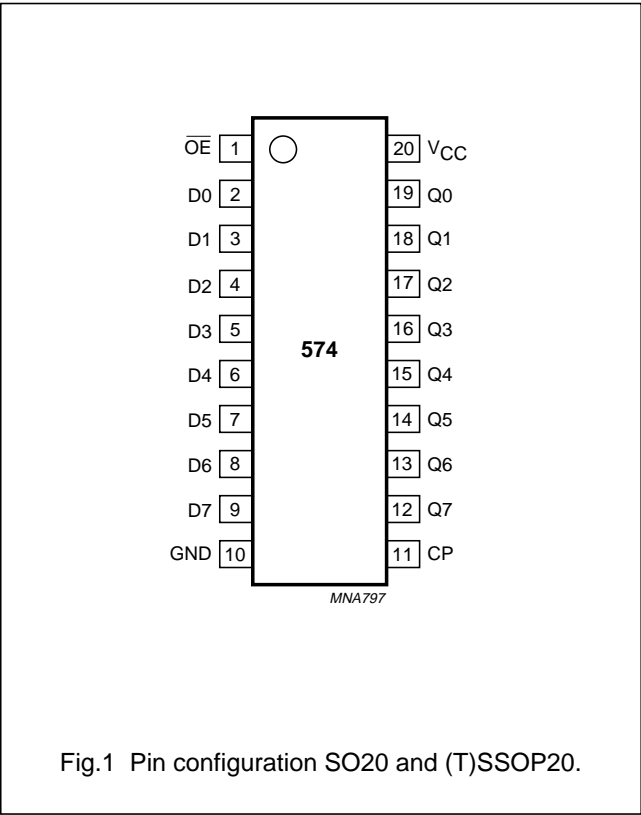
PINNING

PIN	SYMBOL	DESCRIPTION
1	\overline{OE}	output enable input (active LOW)
2	D0	data input
3	D1	data input
4	D2	data input
5	D3	data input
6	D4	data input
7	D5	data input
8	D6	data input
9	D7	data input
10	GND	ground (0 V)

PIN	SYMBOL	DESCRIPTION
11	CP	clock input (LOW-to-HIGH; edge triggered)
12	Q7	data output
13	Q6	data output
14	Q5	data output
15	Q4	data output
16	Q3	data output
17	Q2	data output
18	Q1	data output
19	Q0	data output
20	V _{CC}	supply voltage

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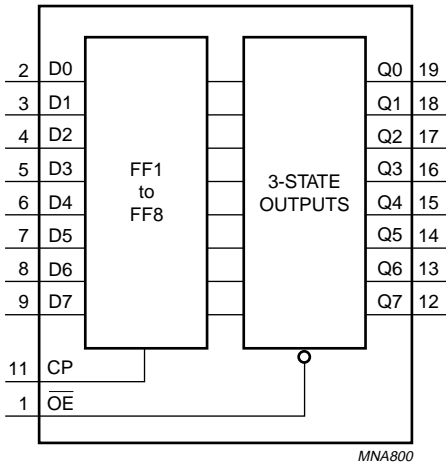


Fig.5 Functional diagram.

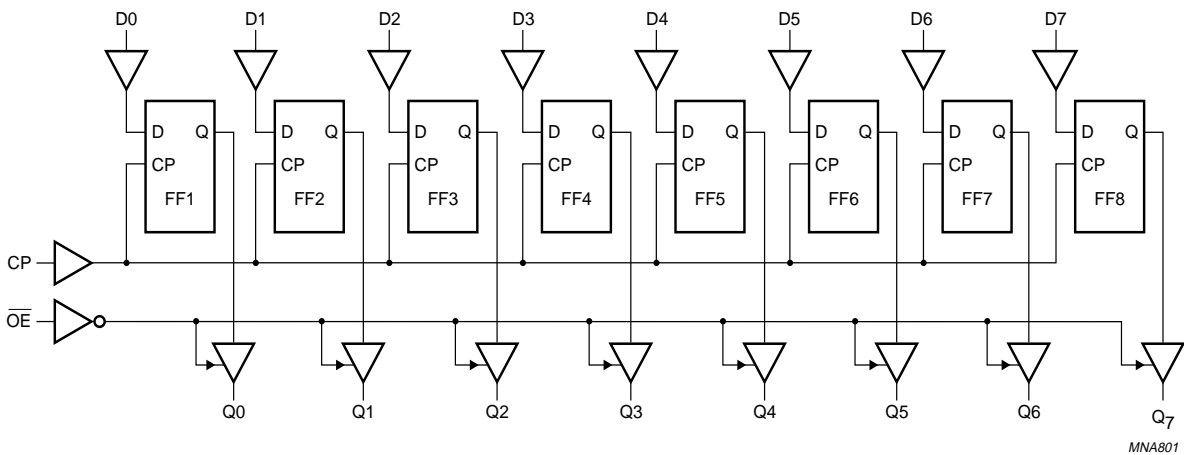


Fig.6 Logic diagram.

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RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CC}	supply voltage	for maximum speed performance	2.7	3.6	V
		for low-voltage applications	1.2	3.6	V
V_I	input voltage		0	5.5	V
V_O	output voltage	output HIGH or LOW state	0	V_{CC}	V
		output 3-state	0	5.5	V
T_{amb}	operating ambient temperature	in free air	-40	+125	°C
t_r, t_f	input rise and fall times	$V_{CC} = 1.2$ to 2.7 V	0	20	ns/V
		$V_{CC} = 2.7$ to 3.6 V	0	10	ns/V

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	+6.5	V
I_{IK}	input diode current	$V_I < 0$	-	-50	mA
V_I	input voltage	note 1	-0.5	+6.5	V
I_{OK}	output diode current	$V_O > V_{CC}$ or $V_O < 0$	-	± 50	mA
V_O	output voltage	output HIGH or LOW state; note 1	-0.5	$V_{CC} + 0.5$	V
		output 3-state; note 1	-0.5	+6.5	V
I_O	output source or sink current	$V_O = 0$ to V_{CC}	-	± 50	mA
I_{CC}, I_{GND}	V_{CC} or GND current		-	± 100	mA
T_{stg}	storage temperature		-65	+150	°C
P_{tot}	power dissipation	$T_{amb} = -40$ to $+125$ °C; note 2	-	500	mW

Notes

1. The input and output voltage ratings may be exceeded if the input and output current ratings are observed.
2. For SO20 packages: above 70 °C the value of P_{tot} derates linearly with 8 mW/K.
For (T)SSOP20 packages: above 60 °C the value of P_{tot} derates linearly with 5.5 mW/K.
For DHVQFN20 packages: above 60 °C the value of P_{tot} derates linearly with 4.5 mW/K.

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DC CHARACTERISTICS

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

SYMBOL	PARAMETER	TEST CONDITIONS		MIN.	TYP. ⁽¹⁾	MAX.	UNIT
		OTHER	V _{CC} (V)				
T _{amb} = −40 to +85 °C							
V _{IH}	HIGH-level input voltage		1.2	V _{CC}	–	–	V
			2.7 to 3.6	2.0	–	–	V
V _{IL}	LOW-level input voltage		1.2	–	–	GND	V
			2.7 to 3.6	–	–	0.8	V
V _{OH}	HIGH-level output voltage	V _I = V _{IH} or V _{IL}					
		I _O = −12 mA	2.7	V _{CC} − 0.5	–	–	V
		I _O = −100 μA	3.0	V _{CC} − 0.2	V _{CC}	–	V
		I _O = −18 mA	3.0	V _{CC} − 0.6	–	–	V
		I _O = −24 mA	3.0	V _{CC} − 0.8	–	–	V
V _{OL}	LOW-level output voltage	V _I = V _{IH} or V _{IL}					
		I _O = 12 mA	2.7	–	–	0.40	V
		I _O = 100 μA	3.0	–	GND	0.20	V
		I _O = 24 mA	3.0	–	–	0.55	V
I _{LI}	input leakage current	V _I = 5.5 V or GND; note 2	3.6	–	±0.1	±5	μA
I _{OZ}	3-state output OFF-state current	V _I = V _{IH} or V _{IL} ; V _O = 5.5 V or GND	3.6	–	0.1	±10	μA
I _{off}	power-off leakage supply	V _I or V _O = 5.5 V	0.0	–	0.1	±10	μA
I _{CC}	quiescent supply current	V _I = V _{CC} or GND; I _O = 0	3.6	–	0.1	10	μA
ΔI _{CC}	additional quiescent supply current per input pin	V _I = V _{CC} − 0.6 V; I _O = 0	2.7 to 3.6	–	5	500	μA

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SYMBOL	PARAMETER	TEST CONDITIONS		MIN.	TYP. ⁽¹⁾	MAX.	UNIT
		OTHER	V _{CC} (V)				
T _{amb} = −40 to +125 °C							
V _{IH}	HIGH-level input voltage		1.2	V _{CC}	–	–	V
			2.7 to 3.6	2.0	–	–	V
V _{IL}	LOW-level input voltage		1.2	–	–	GND	V
			2.7 to 3.6	–	–	0.8	V
V _{OH}	HIGH-level output voltage	V _I = V _{IH} or V _{IL}					
		I _O = −12 mA	2.7	V _{CC} − 0.65	–	–	V
		I _O = −100 μA	2.7 to 3.6	V _{CC} − 0.3	–	–	V
		I _O = −18 mA	3.0	V _{CC} − 0.75	–	–	V
		I _O = −24 mA	3.0	V _{CC} − 1	–	–	V
V _{OL}	LOW-level output voltage	V _I = V _{IH} or V _{IL}					
		I _O = 12 mA	2.7	–	–	0.6	V
		I _O = 100 μA	2.7 to 3.6	–	–	0.3	V
		I _O = 24 mA	3.0	–	–	0.8	V
I _{LI}	input leakage current	V _I = 5.5 V or GND	3.6	–	–	±20	μA
I _{OZ}	3-state output OFF-state current	V _I = V _{IH} or V _{IL} ; V _O = 5.5 V or GND	3.6	–	–	±20	μA
I _{off}	power-off leakage supply	V _I or V _O = 5.5 V	0.0	–	–	±20	μA
I _{CC}	quiescent supply current	V _I = V _{CC} or GND; I _O = 0	3.6	–	–	40	μA
ΔI _{CC}	additional quiescent supply current per input pin	V _I = V _{CC} − 0.6 V; I _O = 0	2.7 to 3.6	–	–	5000	μA

Notes

1. All typical values are measured at V_{CC} = 3.3 V and T_{amb} = 25 °C.
2. The specified overdrive current at the data input forces the data input to the opposite logic input state.

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AC CHARACTERISTICS

GND = 0 V; $t_r = t_f \leq 2.5$ ns; $C_L = 50$ pF; $R_L = 500 \Omega$.

SYMBOL	PARAMETER	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
		WAVEFORMS	V _{CC} (V)				
T _{amb} = −40 to +85 °C; note 1							
t _{PHL} /t _{PLH}	propagation delay CP to Qn	see Figs 7 and 10	2.7	1.5	3.6	8.0	ns
			3.0 to 3.6	1.5	3.2 ⁽²⁾	7.0	ns
t _{PZH} /t _{PZL}	3-state output enable time OE to Qn	see Figs 9 and 10	2.7	1.5	4.3	8.5	ns
			3.0 to 3.6	1.5	3.5 ⁽²⁾	7.5	ns
t _{PHZ} /t _{PLZ}	3-state output disable time OE to Qn	see Figs 9 and 10	2.7	1.5	2.8	6.5	ns
			3.0 to 3.6	1.5	2.5 ⁽²⁾	6.0	ns
t _W	clock pulse width HIGH or LOW	see Fig.7	2.7	—	—	3.3	ns
			3.0 to 3.6	—	1.7 ⁽²⁾	3.4	ns
t _{su}	set-up time Dn to CP	see Fig.8	2.7	—	—	2.0	ns
			3.0 to 3.6	—	0.3 ⁽²⁾	2.0	ns
t _h	hold time Dn to CP	see Fig.8	2.7	—	—	1.5	ns
			3.0 to 3.6	—	−0.2 ⁽²⁾	1.5	ns
f _{max}	maximum clock frequency		2.7	80	—	—	MHz
			3.0 to 3.6	100	150 ⁽²⁾	—	MHz
t _{sk(0)}	skew	note 3	3.0 to 3.6	—	—	1.0	ns
T _{amb} = −40 to +125 °C							
t _{PHL} /t _{PLH}	propagation delay CP to Qn	see Figs 7 and 10	2.7	—	—	10.0	ns
			3.0 to 3.6	—	—	9.0	ns
t _{PZH} /t _{PZL}	3-state output enable time OE to Qn	see Figs 9 and 10	2.7	—	—	11.0	ns
			3.0 to 3.6	—	—	9.5	ns
t _{PHZ} /t _{PLZ}	3-state output disable time OE to Qn	see Figs 9 and 10	2.7	—	—	8.5	ns
			3.0 to 3.6	—	—	7.5	ns
t _W	clock pulse width HIGH or LOW	see Fig.7	2.7	—	—	—	ns
			3.0 to 3.6	—	—	—	ns
t _{su}	set-up time Dn to CP	see Fig.8	2.7	—	—	—	ns
			3.0 to 3.6	—	—	—	ns
t _h	hold time Dn to CP	see Fig.8	2.7	—	—	—	ns
			3.0 to 3.6	—	—	—	ns
f _{max}	maximum clock frequency		2.7	—	—	—	MHz
			3.0 to 3.6	—	—	—	MHz
t _{sk(0)}	skew	note 3	3.0 to 3.6	—	—	—	ns

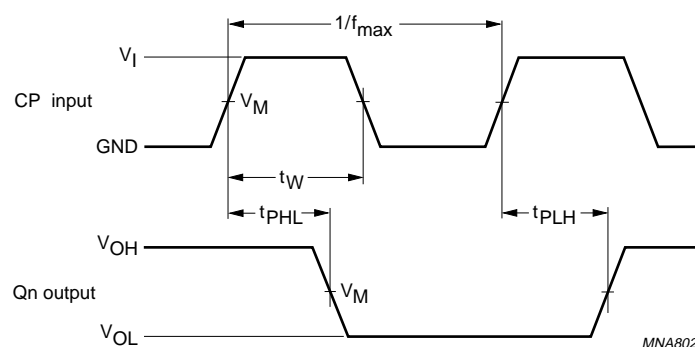
Notes

1. All typical values are measured at T_{amb} = 25 °C.
2. These typical values are measured at V_{CC} = 3.3 V.
3. Skew between any two outputs of the same package switching in the same direction. This parameter is guaranteed by design.

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AC WAVEFORMS



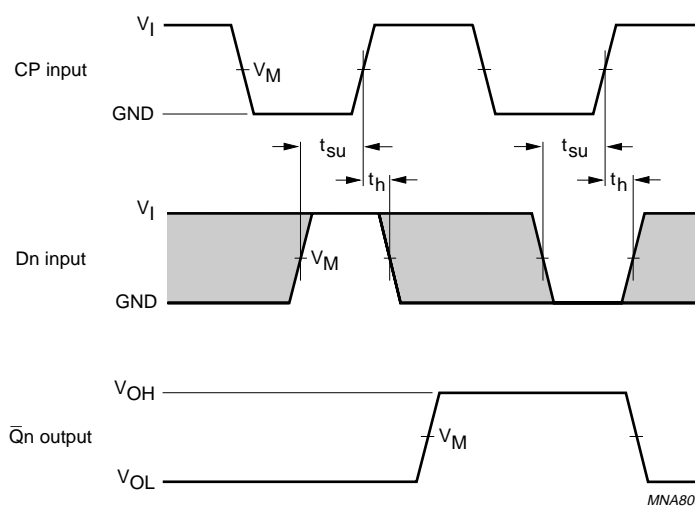
MNA802

$V_M = 1.5 \text{ V}$ at $V_{CC} \geq 2.7 \text{ V}$.

$V_M = 0.5 V_{CC}$ at $V_{CC} < 2.7 \text{ V}$.

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

Fig. 7 Clock (CP) to output (Qn) propagation delays, the clock pulse width, output transition times and the maximum clock pulse frequency.



MNA803

$V_M = 1.5 \text{ V}$ at $V_{CC} \geq 2.7 \text{ V}$.

$V_M = 0.5 V_{CC}$ at $V_{CC} < 2.7 \text{ V}$.

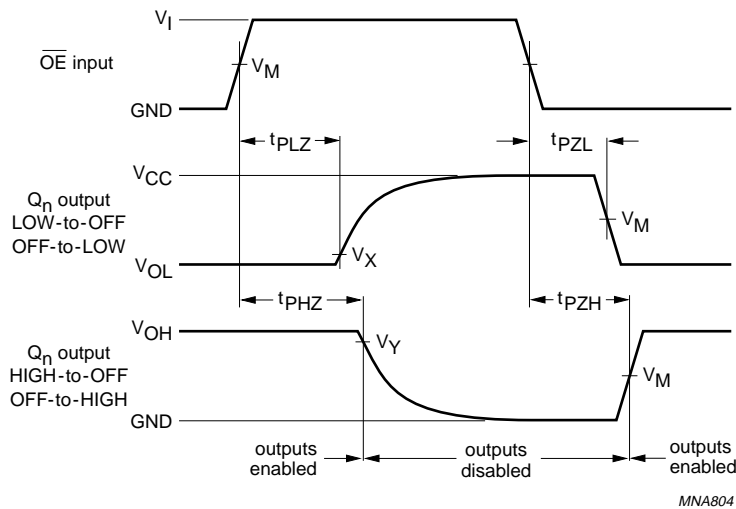
V_{OL} and V_{OH} are the typical output voltage drop that occur with the output load.

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

Fig. 8 Data setup and hold times for the Dn input to the CP input.

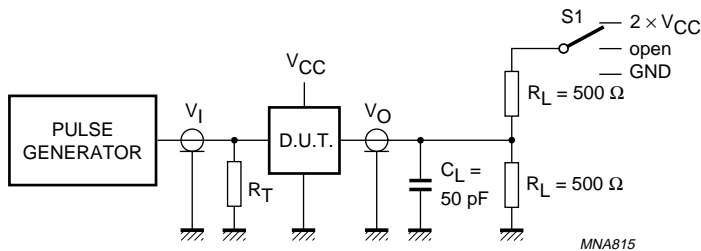
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$V_M = 1.5\text{ V}$ at $V_{CC} \geq 2.7\text{ V}$.
 $V_M = 0.5V_{CC}$ at $V_{CC} < 2.7\text{ V}$.
 V_{OL} and V_{OH} are the typical output voltage drop that occur with the output load.
 $V_X = V_{OL} + 0.3\text{ V}$ at $V_{CC} \geq 2.7\text{ V}$;
 $V_X = V_{OL} + 0.1V_{CC}$ at $V_{CC} < 2.7\text{ V}$.
 $V_Y = V_{OH} - 0.3\text{ V}$ at $V_{CC} \geq 2.7\text{ V}$;
 $V_Y = V_{OH} - 0.1V_{CC}$ at $V_{CC} < 2.7\text{ V}$.

Fig.9 3-state enable and disable times.



TEST	S1
t_{PLH}/t_{PHL}	open
t_{PLZ}/t_{PZL}	$2 \times V_{CC}$
t_{PHZ}/t_{PZH}	GND

V_{CC}	V_I
$< 2.7\text{ V}$	V_{CC}
2.7 to 3.6 V	2.7 V

Definitions for test circuit:
 R_L = load resistor.
 C_L = load capacitance includes jig and probe capacitance.
 R_T = termination resistance should be equal to Z_o of pulse generators.

Fig.10 Load circuitry for switching times.

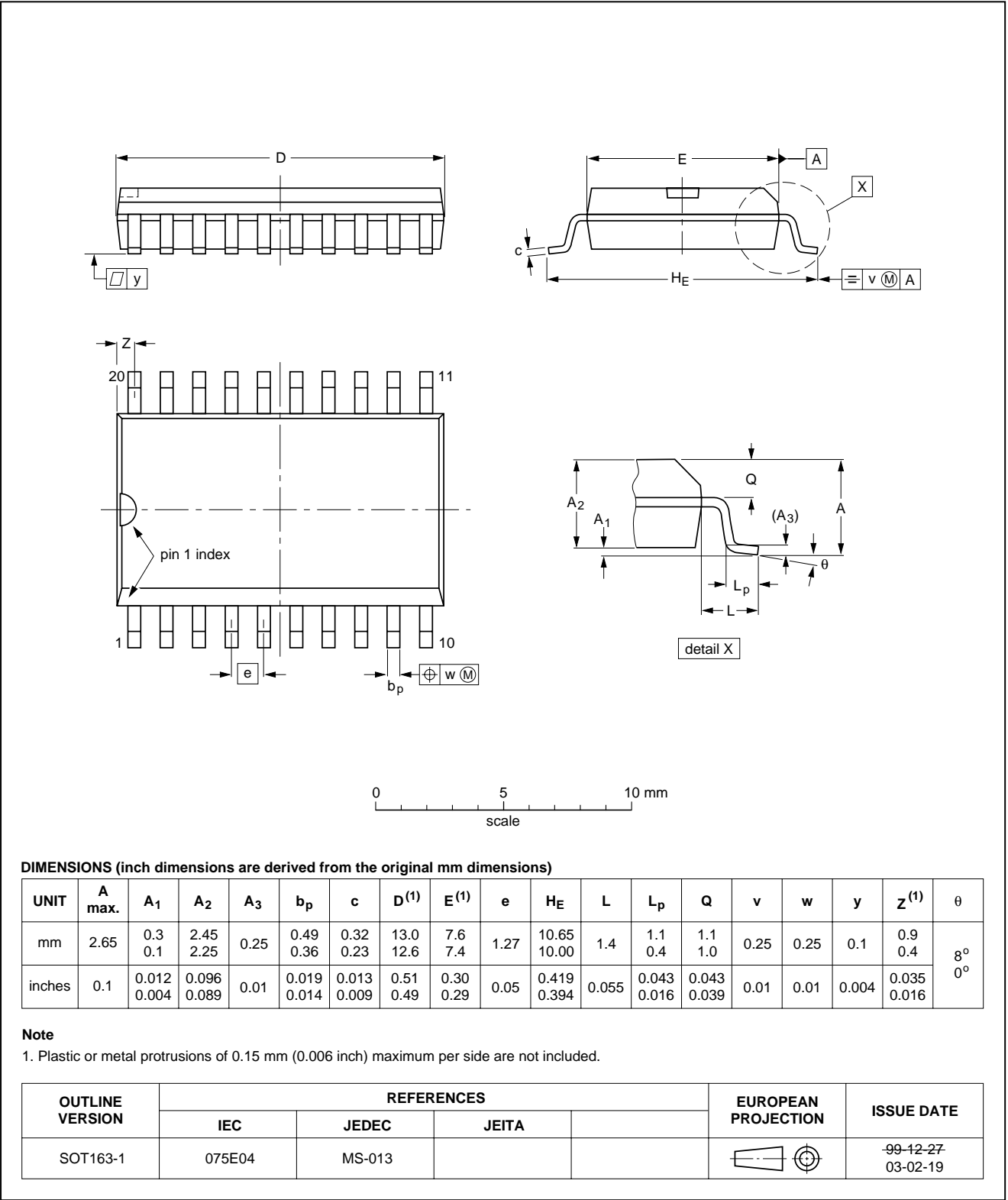
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PACKAGE OUTLINES

SO20: plastic small outline package; 20 leads; body width 7.5 mm

SOT163-1

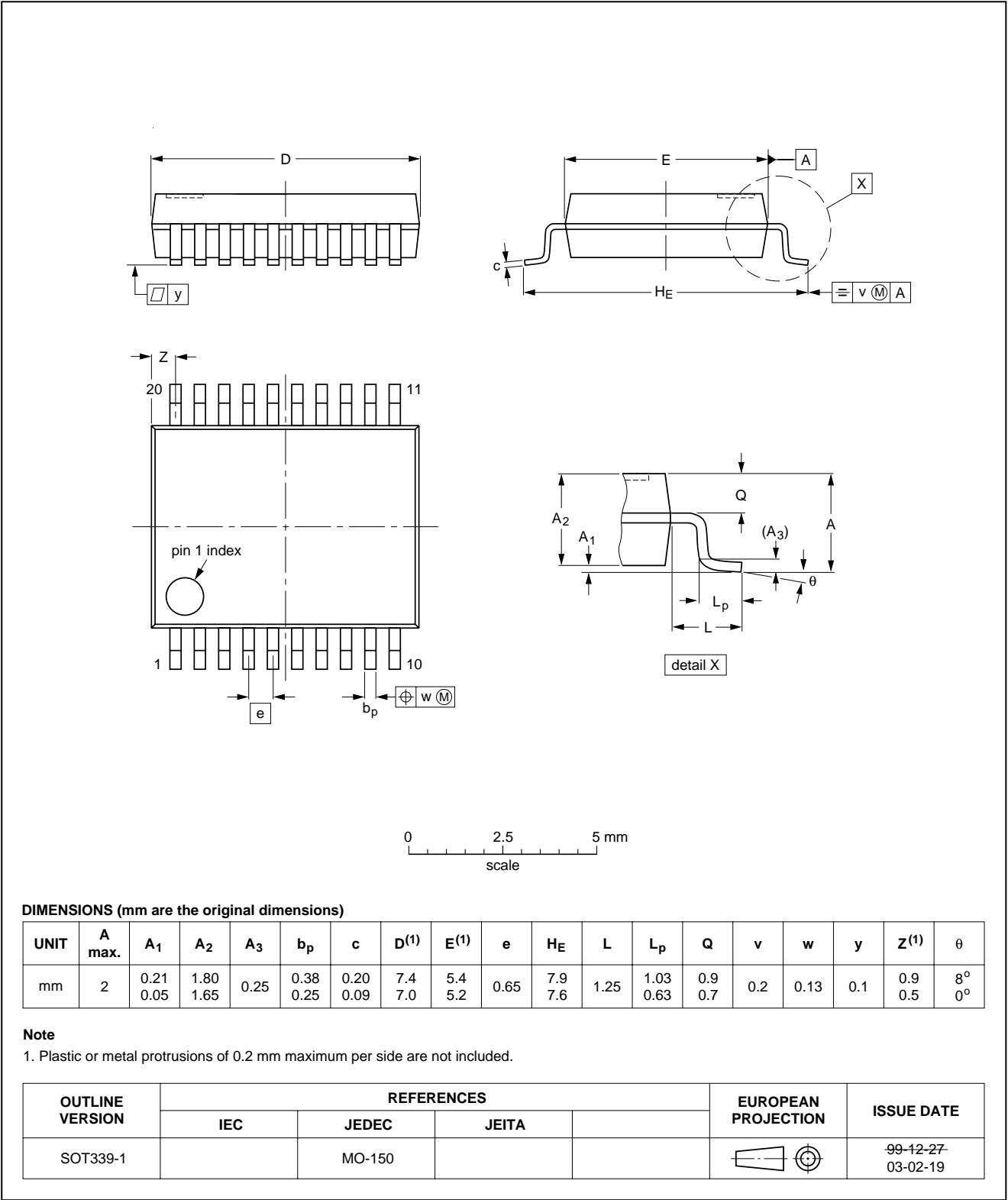


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SSOP20: plastic shrink small outline package; 20 leads; body width 5.3 mm

SOT339-1

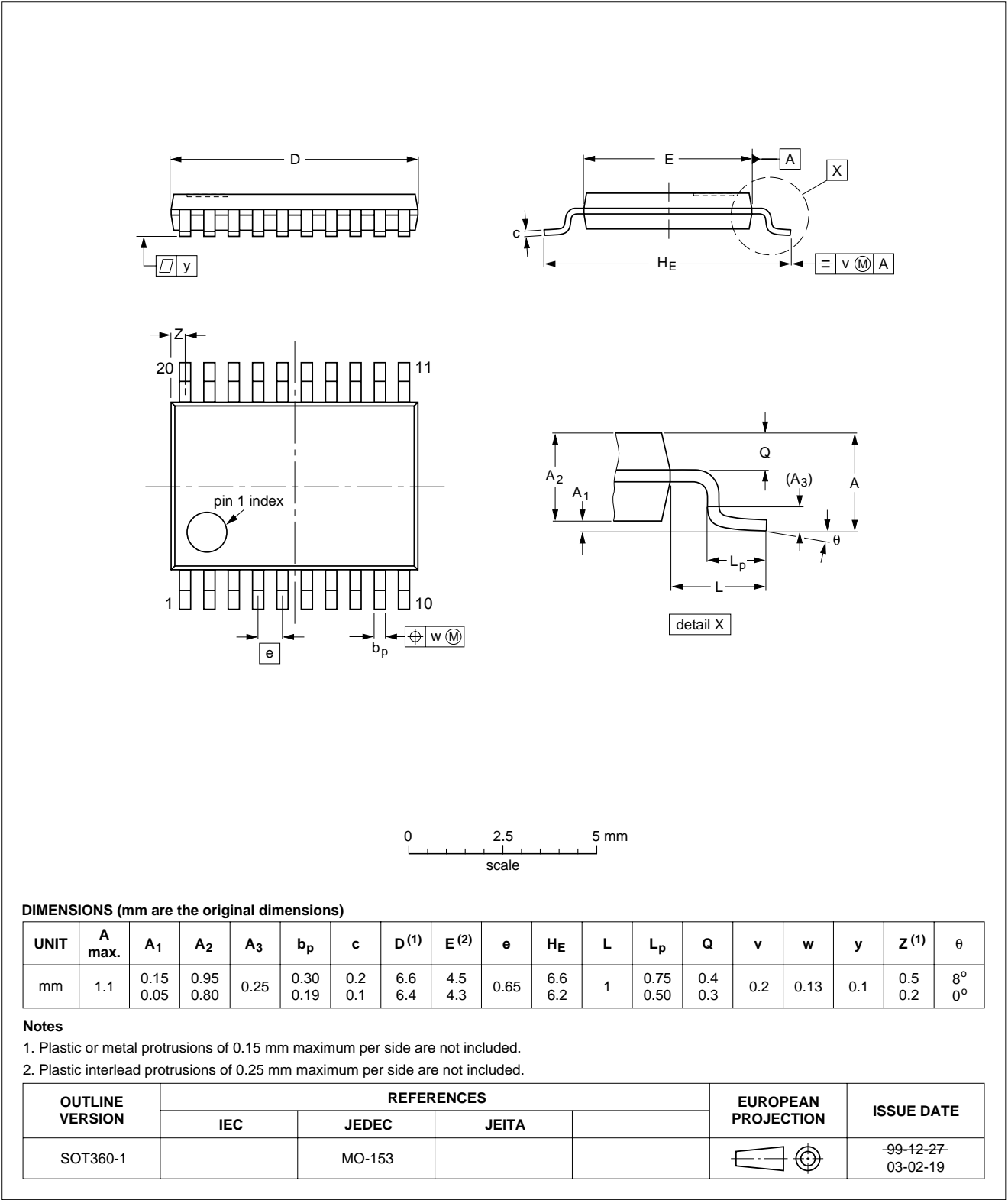


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TSSOP20: plastic thin shrink small outline package; 20 leads; body width 4.4 mm

SOT360-1

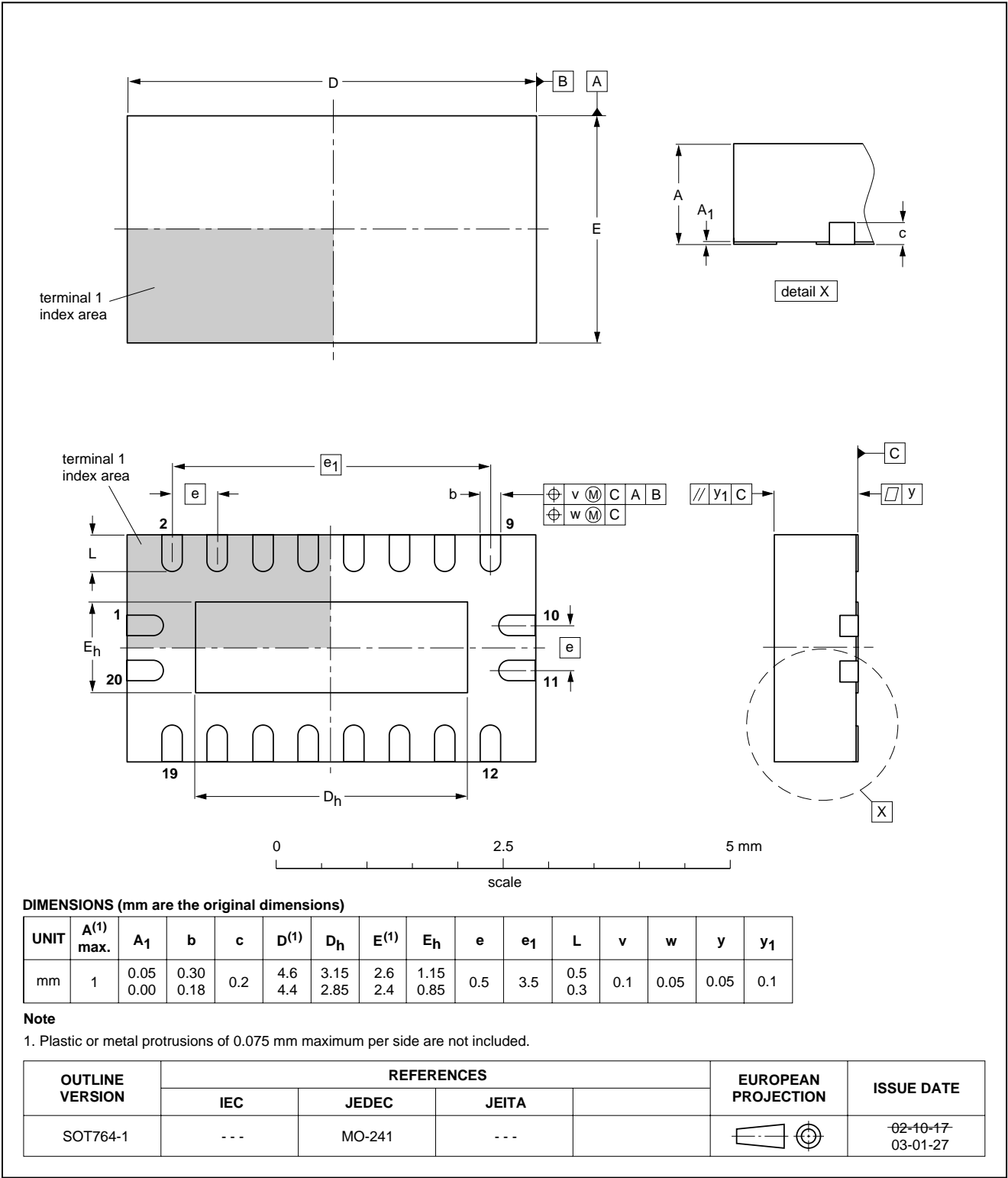


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DHVQFN20: plastic dual in-line compatible thermal enhanced very thin quad flat package; no leads;
20 terminals; body 2.5 x 4.5 x 0.85 mm

SOT764-1



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SOLDERING

Introduction to soldering surface mount packages

This text gives a very brief insight to a complex technology. A more in-depth account of soldering ICs can be found in our *"Data Handbook IC26; Integrated Circuit Packages"* (document order number 9398 652 90011).

There is no soldering method that is ideal for all surface mount IC packages. Wave soldering can still be used for certain surface mount ICs, but it is not suitable for fine pitch SMDs. In these situations reflow soldering is recommended.

Reflow soldering

Reflow soldering requires solder paste (a suspension of fine solder particles, flux and binding agent) to be applied to the printed-circuit board by screen printing, stencilling or pressure-syringe dispensing before package placement. Driven by legislation and environmental forces the worldwide use of lead-free solder pastes is increasing.

Several methods exist for reflowing; for example, convection or convection/infrared heating in a conveyor type oven. Throughput times (preheating, soldering and cooling) vary between 100 and 200 seconds depending on heating method.

Typical reflow peak temperatures range from 215 to 270 °C depending on solder paste material. The top-surface temperature of the packages should preferably be kept:

- below 220 °C (SnPb process) or below 245 °C (Pb-free process)
 - for all BGA and SSOP-T packages
 - for packages with a thickness ≥ 2.5 mm
 - for packages with a thickness < 2.5 mm and a volume ≥ 350 mm³ so called thick/large packages.
- below 235 °C (SnPb process) or below 260 °C (Pb-free process) for packages with a thickness < 2.5 mm and a volume < 350 mm³ so called small/thin packages.

Moisture sensitivity precautions, as indicated on packing, must be respected at all times.

Wave soldering

Conventional single wave soldering is not recommended for surface mount devices (SMDs) or printed-circuit boards with a high component density, as solder bridging and non-wetting can present major problems.

To overcome these problems the double-wave soldering method was specifically developed.

If wave soldering is used the following conditions must be observed for optimal results:

- Use a double-wave soldering method comprising a turbulent wave with high upward pressure followed by a smooth laminar wave.
- For packages with leads on two sides and a pitch (e):
 - larger than or equal to 1.27 mm, the footprint longitudinal axis is **preferred** to be parallel to the transport direction of the printed-circuit board;
 - smaller than 1.27 mm, the footprint longitudinal axis **must** be parallel to the transport direction of the printed-circuit board.

The footprint must incorporate solder thieves at the downstream end.

- For packages with leads on four sides, the footprint must be placed at a 45° angle to the transport direction of the printed-circuit board. The footprint must incorporate solder thieves downstream and at the side corners.

During placement and before soldering, the package must be fixed with a droplet of adhesive. The adhesive can be applied by screen printing, pin transfer or syringe dispensing. The package can be soldered after the adhesive is cured.

Typical dwell time of the leads in the wave ranges from 3 to 4 seconds at 250 °C or 265 °C, depending on solder material applied, SnPb or Pb-free respectively.

A mildly-activated flux will eliminate the need for removal of corrosive residues in most applications.

Manual soldering

Fix the component by first soldering two diagonally-opposite end leads. Use a low voltage (24 V or less) soldering iron applied to the flat part of the lead. Contact time must be limited to 10 seconds at up to 300 °C.

When using a dedicated tool, all other leads can be soldered in one operation within 2 to 5 seconds between 270 and 320 °C.

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Suitability of surface mount IC packages for wave and reflow soldering methods

PACKAGE ⁽¹⁾	SOLDERING METHOD	
	WAVE	REFLOW ⁽²⁾
BGA, LBGA, LFBGA, SQFP, SSOP-T ⁽³⁾ , TFBGA, VFBGA	not suitable	suitable
DHVQFN, HBCC, HBGA, HLQFP, HSQFP, HSOP, HTQFP, HTSSOP, HVQFN, HVSON, SMS	not suitable ⁽⁴⁾	suitable
PLCC ⁽⁵⁾ , SO, SOJ	suitable	suitable
LQFP, QFP, TQFP	not recommended ⁽⁵⁾⁽⁶⁾	suitable
SSOP, TSSOP, VSO, VSSOP	not recommended ⁽⁷⁾	suitable

Notes

- For more detailed information on the BGA packages refer to the “(LF)BGA Application Note” (AN01026); order a copy from your Philips Semiconductors sales office.
- All surface mount (SMD) packages are moisture sensitive. Depending upon the moisture content, the maximum temperature (with respect to time) and body size of the package, there is a risk that internal or external package cracks may occur due to vaporization of the moisture in them (the so called popcorn effect). For details, refer to the Drypack information in the “Data Handbook IC26; Integrated Circuit Packages; Section: Packing Methods”.
- These transparent plastic packages are extremely sensitive to reflow soldering conditions and must on no account be processed through more than one soldering cycle or subjected to infrared reflow soldering with peak temperature exceeding $217\text{ °C} \pm 10\text{ °C}$ measured in the atmosphere of the reflow oven. The package body peak temperature must be kept as low as possible.
- These packages are not suitable for wave soldering. On versions with the heatsink on the bottom side, the solder cannot penetrate between the printed-circuit board and the heatsink. On versions with the heatsink on the top side, the solder might be deposited on the heatsink surface.
- If wave soldering is considered, then the package must be placed at a 45° angle to the solder wave direction. The package footprint must incorporate solder thieves downstream and at the side corners.
- Wave soldering is suitable for LQFP, TQFP and QFP packages with a pitch (e) larger than 0.8 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.65 mm.
- Wave soldering is suitable for SSOP, TSSOP, VSO and VSSOP packages with a pitch (e) equal to or larger than 0.65 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.5 mm.

Octal D-type flip-flop with 5 V tolerant inputs/outputs; positive edge-trigger (3-state)

74LVC574A

DATA SHEET STATUS

LEVEL	DATA SHEET STATUS ⁽¹⁾	PRODUCT STATUS ⁽²⁾⁽³⁾	DEFINITION
I	Objective data	Development	This data sheet contains data from the objective specification for product development. Philips Semiconductors reserves the right to change the specification in any manner without notice.
II	Preliminary data	Qualification	This data sheet contains data from the preliminary specification. Supplementary data will be published at a later date. Philips Semiconductors reserves the right to change the specification without notice, in order to improve the design and supply the best possible product.
III	Product data	Production	This data sheet contains data from the product specification. Philips Semiconductors reserves the right to make changes at any time in order to improve the design, manufacturing and supply. Relevant changes will be communicated via a Customer Product/Process Change Notification (CPCN).

Notes

1. Please consult the most recently issued data sheet before initiating or completing a design.
2. The product status of the device(s) described in this data sheet may have changed since this data sheet was published. The latest information is available on the Internet at URL <http://www.semiconductors.philips.com>.
3. For data sheets describing multiple type numbers, the highest-level product status determines the data sheet status.

DEFINITIONS

Short-form specification — The data in a short-form specification is extracted from a full data sheet with the same type number and title. For detailed information see the relevant data sheet or data handbook.

Limiting values definition — Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 60134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.

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Octal D-type flip-flop with 5 V tolerant
inputs/outputs; positive edge-trigger (3-state)

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NOTES

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