

74HC138; 74HCT138

3-to-8 line decoder/demultiplexer; inverting

Rev. 8 — 7 April 2020

Product data sheet

1. General description

The 74HC138; 74HCT138 decodes three binary weighted address inputs (A0, A1 and A2) to eight mutually exclusive outputs ($\bar{Y}0$ to $\bar{Y}7$). The device features three enable inputs (E1, E2 and E3). Every output will be HIGH unless E1 and E2 are LOW and E3 is HIGH. This multiple enable function allows easy parallel expansion to a 1-of-32 (5 to 32 lines) decoder with just four '138 ICs and one inverter. The '138 can be used as an eight output demultiplexer by using one of the active LOW enable inputs as the data input and the remaining enable inputs as strobes. Inputs include clamp diodes. This enables the use of current limiting resistors to interface inputs to voltages in excess of V_{CC} .

2. Features and benefits

- Complies with JEDEC standard no. 7A
- Input levels:
 - For 74HC138: CMOS level
 - For 74HCT138: TTL level
- Demultiplexing capability
- Multiple input enable for easy expansion
- Ideal for memory chip select decoding
- Active LOW mutually exclusive outputs
- ESD protection:
 - HBM JESD22-A114F exceeds 2000 V
 - MM JESD22-A115-A exceeds 200 V
- Multiple package options
- Specified from -40 °C to +85 °C and from -40 °C to +125 °C

3. Ordering information

Table 1. Ordering information

| Type number | Package | | | |
|-------------|-------------------|----------|--------------------------------------------------------------------------------------------------------------------------------------|----------|
| | Temperature range | Name | Description | Version |
| 74HC138D | -40 °C to +125 °C | SO16 | plastic small outline package; 16 leads; body width 3.9 mm | SOT109-1 |
| 74HCT138D | | | | |
| 74HC138DB | -40 °C to +125 °C | SSOP16 | plastic shrink small outline package; 16 leads; body width 5.3 mm | SOT338-1 |
| 74HCT138DB | | | | |
| 74HC138PW | -40 °C to +125 °C | TSSOP16 | plastic thin shrink small outline package; 16 leads; body width 4.4 mm | SOT403-1 |
| 74HCT138PW | | | | |
| 74HC138BQ | -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 |
| 74HCT138BQ | | | | |

4. Functional diagram

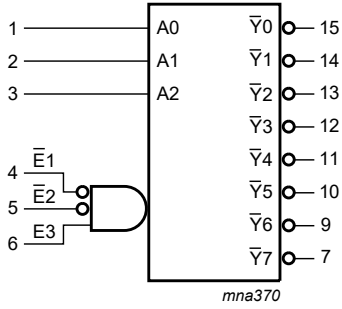


Fig. 1. Logic symbol

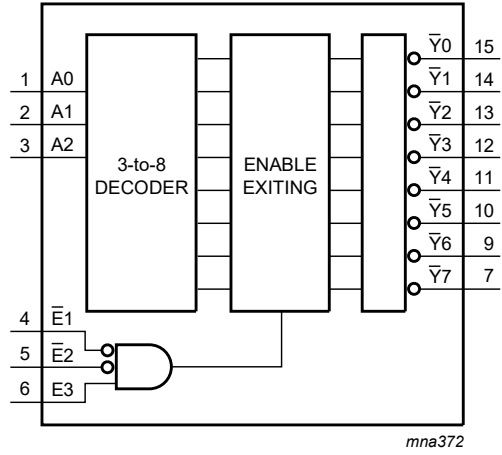


Fig. 2. Functional diagram

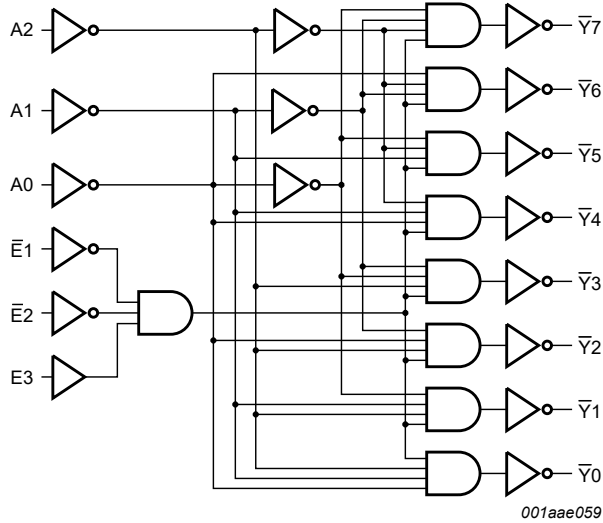
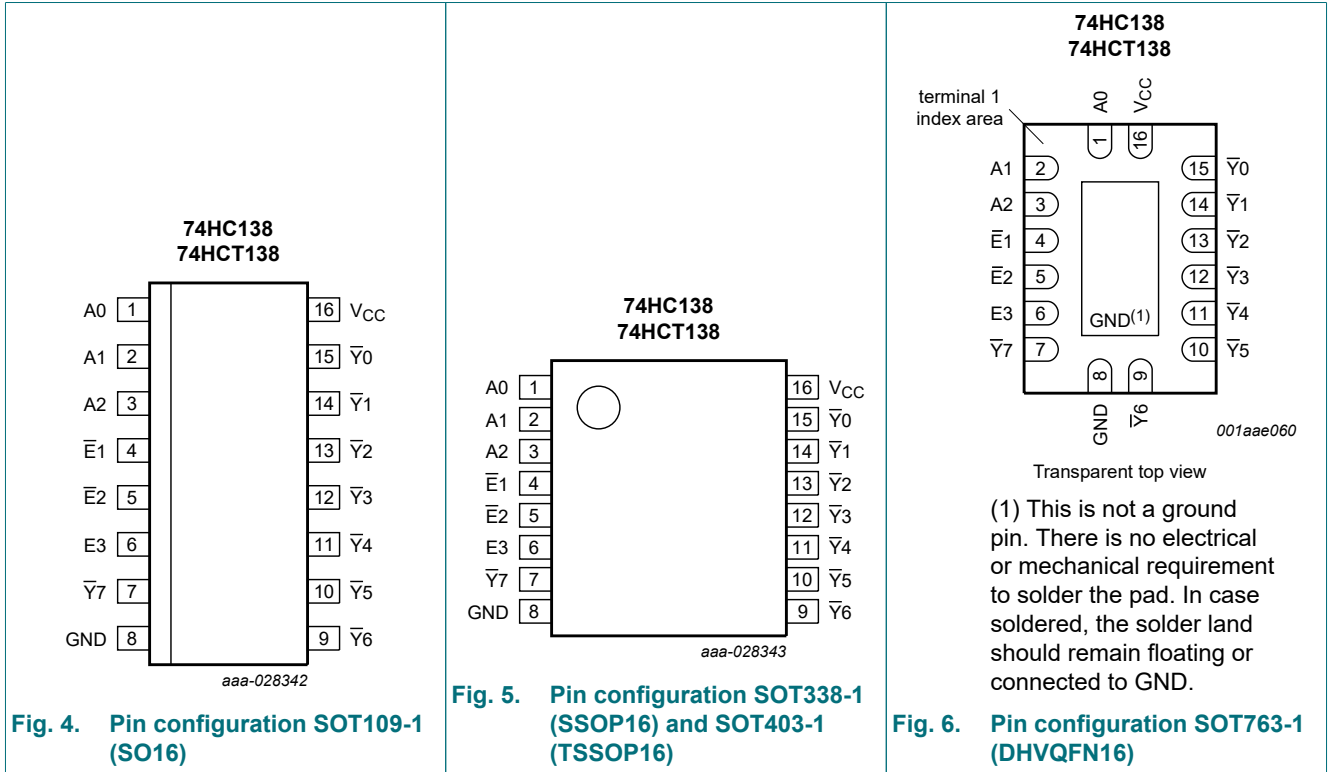


Fig. 3. Logic diagram

5. Pinning information

5.1. Pinning



5.2. Pin description

Table 2. Pin description

| Symbol | Pin | Description |
|----------------------------------------------------------------------------------|------------------------------|----------------------------|
| A0, A1, A2 | 1, 2, 3 | address input |
| $\bar{E}1, \bar{E}2$ | 4, 5 | enable input (active LOW) |
| E3 | 6 | enable input (active HIGH) |
| $\bar{Y}0, \bar{Y}1, \bar{Y}2, \bar{Y}3, \bar{Y}4, \bar{Y}5, \bar{Y}6, \bar{Y}7$ | 15, 14, 13, 12, 11, 10, 9, 7 | output |
| GND | 8 | ground (0 V) |
| V _{CC} | 16 | supply voltage |

6. Functional description

Table 3. Function table

H = HIGH voltage level; L = LOW voltage level; X = don't care.

| Control | | | Input | | | Output | | | | | | | |
|---------|----|----|-------|----|----|--------|----|----|----|----|----|----|----|
| E1 | E2 | E3 | A2 | A1 | A0 | Y7 | Y6 | Y5 | Y4 | Y3 | Y2 | Y1 | Y0 |
| H | X | X | X | X | X | H | H | H | H | H | H | H | H |
| X | H | X | | | | | | | | | | | |
| X | X | L | | | | | | | | | | | |
| L | L | H | L | L | L | H | H | H | H | H | H | H | L |
| | | | L | L | H | H | H | H | H | H | H | L | H |
| | | | L | H | L | H | H | H | H | H | L | H | H |
| | | | L | H | H | H | H | H | H | L | H | H | H |
| | | | H | L | L | H | H | H | L | H | H | H | H |
| | | | H | L | H | H | H | L | H | H | H | H | H |
| | | | H | H | L | H | L | H | H | H | H | H | H |
| | | | H | H | H | L | H | H | H | H | H | H | H |

7. Limiting values

Table 4. 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 | V |
| I_{IK} | input clamping current | $V_I < -0.5\text{ V}$ or $V_I > V_{CC} + 0.5\text{ V}$ | - | ± 20 | mA |
| I_{OK} | output clamping current | $V_O < -0.5\text{ V}$ or $V_O > V_{CC} + 0.5\text{ V}$ | - | ± 20 | mA |
| I_O | output current | $V_O = -0.5\text{ V}$ to $(V_{CC} + 0.5\text{ V})$ | - | ± 25 | mA |
| I_{CC} | quiescent supply current | | - | 50 | mA |
| I_{GND} | ground current | | -50 | - | mA |
| T_{stg} | storage temperature | | -65 | +150 | °C |
| P_{tot} | total power dissipation | [1] | - | 500 | mW |

- [1] For SOT109-1 (SO16) package: P_{tot} derates linearly with 12.4 mW/K above 110 °C.
 For SOT338-1 (SSOP16) package: P_{tot} derates linearly with 8.5 mW/K above 91 °C.
 For SOT403-1 (TSSOP16) package: P_{tot} derates linearly with 8.5 mW/K above 91 °C.
 For SOT763-1 (DHVQFN16) package: P_{tot} derates linearly with 11.2 mW/K above 106 °C.

8. Recommended operating conditions

Table 5. Recommended operating conditions

Voltages are referenced to GND (ground = 0 V)

| Symbol | Parameter | Conditions | 74HC138 | | | 74HCT138 | | | Unit |
|------------------|-------------------------------------|-------------------------|---------|------|-----------------|----------|------|-----------------|------|
| | | | Min | Typ | Max | Min | Typ | Max | |
| V _{CC} | supply voltage | | 2.0 | 5.0 | 6.0 | 4.5 | 5.0 | 5.5 | V |
| V _I | input voltage | | 0 | - | V _{CC} | 0 | - | V _{CC} | V |
| V _O | output voltage | | 0 | - | V _{CC} | 0 | - | V _{CC} | V |
| T _{amb} | ambient temperature | | -40 | +25 | +125 | -40 | +25 | +125 | °C |
| Δt/ΔV | input transition rise and fall rate | V _{CC} = 2.0 V | - | - | 625 | - | - | - | ns/V |
| | | V _{CC} = 4.5 V | - | 1.67 | 139 | - | 1.67 | 139 | ns/V |
| | | V _{CC} = 6.0 V | - | - | 83 | - | - | - | ns/V |

9. Static characteristics

Table 6. Static characteristics

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

| Symbol | Parameter | Conditions | T _{amb} = 25 °C | | | T _{amb} = -40 °C to +85 °C | | T _{amb} = -40 °C to +125 °C | | Unit | | | |
|-----------------|---------------------------|------------------------------------------------------------------|--------------------------|----------------------------------------------------------------------------------------|-------------------|----------------------------------------|------|-----------------------------------------|------|------|-----|----|----|
| | | | Min | Typ | Max | Min | Max | Min | Max | | | | |
| 74HC138 | | | | | | | | | | | | | |
| V _{IH} | HIGH-level input voltage | V _{CC} = 2.0 V | 1.5 | 1.2 | - | 1.5 | - | 1.5 | - | V | | | |
| | | V _{CC} = 4.5 V | 3.15 | 2.4 | - | 3.15 | - | 3.15 | - | V | | | |
| | | V _{CC} = 6.0 V | 4.2 | 3.2 | - | 4.2 | - | 4.2 | - | V | | | |
| V _{IL} | LOW-level input voltage | V _{CC} = 2.0 V | - | 0.8 | 0.5 | - | 0.5 | - | 0.5 | V | | | |
| | | V _{CC} = 4.5 V | - | 2.1 | 1.35 | - | 1.35 | - | 1.35 | V | | | |
| | | V _{CC} = 6.0 V | - | 2.8 | 1.8 | - | 1.8 | - | 1.8 | V | | | |
| V _{OH} | HIGH-level output voltage | V _I = V _{IH} or V _{IL} | | | | | | | | | | | |
| | | I _O = -20 μA; V _{CC} = 2.0 V | 1.9 | 2.0 | - | 1.9 | - | 1.9 | - | V | | | |
| | | I _O = -20 μA; V _{CC} = 4.5 V | 4.4 | 4.5 | - | 4.4 | - | 4.4 | - | V | | | |
| | | I _O = -20 μA; V _{CC} = 6.0 V | 5.9 | 6.0 | - | 5.9 | - | 5.9 | - | V | | | |
| | | I _O = -4.0 mA; V _{CC} = 4.5 V | 3.98 | 4.32 | - | 3.84 | - | 3.7 | - | V | | | |
| V _{OL} | LOW-level output voltage | V _I = V _{IH} or V _{IL} | | | | | | | | | | | |
| | | I _O = 20 μA; V _{CC} = 2.0 V | - | 0 | 0.1 | - | 0.1 | - | 0.1 | V | | | |
| | | I _O = 20 μA; V _{CC} = 4.5 V | - | 0 | 0.1 | - | 0.1 | - | 0.1 | V | | | |
| | | I _O = 20 μA; V _{CC} = 6.0 V | - | 0 | 0.1 | - | 0.1 | - | 0.1 | V | | | |
| | | I _O = 4.0 mA; V _{CC} = 4.5 V | - | 0.15 | 0.26 | - | 0.33 | - | 0.4 | V | | | |
| I _I | input leakage current | V _I = V _{CC} or GND; V _{CC} = 6.0 V | - | - | ±0.1 | - | ±1.0 | - | ±1.0 | μA | | | |
| | | I _{CC} | supply current | V _I = V _{CC} or GND; I _O = 0 A; V _{CC} = 6.0 V | - | - | 8.0 | - | 80 | - | 160 | μA | |
| | | | | C _I | input capacitance | | - | 3.5 | - | | | | pF |

| Symbol | Parameter | Conditions | T _{amb} = 25 °C | | | T _{amb} = -40 °C to +85 °C | | T _{amb} = -40 °C to +125 °C | | Unit |
|------------------|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|------|------|----------------------------------------|-------|-----------------------------------------|-------|------|
| | | | Min | Typ | Max | Min | Max | Min | Max | |
| 74HCT138 | | | | | | | | | | |
| V _{IH} | HIGH-level input voltage | V _{CC} = 4.5 V to 5.5 V | 2.0 | 1.6 | - | 2.0 | - | 2.0 | - | V |
| V _{IL} | LOW-level input voltage | V _{CC} = 4.5 V to 5.5 V | - | 1.2 | 0.8 | - | 0.8 | - | 0.8 | V |
| V _{OH} | HIGH-level output voltage | V _I = V _{IH} or V _{IL} ; V _{CC} = 4.5 V | | | | | | | | |
| | | I _O = -20 µA | 4.4 | 4.5 | - | 4.4 | - | 4.4 | - | V |
| | | I _O = -4 mA | 3.98 | 4.32 | - | 3.84 | - | 3.7 | - | V |
| V _{OL} | LOW-level output voltage | V _I = V _{IH} or V _{IL} ; V _{CC} = 4.5 V | | | | | | | | |
| | | I _O = 20 µA | - | 0 | 0.1 | - | 0.1 | - | 0.1 | V |
| | | I _O = 4.0 mA | - | 0.15 | 0.26 | - | 0.33 | - | 0.4 | V |
| I _I | input leakage current | V _I = V _{CC} or GND; V _{CC} = 5.5 V | - | - | ±0.1 | - | ±1.0 | - | ±1.0 | µA |
| I _{CC} | supply current | V _I = V _{CC} or GND; I _O = 0 A; V _{CC} = 5.5 V | - | - | 8.0 | - | 80 | - | 160 | µA |
| ΔI _{CC} | additional supply current | V _I = V _{CC} - 2.1 V; other inputs at V _{CC} or GND; V _{CC} = 4.5 V to 5.5 V; I _O = 0 A | | | | | | | | |
| | | per input pin; A _n inputs | - | 150 | 540 | - | 675 | - | 735 | µA |
| | | per input pin; \bar{E}_n inputs | - | 125 | 450 | - | 562.5 | - | 612.5 | µA |
| | | per input pin; E ₃ input | - | 100 | 360 | - | 450 | - | 490 | µA |
| C _I | input capacitance | | - | 3.5 | - | - | - | - | - | pF |

10. Dynamic characteristics

Table 7. Dynamic characteristics

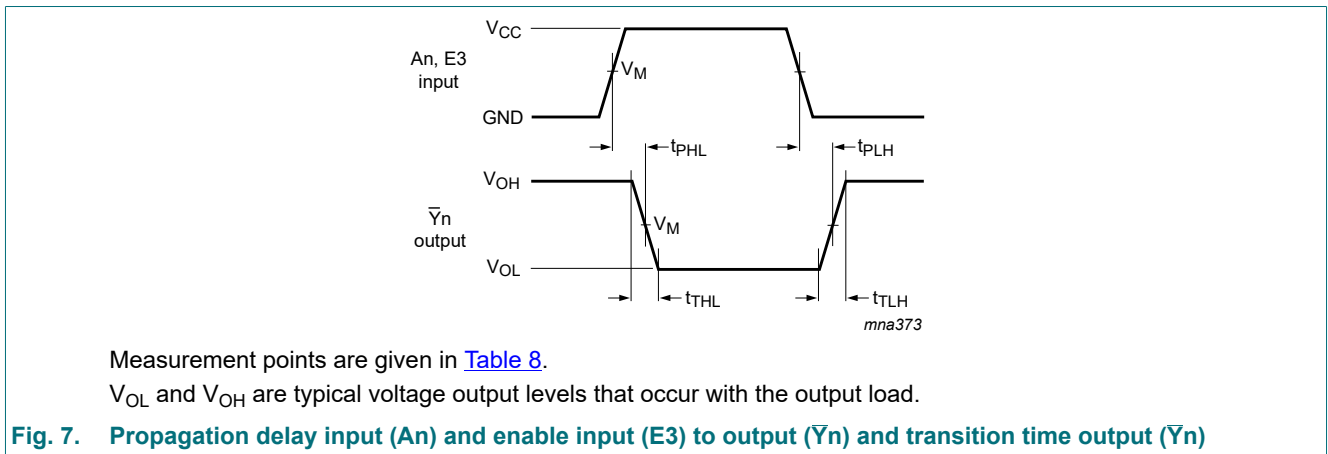
Voltages are referenced to GND (ground = 0 V); $C_L = 50$ pF unless otherwise specified; for test circuit see Fig. 9.

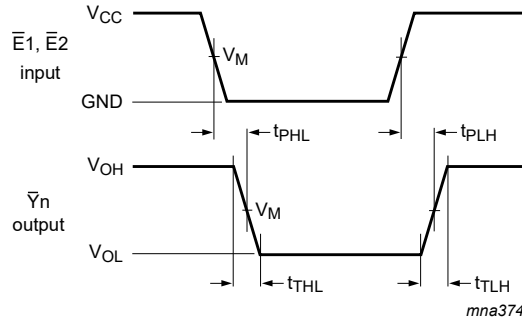
| Symbol | Parameter | Conditions | $T_{amb} = 25\text{ °C}$ | | | $T_{amb} = -40\text{ °C to }+85\text{ °C}$ | | $T_{amb} = -40\text{ °C to }+125\text{ °C}$ | | Unit |
|------------------|-------------------------------|---------------------------------------------------------------|--------------------------|-----|-----|--------------------------------------------|-----|---------------------------------------------|-----|------|
| | | | Min | Typ | Max | Min | Max | Min | Max | |
| 74HC138 | | | | | | | | | | |
| t_{pd} | propagation delay | An to \bar{Y}_n ; see Fig. 7 [1] | | | | | | | | |
| | | $V_{CC} = 2.0$ V | - | 41 | 150 | - | 190 | - | 225 | ns |
| | | $V_{CC} = 4.5$ V | - | 15 | 30 | - | 38 | - | 45 | ns |
| | | $V_{CC} = 5$ V; $C_L = 15$ pF | - | 12 | - | - | - | - | - | ns |
| | | $V_{CC} = 6.0$ V | - | 12 | 26 | - | 33 | - | 38 | ns |
| | | E3 to \bar{Y}_n ; see Fig. 7 [1] | | | | | | | | |
| | | $V_{CC} = 2.0$ V | - | 47 | 150 | - | 190 | - | 225 | ns |
| | | $V_{CC} = 4.5$ V | - | 17 | 20 | - | 38 | - | 45 | ns |
| | | $V_{CC} = 5$ V; $C_L = 15$ pF | - | 14 | - | - | - | - | - | ns |
| | | $V_{CC} = 6.0$ V | - | 14 | 26 | - | 33 | - | 38 | ns |
| | | \bar{E}_n to \bar{Y}_n ; see Fig. 8 [1] | | | | | | | | |
| | | $V_{CC} = 2.0$ V | - | 47 | 150 | - | 190 | - | 225 | ns |
| | | $V_{CC} = 4.5$ V | - | 17 | 20 | - | 38 | - | 45 | ns |
| | | $V_{CC} = 5$ V; $C_L = 15$ pF | - | 14 | - | - | - | - | - | ns |
| $V_{CC} = 6.0$ V | - | 14 | 26 | - | 33 | - | 38 | ns | | |
| t_t | transition time | \bar{Y}_n ; see Fig. 7 and Fig. 8 [2] | | | | | | | | |
| | | $V_{CC} = 2.0$ V | - | 19 | 75 | - | 95 | - | 110 | ns |
| | | $V_{CC} = 4.5$ V | - | 7 | 15 | - | 19 | - | 22 | ns |
| | | $V_{CC} = 6.0$ V | - | 6 | 13 | - | 16 | - | 19 | ns |
| C_{PD} | power dissipation capacitance | $C_L = 50$ pF; $f = 1$ MHz; $V_I = \text{GND to } V_{CC}$ [3] | - | 67 | - | - | - | - | - | pF |

| Symbol | Parameter | Conditions | T _{amb} = 25 °C | | | T _{amb} = -40 °C to +85 °C | | T _{amb} = -40 °C to +125 °C | | Unit |
|-----------------|-------------------------------|----------------------------------------------------------------------------------------|--------------------------|-----|-----|-------------------------------------|-----|--------------------------------------|-----|------|
| | | | Min | Typ | Max | Min | Max | Min | Max | |
| 74HCT138 | | | | | | | | | | |
| t _{pd} | propagation delay | An to \bar{Y}_n ; see Fig. 7 [1] | | | | | | | | |
| | | V _{CC} = 4.5 V | - | 20 | 35 | - | 44 | - | 53 | ns |
| | | V _{CC} = 5 V; C _L = 15 pF | - | 17 | - | - | - | - | - | ns |
| | | E3 to \bar{Y}_n ; see Fig. 7 [1] | | | | | | | | |
| | | V _{CC} = 4.5 V | - | 18 | 40 | - | 50 | - | 60 | ns |
| | | V _{CC} = 5 V; C _L = 15 pF | - | 19 | - | - | - | - | - | ns |
| | | \bar{E}_n to \bar{Y}_n ; see Fig. 8 [1] | | | | | | | | |
| | | V _{CC} = 4.5 V | - | 19 | 40 | - | 50 | - | 60 | ns |
| t _t | transition time | \bar{Y}_n ; see Fig. 7 and Fig. 8 [2] | | | | | | | | |
| | | V _{CC} = 4.5 V | - | 7 | 15 | - | 19 | - | 22 | ns |
| C _{PD} | power dissipation capacitance | C _L = 50 pF; f = 1 MHz; V _I = GND to V _{CC} - 1.5 V [3] | - | 67 | - | - | - | - | - | pF |

- [1] t_{pd} is the same as t_{PLH} and t_{PHL}.
- [2] t_t is the same as t_{THL} and t_{TLH}.
- [3] C_{PD} is used to determine the dynamic power dissipation (P_D in μW).
 $P_D = C_{PD} \times V_{CC}^2 \times f_i \times N + \Sigma(C_L \times V_{CC}^2 \times f_o)$ 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 V;
 N = number of inputs switching;
 Σ(C_L × V_{CC}² × f_o) = sum of outputs.

10.1. Waveforms and test circuit





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

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

Fig. 8. Propagation delay enable input ($\bar{E}n$) to output ($\bar{Y}n$) and transition time output ($\bar{Y}n$)

Table 8. Measurement points

| Type | Input | Output |
|----------|-------------|-------------|
| | V_M | V_M |
| 74HC138 | $0.5V_{CC}$ | $0.5V_{CC}$ |
| 74HCT138 | 1.3 V | 1.3 V |



Test data is given in [Table 9](#).

Definitions test circuit:

R_T = Termination resistance should be equal to output impedance Z_o of the pulse generator.

C_L = Load capacitance including jig and probe capacitance.

R_L = Load resistance.

S1 = Test selection switch.

Fig. 9. Test circuit for measuring switching times

Table 9. Test data

| Type | Input | | Load | | S1 position | | |
|----------|----------|------------|--------------|--------------|--------------------|--------------------|--------------------|
| | V_I | t_r, t_f | C_L | R_L | t_{PHL}, t_{PLH} | t_{PZH}, t_{PHZ} | t_{PZL}, t_{PLZ} |
| 74HC138 | V_{CC} | 6 ns | 15 pF, 50 pF | 1 k Ω | open | GND | V_{CC} |
| 74HCT138 | 3 V | 6 ns | 15 pF, 50 pF | 1 k Ω | open | GND | V_{CC} |

11. Package outline

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

SOT109-1



Fig. 10. Package outline SOT109-1 (SO16)

SSOP16: plastic shrink small outline package; 16 leads; body width 5.3 mm

SOT338-1

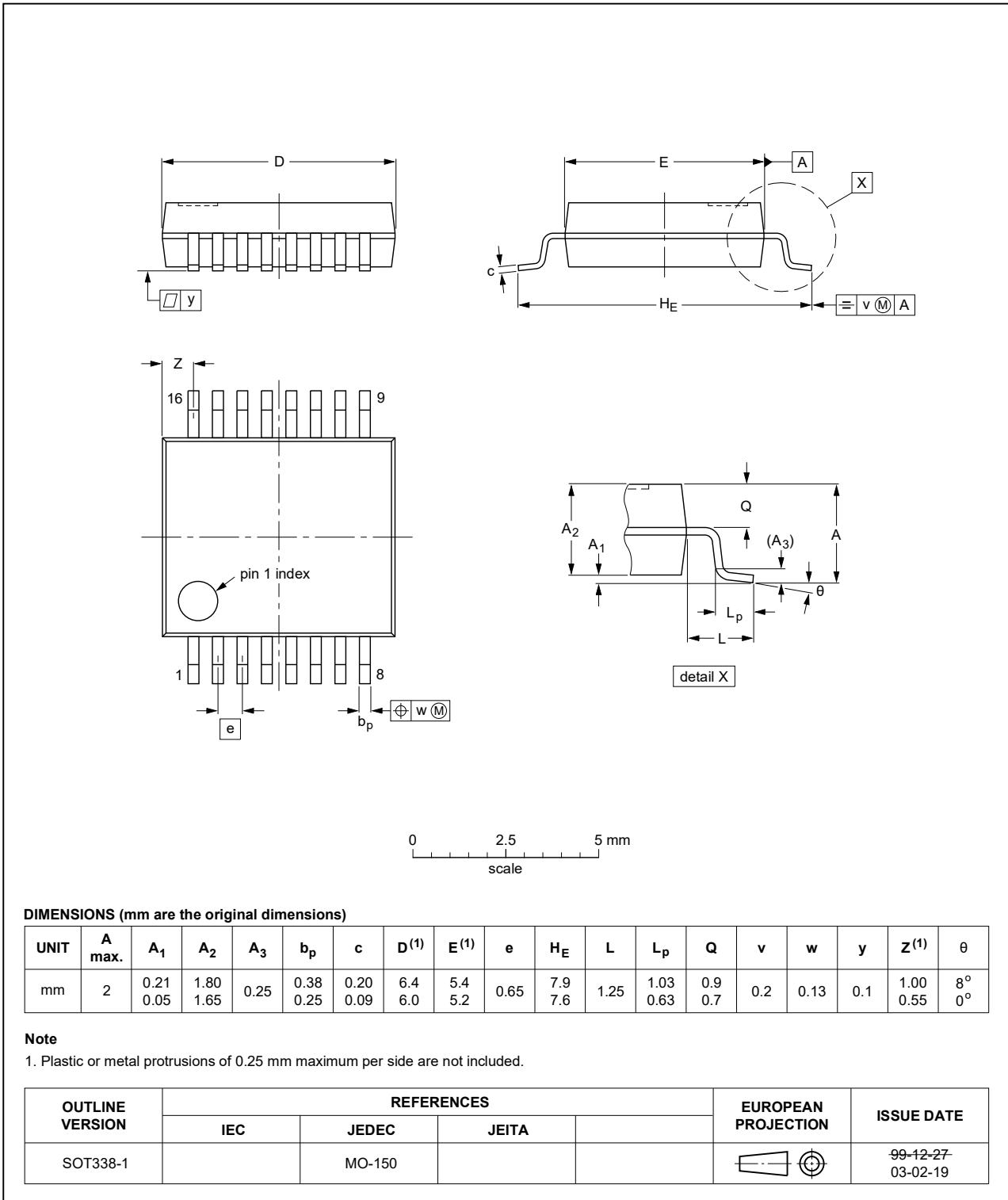


Fig. 11. Package outline SOT338-1 (SSOP16)

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

SOT403-1

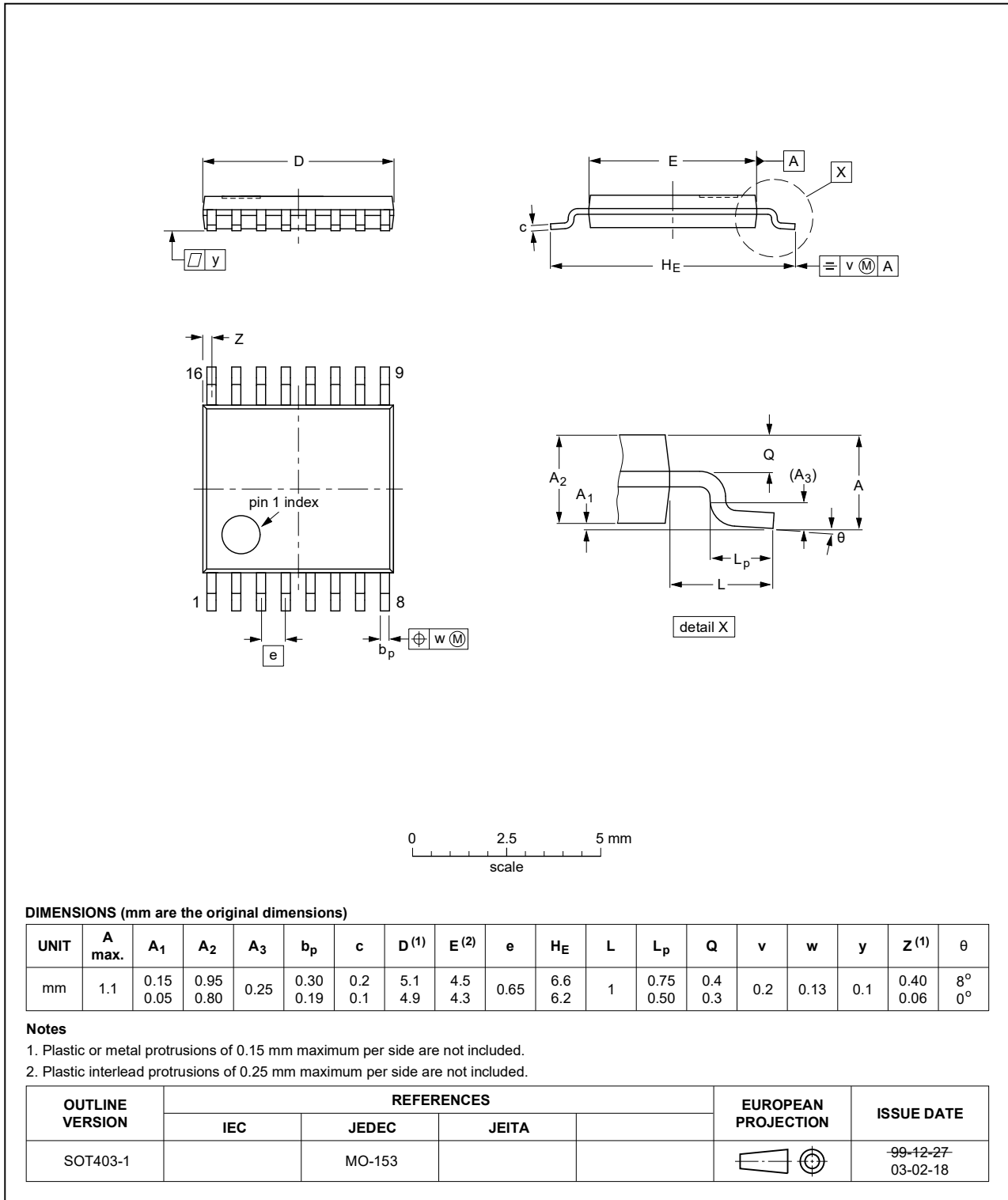


Fig. 12. Package outline SOT403-1 (TSSOP16)

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

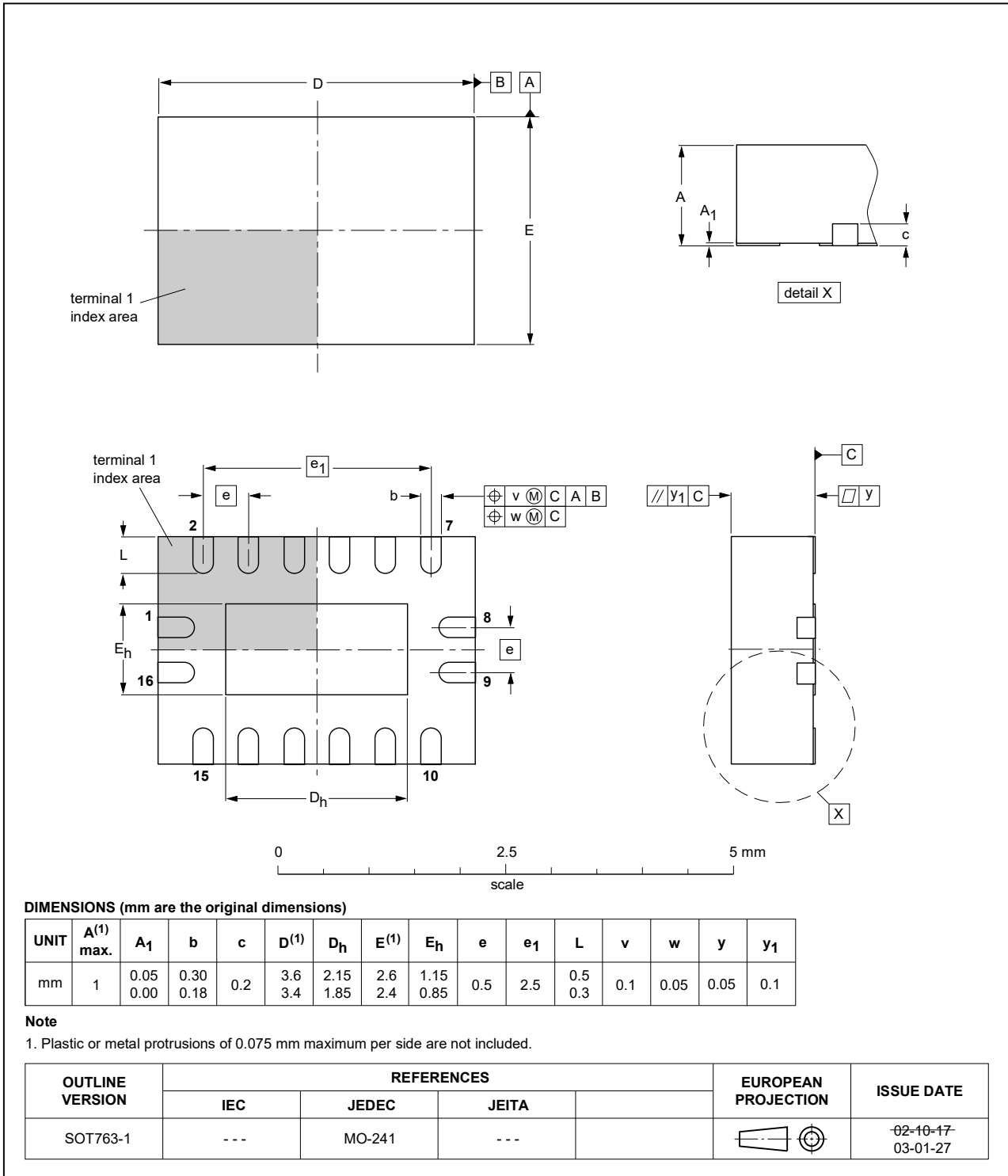


Fig. 13. Package outline SOT763-1 (DHVQFN16)

12. Abbreviations

Table 10. Abbreviations

| Acronym | Description |
|---------|-----------------------------------------|
| CMOS | Complementary Metal-Oxide Semiconductor |
| DUT | Device Under Test |
| ESD | ElectroStatic Discharge |
| HBM | Human Body Model |
| MM | Machine Model |
| TTL | Transistor-Transistor Logic |

13. Revision history

Table 11. Revision history

| Document ID | Release date | Data sheet status | Change notice | Supersedes |
|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|---------------|---------------------|
| 74HC_HCT138 v.8 | 20200407 | Product data sheet | - | 74HC_HCT138 v.7 |
| Modifications: | <ul style="list-style-type: none"> • Fig. 6 corrected (Errata). • Table 4: Derating values for P_{tot} total power dissipation updated. | | | |
| 74HC_HCT138 v.7 | 20180326 | Product data sheet | - | 74HC_HCT138 v.6 |
| Modifications: | <ul style="list-style-type: none"> • The format of this data sheet has been redesigned to comply with the identity guidelines of Nexperia. • Legal texts have been adapted to the new company name where appropriate. | | | |
| 74HC_HCT138 v.6 | 20151228 | Product data sheet | - | 74HC_HCT138 v.5 |
| Modifications: | <ul style="list-style-type: none"> • Type numbers 74HC138N and 74HCT138N (SOT38-4) removed. | | | |
| 74HC_HCT138 v.5 | 20150126 | Product data sheet | - | 74HC_HCT138 v.4 |
| Modifications: | <ul style="list-style-type: none"> • Section 9: OFF-state output current removed because device has no 3-state outputs. • Section 10: Power dissipation capacitance condition for 74HCT138 is corrected. | | | |
| 74HC_HCT138 v.4 | 20120627 | Product data sheet | - | 74HC_HCT138 v.3 |
| Modifications: | <ul style="list-style-type: none"> • The format of this data sheet has been redesigned to comply with the new identity guidelines of NXP Semiconductors. • Legal texts have been adapted to the new company name where appropriate. • SOT38-1 changed to SOT38-4. | | | |
| 74HC_HCT138 v.3 | 20051223 | Product data sheet | - | 74HC_HCT138_CNV v.2 |
| Modifications: | <ul style="list-style-type: none"> • The format of this data sheet has been redesigned to comply with the new presentation and information standard of Philips Semiconductors. • Section 3, Section 5 and Section 11: Added DHVQFN package information • Section 9: Added from the family specification | | | |
| 74HC_HCT138_CNV v.2 | 19970827 | Product specification | - | - |

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".
- [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 <https://www.nexperia.com>.

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