

**NCT5927W**  
**Nuvoton**  
**Level translating**  
**I<sup>2</sup>C-bus/SMBus Repeater**

Date: Nov.14, 2014    Revision: 1.01

**NCT5927W Datasheet Revision History**

|   | PAGES | DATES      | VERSION | MAIN CONTENTS  |
|---|-------|------------|---------|--|
| 1 |       | 2012/07/13 | 0.1     | Draft version.   |
| 2 |       | 2012/08/15 | 0.2     | 1. Modify application circuit on fig2<br>2. Modify test conditions and dynamic characteristics |
| 3 |       | 2013/05/24 | 0.5     | 1. Modify DC/AC specification  |
| 4 |       | 2013/10/02 | 0.6     | 1, Modify B port VIL<br>2, Modify B port low level current                                     |
| 5 |       | 2013/10/21 | 1.0     | 1. Modified capacitance values in general description<br>2. Modified A Port VIL                |
| 6 | 1     | 2014/11/14 | 1.01    | 1. Update the typo in the General description  |
|   |       |            |         |  |

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## 1. GENERAL DESCRIPTION

The NCT5927W is a CMOS integrated circuit that provides bidirectional level shifting between higher voltage (2.2 V to 5.5 V) and low voltage (down to 0.8 V) up to 1MHz for SMBus™ applications. While retaining all the operating modes and features of the I<sup>2</sup>C-bus system during the level shifts, it also permits extension of the I<sup>2</sup>C-bus by providing bidirectional buffering for both the data (SDA) and the clock (SCL) lines, thus enabling two buses at lower speeds. The SDA and SCL pins are 5V tolerant and are high-impedance when the NCT5927W is unpowered.

The NCT5927W drivers are not enabled unless  $V_{CCB}$  is above 2.2 V and  $V_{CCA}$  is above 0.8 V. The EN pin can also be used to turn the drivers on and off under system control. Caution should be observed to only change the state of the enable pin when the bus is idle.

The output pull-down on the B-side internal buffer LOW is set for approximately 0.55 V, while the input threshold of the internal buffer is set about 150 mV lower (0.4 V). When the B-side I/O is driven LOW internally, the LOW is not recognized as a LOW by the input. This prevents a lock-up condition from occurring. The output pull-down on the A-side drives a hard LOW and the input level is set at  $0.3V_{CCA}$  to accommodate the need for a lower LOW level in systems where the low voltage side supply voltage is as low as 0.8 V. The NCT5927W is packaged in MSOP-8 type.

## 2. FEATURES

- 2 channels, bidirectional voltage level from 0.8V to 5.5V and from 2.2V to 5.5V
- A side operating supply voltage  $V_{CCA}$  range from 0.8V to 5.5V
- B side operating supply voltage  $V_{CCB}$  range from 2.2V to 5.5V
- Isolates Input/output sides
- I<sup>2</sup>C® Compatible System Management bus (SMBus™) operated up to 1MHz
- High active's enable input
- 5V tolerant I<sup>2</sup>C-bus and active high enable pin
- high-impedance for I<sup>2</sup>C-bus pins in power-off
- 8-pin MSOP Green Package (Halogen-free)
- ESD protection exceeds 5500V HBM, 500V MM, and 1000V CDM
- Latch-up exceeds 100mA

3. BLOCK DIAGRAM

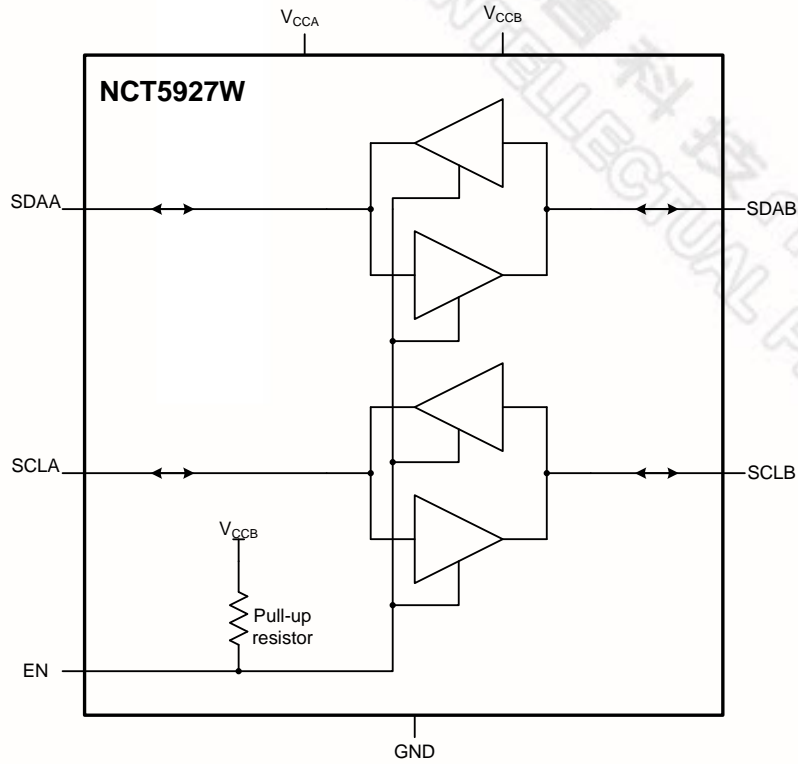
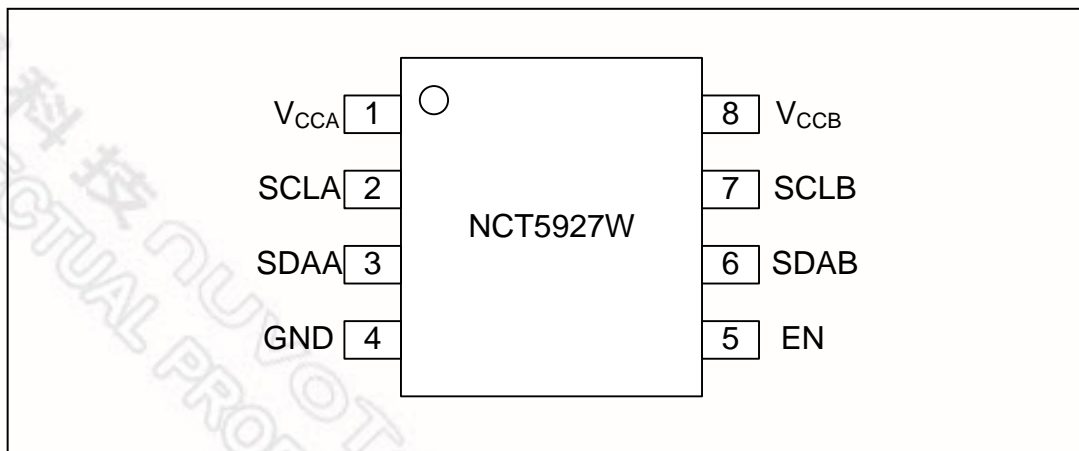


Figure 1 – Functional Diagram

4. PIN CONFIGURATION



**4.1 Pin Description**

| PIN | NAME             | DESCRIPTION                          |
|-----|------------------|--------------------------------------|
| 1   | V <sub>CCA</sub> | A-side supply voltage (0.8V to 5.5V) |
| 2   | SCLA             | Serial clock bus, A side.            |
| 3   | SDAA             | Serial data bus, A side.             |
| 4   | GND              | Supply ground                        |
| 5   | EN               | Active-high repeater enable input.   |
| 6   | SDAB             | Serial data bus, B side.             |
| 7   | SCLB             | Serial clock bus, B side.            |
| 8   | V <sub>CCB</sub> | B-side supply voltage (2.2V to 5.5V) |

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### 5. FUNCTIONAL DESCRIPTION

A typical application is shown in Figure 2. In this example, the memory is running on a 2.2V I<sup>2</sup>C-bus while CPU is connected to a 0.9V bus. Both buses run at 1MHz.

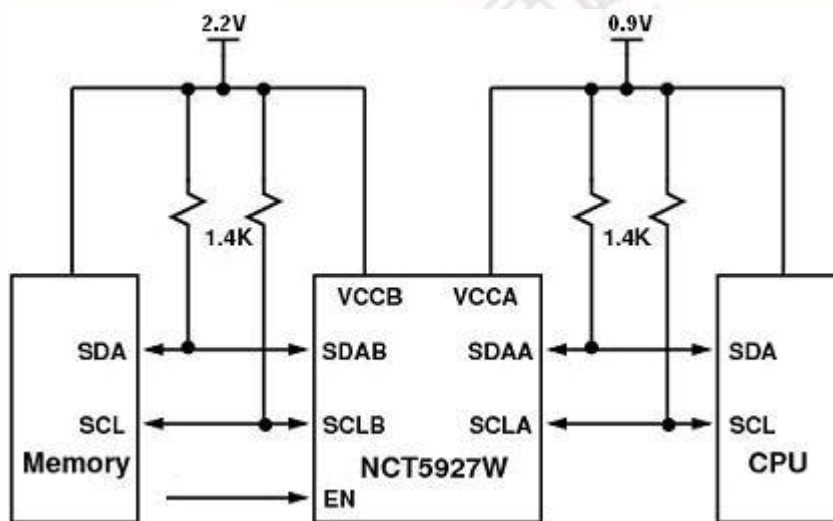


Figure 2 - Typical Application

The NCT5927W is 5V tolerant, so it does not require any additional circuitry to translate between 0.8V to 5.5 V bus voltages and 2.2V to 5.5V bus voltages.

When the A-side of the NCT5927W is pulled LOW by a driver on the I<sup>2</sup>C-bus, a comparator detects the falling edge when it goes below 0.3V<sub>VCCA</sub> and causes the internal driver on the B-side to turn on, causing the B-side to pull down to about 0.55 V. When the B-side of the NCT5927W falls, first a CMOS hysteresis type input detects the falling edge and causes the internal driver on the A-side to turn on and pull the A-side pin down to ground. In order to illustrate what would be seen in a typical application, refer to Figure 3 and Figure 4. If the bus master in Figure 3 were to write to the slave through the NCT5927W, waveforms shown in Figure 6 would be observed on the A bus. This looks like a normal I<sup>2</sup>C-bus transmission except that the HIGH level may be as low as 0.8 V, and the turn on and turn off of the acknowledge signals are slightly delayed.

On the B bus side of the NCT5927W, the clock and data lines would have a positive offset from ground equal to the V<sub>OL</sub> of the NCT5927W B side. After the 8th clock pulse, the data line will be pulled to the V<sub>OL</sub> of the NCT5927W in this example. At the end of the acknowledge, the level rises from the LOW level set by the driver in the NCT5927W while the A bus side rises above 0.3V<sub>VCCA</sub>, then it continues HIGH. It is important to note that any arbitration or clock stretching events require that the LOW level on the B bus side at the input of the NCT5927W (V<sub>IL</sub>) be at or below 0.4 V to be recognized by the

NCT5927W and then transmitted to the A bus side. The NCT5927W includes a VCCA over voltage disable that turns the channel off if  $0.4V_{CCA} + 0.8V > V_{CCB}$ .

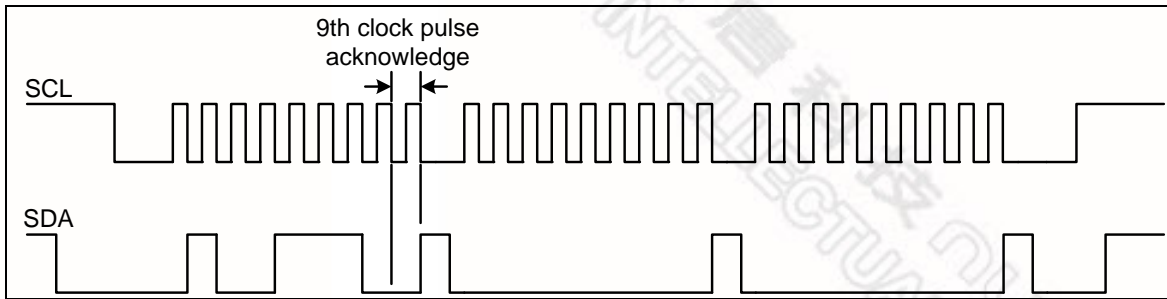


Figure 3 - Bus A (0.8V to 5.5V bus) waveform

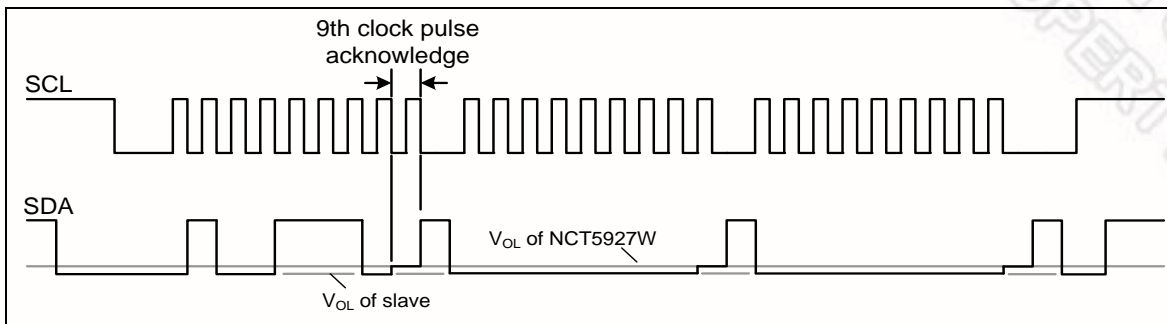


Figure 4 - Bus B (2.2V to 5.5V bus) waveform

### 5.1 Enable Pin

The EN pin is active HIGH with thresholds reference to VCCB with an internal pull-up to VCCB and allows the user to select when the repeater is active. This can be used to isolate a badly behaved slave on power-up until after the system power-up reset. It should never change state during and I<sup>2</sup>C-bus operation because disabling during a bus operation will hang the bus and enabling part way through a bus cycle could confuse the I<sup>2</sup>C-bus parts being enabled.

The enable pin should only change state when the global bus and the repeater port are in an idle state to prevent system failures.

| INPUT EN | FUNCTION                   |
|----------|----------------------------|
| L        | Output Disable             |
| H        | SDAA = SDAB<br>SCLA = SCLB |



## 6. ELECTRICAL CHARACTERISTICS

### 6.1 Absolute Maximum Ratings

| PARAMETER                                      | RATING      | UNIT |
|--|-------------|------|
| Power Supply Voltage ( $V_{CCA}$ , $V_{CCB}$ ) | -0.5 to 6.0 | V    |
| Input/Output Voltage                           | -0.5 to 6.0 | V    |
| Operating Temperature (in free air)            | -40 to + 85 | °C   |
| Storage Temperature                            | -55 to +125 | °C   |
| Junction temperature                           | 125         | °C   |

**Note:** Exposure to conditions beyond those listed under Absolute Maximum Ratings may adversely affect the life and reliability of the device.

### 6.2 DC Characteristics

$V_{CCA}=0.8V$  to  $5.5V^{[1]}$ ;  $V_{CCB}=2.2V$  to  $5.5V$ ;  $GND=0V$ ;  $T_{amb}=-40$  °C to  $85$ °C; unless otherwise specified.<sup>[1]</sup>

| Symbol                                | Parameter                          | Conditions   | Min          | Typ  | Max  | Unit |
|---------------------------------------|------------------------------------|--|--------------|------|------|------|
| $V_{CCB}$                             | Supply voltage, B-side bus         |  | 2.2          | -    | 5.5  | V    |
| $V_{CCA}$                             | Supply voltage, A-side bus         |  | 0.8          | -    | 5.5  | V    |
| $I_{CC(VCCA)}$                        | Supply current on pin $V_{CCA}$    | $V_{CCA} = 5.5V$   | -            | -    | 50   | µA   |
| $I_{CCH}$                             | HIGH-state supply current          | Both channels HIGH;<br>$V_{CCB} = 5.5V$ ;<br>$SDAn = SCLn = V_{CC(n)}$                     | -            | 2    | 2.5  | mA   |
| $I_{CCL}$                             | LOW-state supply current           | Both channels LOW;<br>$V_{CC} = 5.5V$ ;<br>One SDA and SCL = GND; other SDA and SCL = open | -            | 1.8  | 2.9  | mA   |
| <b>Input and output SDAB and SCLB</b> |                                    |  |              |      |      |      |
| $V_{IH}$                              | HIGH-level input voltage           |  | $0.7V_{CCB}$ | -    | 5.5  | V    |
| $V_{IL}$                              | LOW-level input voltage            |  | -0.5         | -    | +0.4 | V    |
| $V_{ILc}$                             | LOW-level input voltage contention |  | -0.5         | 0.4  | -    | V    |
| $V_{ILK}$                             | Input clamping voltage             | $I_I = -18mA$  | -1.2         | -    | -0.3 | V    |
| $I_{LI}$                              | Input leakage current              | $V_I = 5.5V$   | -            | -    | ±1   | µA   |
| $I_{IL}$                              | LOW-level input current            | SDA, SCL; $V_I = 0.2V$   | -            | -    | 100  | µA   |
| $V_{OL}$                              | LOW-level output voltage           | $I_{OL} = 150 \mu A$ or 6mA  | 0.47         | 0.55 | 0.65 | V    |
| $V_{OL-V_{ILC}}$                      | LOW-level input voltage below      | Guaranteed by design   | -            | 150  | -    | mV   |

| Symbol                                | Parameter                         | Conditions  | Min                 | Typ | Max                  | Unit |
|---------------------------------------|-----------------------------------|---|---------------------|-----|----------------------|------|
|                                       | output LOW-level voltage          |   |                     |     |                      |      |
| C <sub>io</sub>                       | Input/output capacitance          | VI=3V or 0V; VCC=3.3V                             | -                   | 7   | 10                   | pF   |
|                                       |                                   | VI=3V or 0V; VCC=0V                               |                     |     |                      |      |
| <b>Input and output SDAA and SCLA</b> |                                   |   |                     |     |                      |      |
| V <sub>IH</sub>                       | HIGH-level input voltage          |   | 0.7V <sub>CCA</sub> | -   | 5.5                  | V    |
| V <sub>IL</sub>                       | LOW-level input voltage           |   | [1]-0.5             | -   | 0.25V <sub>CCA</sub> | V    |
| V <sub>ILK</sub>                      | Input clamping voltage            | I <sub>i</sub> =-18mA                             | -1.2                | -   | -0.3                 | V    |
| I <sub>LI</sub>                       | Input leakage current             | V <sub>I</sub> =5.5V                              | -                   | -   | ±1                   | μA   |
| I <sub>IL</sub>                       | LOW-level input current           | SDA, SCL; V <sub>I</sub> = 0.2V                   | -                   | -   | 10                   | μA   |
| V <sub>OL</sub>                       | LOW-level output voltage          | I <sub>OL</sub> = 6mA                             | -                   | 0.1 | 0.2                  | V    |
| C <sub>io</sub>                       | Input/output capacitance          | VI=3V or 0V; VCC=3.3V                             | -                   | 7   | 10                   | pF   |
|                                       |                                   | VI=3V or 0V; VCC=0V                               |                     |     |                      |      |
| <b>Enable</b>                         |                                   |   |                     |     |                      |      |
| V <sub>IL</sub>                       | LOW-level input voltage           |   | -0.5                | -   | +0.3V <sub>CCB</sub> | V    |
| V <sub>IH</sub>                       | HIGH-level input voltage          |   | 0.7V <sub>CCB</sub> | -   | 5.5                  | V    |
| I <sub>IL(EN)</sub>                   | LOW-level input current on pin EN | V <sub>I</sub> = 0.2V, EN; V <sub>CCB</sub> =2.2V | -                   | -10 |                      | μA   |
| I <sub>LI</sub>                       | Input leakage current             |   | -1                  | -   | +1                   | μA   |
| C <sub>i</sub>                        | Input capacitance                 | V <sub>I</sub> = V <sub>CCB</sub>                 | -                   | 6   | 7                    | pF   |

[1] V<sub>CCA</sub> may be as high as 5.5V for over voltage tolerance but 0.4V<sub>CCA</sub> + 0.8V < V<sub>CCB</sub> for the channels to be enable and functional normally

[2] V<sub>IL</sub> for A-side with envelope noise must be below 0.3V<sub>CCA</sub> for stable performance

[3] Power supply decoupling capacitors need to be present for both V<sub>CCA</sub> and V<sub>CCB</sub> and the 0.1uF decoupling for V<sub>CCB</sub> needs to be located near the pin

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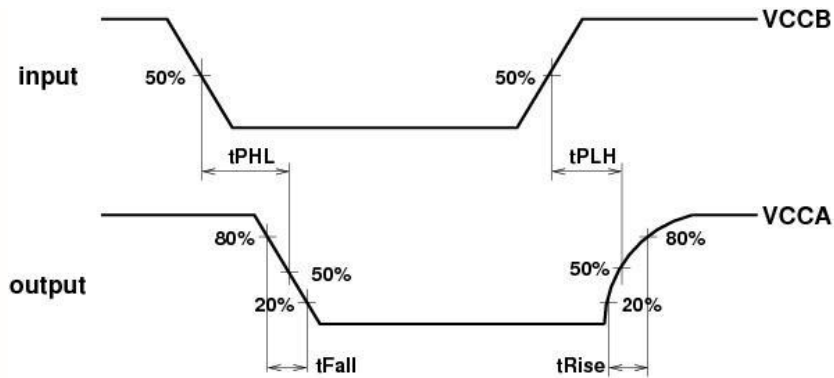


Figure 5 - Propagation delay and transition (rise/fall) times; B-side to A-side

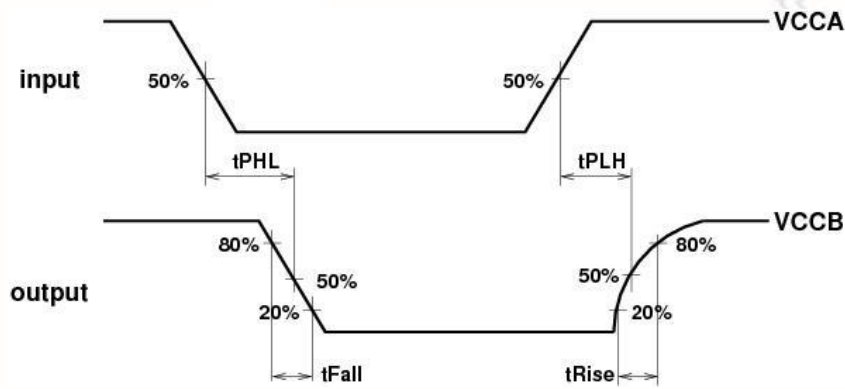


Figure 6 - Propagation delay and transition (rise/fall) times; A-side to B-side

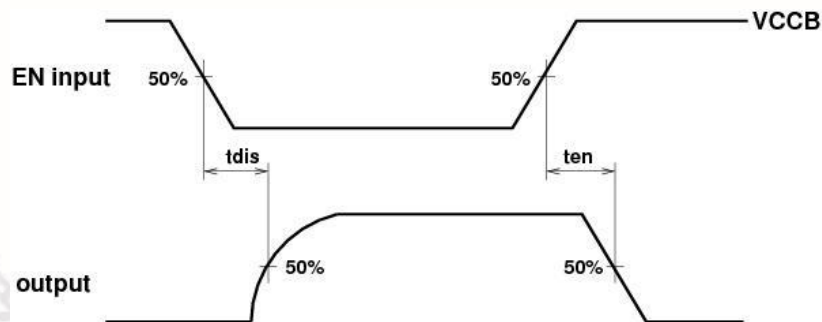


Figure 7 - Enable and disable time

### 6.3 AC CHARACTERISTICS

$V_{CCA}=0.8V$  to  $5.5V$ ;  $V_{CCB}=2.2V$  to  $5.5V$ ;  $GND=0V$ ;  $T_{amb}=-40$  °C to  $85$  °C; unless otherwise specified.<sup>[1][2][3]</sup>

| Symbol     | Parameter                     | Conditions                  | Min | Typ | Max | Unit |
|------------|-------------------------------|-----------------------------|-----|-----|-----|------|
| $t_{PLH}$  | LOW-to-HIGH propagation delay | B-side to A-side; figure 5  | 60  | 90  | 130 | ns   |
| $t_{PHL}$  | HIGH-to-LOW propagation delay | B-side to A-side; figure 5  | 40  | 70  | 100 | ns   |
| $t_{rise}$ | Rise time                     | A-side; figure 5            | -   | 100 | -   | ns   |
| $t_{fall}$ | Fall time                     | A-side; figure 5            | 2   | 4   | 6   | ns   |
| $t_{PLH}$  | LOW-to-HIGH propagation delay | A-side to B-side; figure 6  | 30  | 60  | 80  | ns   |
| $t_{PHL}$  | HIGH-to-LOW propagation delay | A-side to B-side; figure 6  | 40  | 70  | 90  | ns   |
| $t_{rise}$ | Rise time                     | B-side; figure 6            | -   | 100 | -   | ns   |
| $t_{fall}$ | Fall time                     | B-side; figure 6            | 5   | 20  | 35  | ns   |
| $t_{en}$   | Enable time                   | EN HIGH to enable; figure 7 | -   | -   | 200 | ns   |
| $t_{dis}$  | Disable time                  | EN LOW to disable; figure 7 | -   | -   | 200 | ns   |

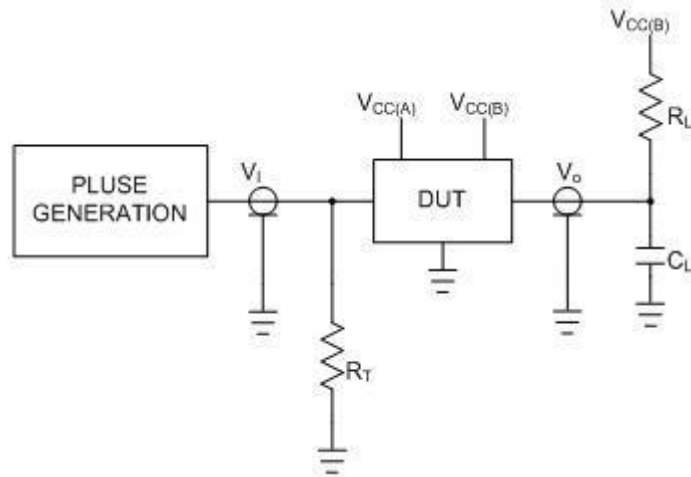
[1] Times are specified with loads of 1.35k pull-up resistance and 50 pF load capacitance on the A/B-side and falling edge slew rate of 0.05V/ns input signals. Different load resistance and capacitance will alter the RC time constant, thereby changing the propagation delay and transition times

[2] Pull-up voltages are  $V_{CCA}$  on the A-side and  $V_{CCB}$  on the B-side.

[3] Typical values were measured with  $V_{CCA} = 0.95 V$ ,  $V_{CCB} = 2.5 V$  at  $T_{amb} = 25$  °C, unless otherwise noted.

[4] The enable pin, EN, should only change state when the global bus and the repeater port are in an idle state.

6.4 Test Information



$R_L$  = load resistor; 1.35K on A/B port

$C_L$  = load capacitor; 50pF

$R_T$  = termination resistor that should be equal to chacteristic resistance of pulse generation

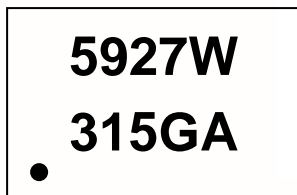
Figure 8 - Test circuit for open-drain outputs

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7. ORDER INSTRUCTION

| PART NO. | PACKAGE                 | SUPPLIED AS  |
|----------|-------------------------|--|
| NCT5927W | MSOP-8<br>Green Package | E shape (Tube)<br>T shape (Tape & Reel); MOQ=4Kpcs |

8. TOP MARKING SPECIFICATION



1<sup>st</sup> line: Part number: 5927W means NCT5927W

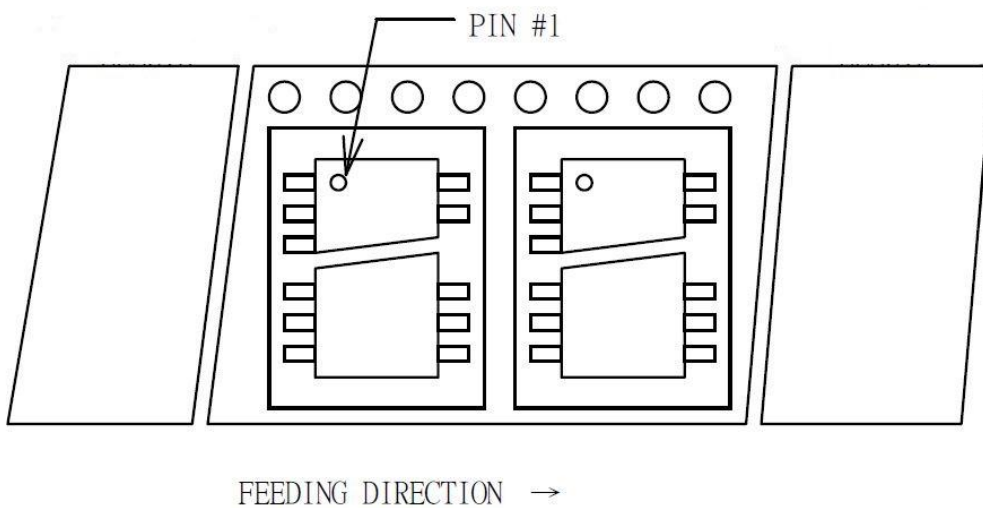
2<sup>nd</sup> line: Assembly tracking code

3 15 : packages made in year 2013, week 15

G: Assembly house code

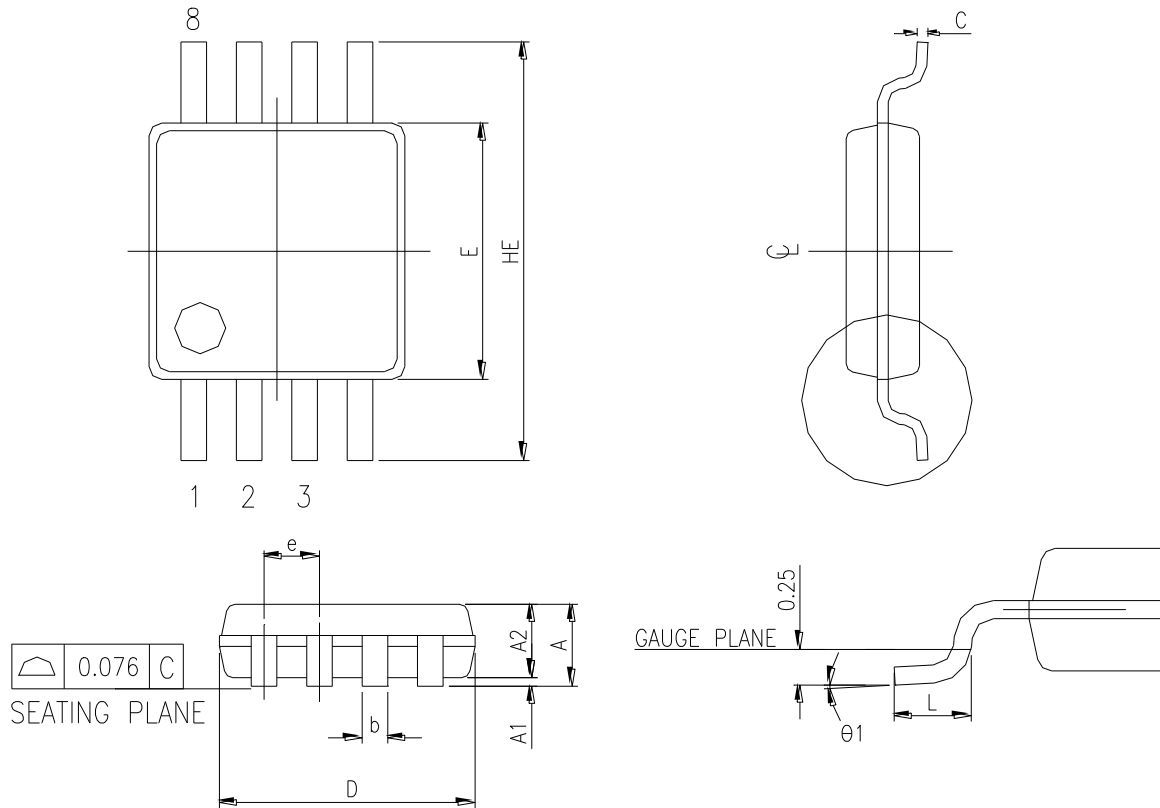
A: Nuvoton internal tracking code

9. TAPING SPECIFICATION



10. PACKAGE DRAWING AND DIMENSIONS

MSOP-8L 3 X 3mm



CONTROLLING DIMENSION : MILLIMETERS

| SYMBOL | DIMENSION IN MM |      |       | DIMENSION IN INCH |        |        |
|--------|-----------------|------|-------|-------------------|--------|--------|
|        | MIN.            | NOM. | MAX.  | MIN.              | NOM.   | MAX.   |
| A      | ---             | ---  | 1.10  | ---               | ---    | 0.043  |
| A1     | 0.05            | ---  | 0.15  | 0.002             | ---    | 0.006  |
| A2     | 0.81            | 0.86 | 0.91  | 0.032             | 0.034  | 0.036  |
| c      | 0.13            | ---  | 0.23  | 0.005             | ---    | 0.009  |
| b      | 0.25            | ---  | 0.40  | 0.0098            | ---    | 0.0157 |
| D      | 2.90            | 3.00 | 3.10  | 0.114             | 0.118  | 0.122  |
| E      | 2.90            | 3.00 | 3.10  | 0.114             | 0.118  | 0.122  |
| HE     | 4.90 BSC        |      |       | 0.193 BSC         |        |        |
| L      | 0.445           | 0.55 | 0.648 | 0.0175            | 0.0217 | 0.0255 |
| theta1 | 0°              |      | 6°    | 0°                |        | 6°     |
| e      | 0.65 BSC        |      |       | 0.026 BSC         |        |        |

### Important Notice

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Insecure usage includes, but is not limited to: equipment for surgical implementation, atomic energy control instruments, airplane or spaceship instruments, the control or operation of dynamic, brake or safety systems designed for vehicular use, traffic signal instruments, all types of safety devices, and other applications intended to support or sustain life.

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