# STVM100

## I²C LCD VCOM calibrator

## Features

- I²C interface, slave address: 1001111
- 7-bit adjustable sink current output
- 2.25V to 3.6V logic supply voltage $V_{DD}$
- $AV_{DD}$ operating voltages
  - 4.5V to 20V for $V_{DD}$ from 2.6V to 3.6V
  - 4.5V to 13V for $V_{DD}$ from 2.25V to 3.6V
- EEPROM for storing the optimum $V_{COM}$ setting
- Guaranteed monotonic output over operating range
- 400kHz maximum interface bus speed
- Operating temperature: –40°C to 85°C
- Available in an 8-pin 3mm x 3mm TDFN8 or 3mm x 3mm TSSOP8 Package

## Applications

- TFT-LCD panels

TDFN8 (3mm x 3mm) (DC)

TSSOP8 (3mm x 3mm) (DS)

## Description

The STVM100 is a programmable VCOM adjustment solution for thin-film transistor (TFT) liquid-crystal displays (LCDs) to remove “flickers”. It can replace a mechanical potentiometer, so that the factory operator can physically view the front screen when performing the VCOM adjustment. This significantly reduces labor costs, increases reliability, and enables automation.

STVM100 provides a digital I²C interface to control the sink current output ($I_{OUT}$). This output drives an external resistive voltage divider, which can then be applied to an external $V_{COM}$ buffer. Three external resistors $R_1$, $R_2$, and $R_{SET}$ determine the highest and lowest value of the $V_{COM}$. An increase in the output sink current will lower the voltage on the external divider so that the $V_{COM}$ can be adjusted by 128 steps within this range. Once the desired $V_{COM}$ setting is achieved, it can be stored in the internal EEPROM that will be automatically recalled during each power-up.

STVM100 is available in an 8-pin, 3mm x 3mm TDFN8 or 3mm x 3mm TSSOP8 package.

**Table 1. Device summary**

| Order code | Optimum temperature range | Package | Packing |
|---|---|---|---|
| STVM100DC6E | -40°C to 85°C | TDFN | ECOPACK package, tubes |
| STVM100DS6F | -40°C to 85°C | TSSOP | ECOPACK package, tape and reel |

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# 1 Device overview

**Figure 1. Logic diagram**

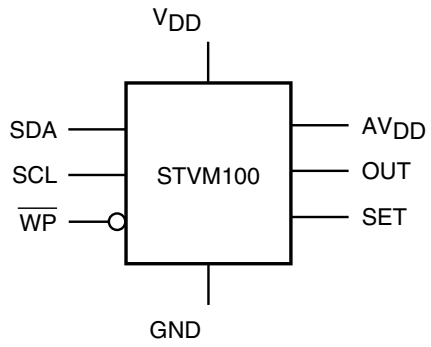



**Table 2. Pin names and functions**

| Name | Type | Function |
|---|---|---|
| OUT | Analog | Adjustable sink current output pin. (1)<br>See *Section 3: Application information on page 11*. |
| $AV_{DD}$ | Supply | High-voltage analog supply.<br>Bypass to GND with a 0.1µF capacitor. |
| $\overline{WP}$ | Input | WRITE protectection.<br>Active-low. To enable write operations to the DAC or to the EEPROM writing, connect to $0.7V_{DD}$ or greater. Internally pulled down by a 130kΩ resistor. |
| GND | | Supply ground. |
| $V_{DD}$ | Supply | System power supply input.<br>Bypass to GND with a 0.1µF capacitor. |
| SDA | In/Out | $I^2C$ serial data input/output. |
| SCL | Input | $I^2C$ serial clock input. |
| SET | Analog | Maximum sink current adjustment point.<br>Connect a resistor from SET to GND to set the maximum adjustable sink current of the OUT pin. The maximum adjustable sink current is equal to $AV_{DD}$ /20 divided by $R_{SET}$ (see *Figure 4 on page 6*). |

1. See SET pin function in this table for the maximum adjustable sink current setting.

**Figure 2. Connections diagram**

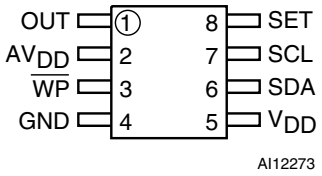



**Figure 3. Block diagram**

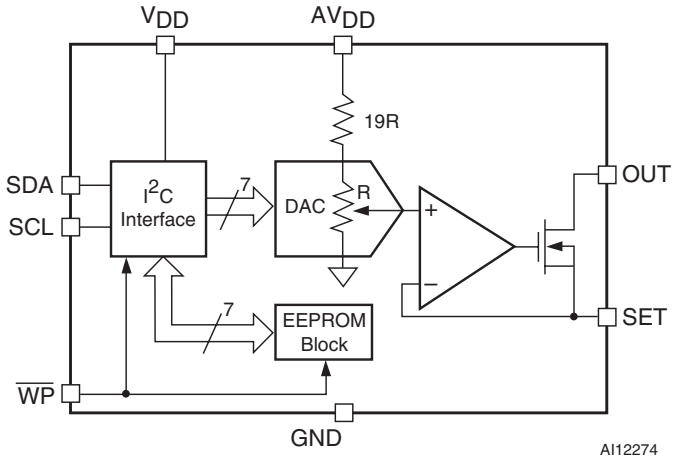
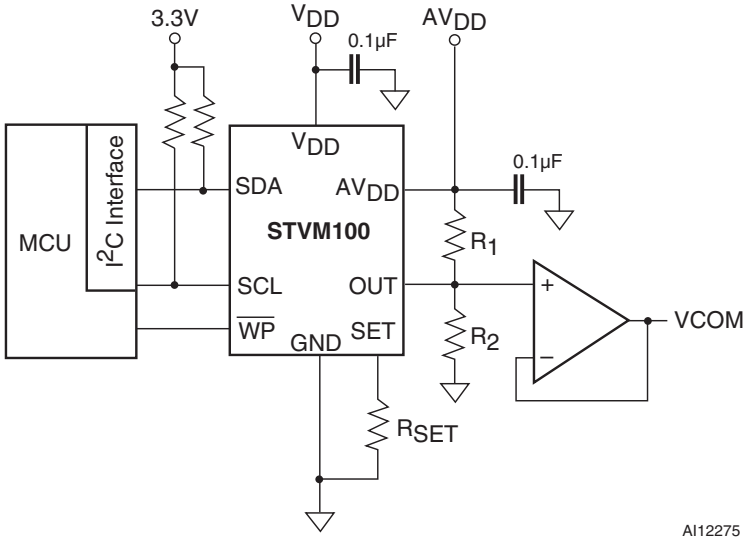



**Figure 4. Hardware hookup**



# 2 Device operation

The STVM100 operates as a slave device on the serial bus. Access is obtained by implementing a Start condition, followed by the 7-bit slave address (1001111), and the eighth bit for READ/WRITE identification. The volatile DAC register and non-volatile EEPROM values can be read out or written in.

## 2.1 2-wire bus characteristics and conditions

This bus is intended for communication between different ICs. It consists of two lines:

- a bi-directional data signal (SDA).
- a clock signal (SCL).

The SDA and SCL lines must be connected to a positive supply voltage via a pull-up resistor. The following protocols have been defined:

- Data transfer may be initiated only when the bus is not busy.
- During data transfer, the data line must remain stable whenever the clock line is high.
- Changes in the data line while the clock line is high will be interpreted as control signals.

### 2.1.1 Bus not busy

Both data and clock lines remain High.

### 2.1.2 Start data transfer

A change in the data line state from high-to-low while the clock is high indicate the Start condition.

### 2.1.3 Stop data transfer

A change in the data line state from low-to-high while the clock is high indicates the Stop condition.

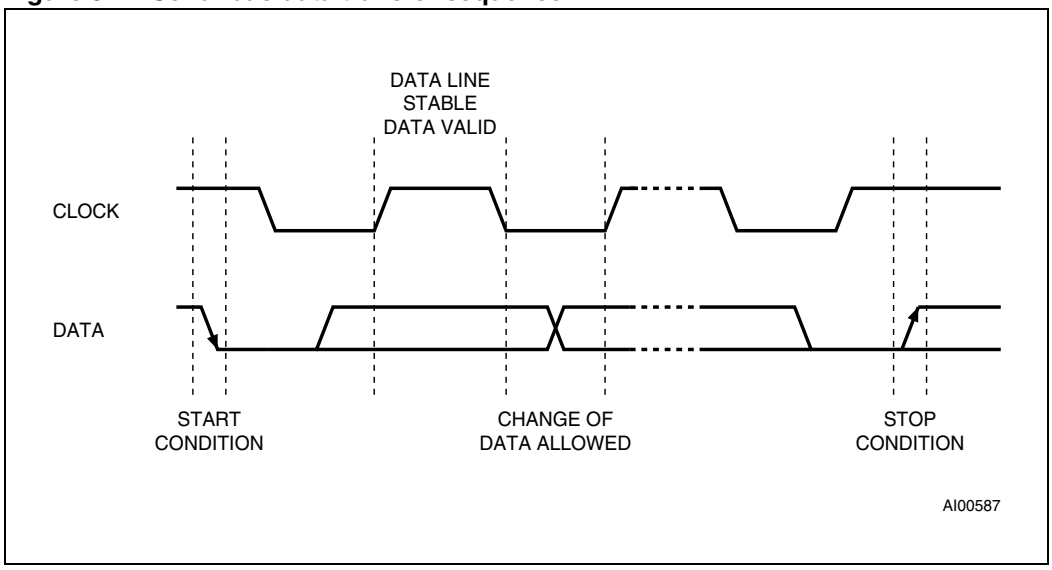
### 2.1.4 Data valid

The data on the SDA line must be stable during the HIGH period of the clock. The HIGH or LOW state of the data line can only change when the clock signal on the SCL line is low (see *Figure 5*). The data on the line may be changed during the clock signal low period. There is one clock pulse per bit of data.

Each data transfer is initiated with a Start condition and terminated with a Stop condition. The number of data bytes transferred between the Start and Stop conditions is not limited. The information is transmitted byte-wide and each receiver acknowledges transmission with a ninth bit.

By definition, the device that gives out a message is called “transmitter”, the device that gets the message is called “receiver”. The device that controls the message is called the “master”. The devices controlled by the master are called “slave” devices.

**Figure 5. Serial bus data transfer sequence**

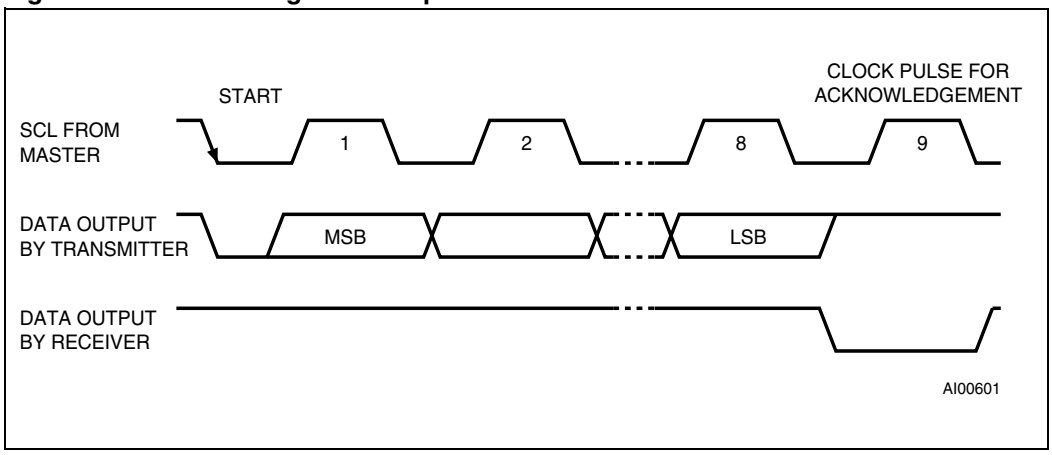


### 2.1.5 Acknowledge

Each byte of eight bits is followed by one Acknowledge bit. This Acknowledge bit is a low level signal put on the bus by the receiver, whereas the master generates an extra acknowledge-related clock pulse (see *Figure 6*). A slave receiver which is addressed is obliged to generate an acknowledge signal after the reception of each byte that has been clocked out of the slave transmitter.

The device that acknowledges transmissions has to pull down the SDA line during the acknowledge clock pulse in such a way, that the SDA line is a stable low during the high period of the acknowledge-related clock pulse. The setup and hold times must be taken into account. A master receiver must signal an end of transmitted data to the slave transmitter by not generating an acknowledge on the last byte that has been clocked out of the slave. In this case, the transmitter must leave the data line high to enable the master to generate the Stop condition.

**Figure 6. Acknowledgement sequence**



## 2.2 Read mode

In READ mode, after the Start condition, the master sets the slave address (see *Figure 7*). Followed by the READ/WRITE Mode Control bit (R/$\overline{W}$=1) and the Acknowledge bit, the value in DAC register will be transmitted and the master receiver will send an Acknowledge bit to the slave transmitter. Finally the Stop condition will terminate the READ operation. In READ mode, the valid data is the first 7 bits and the P bit (the eight bit) is don't care.

## 2.3 Write mode

In WRITE mode the master transmits to the STVM100 slave receiver. The bus protocol is shown in *Figure 7*. Following the Start condition and slave address, a logic '0' (R/$\overline{W}$ = 0) is placed on the bus to identify a WRITE operation. After the acknowledgement by the slave, the data will be transmitted to the slave with the 7-bit which indicates the data is valid as well as the eighth bit "P" for the register's identification. When P = 1, the DAC register is written to, and when P = 0, the EEPROM is written to (**P**rogramming). After receiving the data, the slave will generate an acknowledge signal, then a Stop condition will terminate the WRITE operation. STVM100 is pre-programmed with 80H in the EEPROM after manufacturing.

A period of tW (see *Table 8*) is needed for EEPROM programming. During this period, the slave will not acknowledge any WRITE operation.

The bit P values in both READ and WRITE modes are shown in *Table 3*.

**Figure 7. Read/write mode sequence**

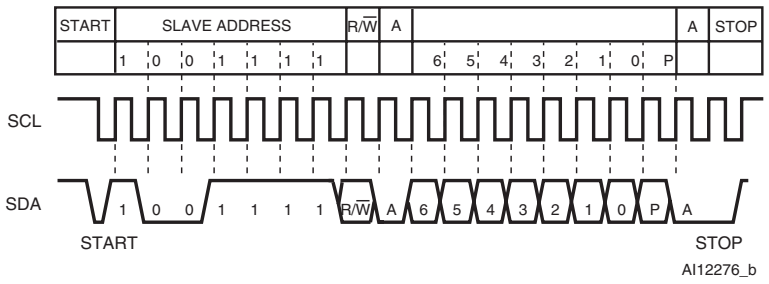



**Table 3. Bit P read and write mode values**

| Operation | P-bit value | Description |
|---|---|---|
| READ | X | Don't care |
| WRITE | 1 | DAC register WRITE |
| | 0 | EEPROM WRITE (programming) |

## 2.4 $V_{DD}$ power supply ramp-up

The ramp-up from 10% $V_{DD}$ to 90%$V_{DD}$ level should be achieved in less than or equal to 10ms to ensure that the EEPROM and power-on reset circuits are synchronized, and the correct value is read from the EEPROM.

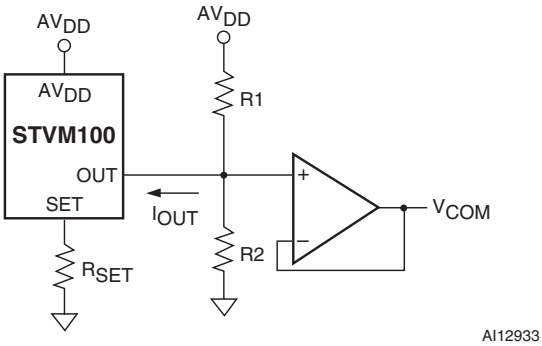
# 3 Application information

The STVM100 is a programmable $V_{COM}$ calibrator for the TFT-LCD to remove flickers. It provides a digital $I^2C$ interface to control the sink current output. This output drives an external resistive voltage divider, which can then be applied to an external $V_{COM}$ buffer.

The highest and lowest $V_{COM}$ value is determined by three resistors, $R_1$, $R_2$, and $R_{SET}$. The connection is shown in *Figure 8*.

The sink current from the STVM100 OUT pin is given in *Equation 1*. This current then flows through $R_{SET}$. This current must be less than 120µA (see $I_{SET}$ value in *Table 7 on page 15*).

**Figure 8. $R_1$, $R_2$, and $R_{SET}$ connection**




**Equation 1**

$$I_{OUT} = \frac{D+1}{128} \cdot \frac{AV_{DD}}{20(R_{SET})}$$

*Note: "D" is a user-selected value, an integer ranging from 0 to 127.*

The $V_{COM}$ value can be obtained in *Equation 2*.

**Equation 2**

$$V_{COM} = \frac{R_2}{R_1 + R_2} \cdot AV_{DD}\left(1 - \frac{D+1}{128} \cdot \frac{R_1}{20(R_{SET})}\right)$$

If the user-selected value is 0 (zero scale), the minimum current is sunk. The maximum $V_{COM}$ value is obtained in *Equation 3*.

**Equation 3**

$$V_{COM(max)} = \frac{R_2}{R_1 + R_2} \cdot AV_{DD}\left(1 - \frac{1}{128} \cdot \frac{R_1}{20(R_{SET})}\right)$$

If the user-selected value is 127 (full scale), the maximum current is sunk and the minimum $V_{COM}$ value is obtained in *Equation 4*.

**Equation 4**

$$V_{COM(min)} = \frac{R_2}{R_1 + R_2} \cdot AV_{DD}\left(1 - \frac{R_1}{20(R_{SET})}\right)$$

During operation, the $V_{COM(max)}$ and $V_{COM(min)}$ range is set, based on different TFT-LCD processes.The R1 value is given based on the acceptable power loss from the $AV_{DD}$ supply rail. Using *Equation 3* and *Equation 4*, the $R_2$ and $R_{SET}$ values can be calculated. If $R_{SET}$ is put into *Equation 1 on page 11* and maximum $I_{OUT} \geq 120\mu A$, then $R_1$ should be increased.

# 4 Maximum rating

Stressing the device above the ratings listed in the “Absolute Maximum Ratings” table may cause permanent damage to the device. These are stress ratings only and operation of the device at these or any other conditions above those indicated in the Operating sections of this specification is not implied. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability. Refer also to the STMicroelectronics SURE Program and other relevant quality documents.

**Table 4. Absolute maximum ratings**

| Symbol | Parameter | | Value | Unit |
|---|---|---|---|---|
| $T_{STG}$ | Storage temperature ($V_{DD}$ Off, $AV_{DD}$ Off) | | –55 to 150 | °C |
| $T_{SLD}$(1) | Lead solder temperature for 10 seconds | | 260 | °C |
| $T_J$ | Maximum junction temperature (plastic package) | | 150 | °C |
| $V_{OUT}$ | Output voltage (OUT pin to GND) | | –0.3 to 20 | V |
| $V_{DD}$ | $V_{DD}$ to GND | | +5.5 | V |
| $AV_{DD}$ | $AV_{DD}$ input voltage to GND | | –0.3 to 20 | V |
| $V_{SET}$ | Output voltage (SET pin to GND) | | –0.3 to 5.5 | V |
| $P_{DIS}$ | Power dissipation | TDFN8 | 2.66 | W |
| | | TSSOP8 | 0.53 | W |

1. Reflow at peak temperature of 255°C to 260°C for < 30 seconds (total thermal budget not to exceed 180°C for between 90 to 150 seconds).

# 5 DC and AC parameters

This section summarizes the operating measurement conditions, and the dc and ac characteristics of the device. The parameters in the DC and AC characteristics tables that follow, are derived from tests performed under the Measurement Conditions summarized in *Table 5*, Operating and ac Measurement Conditions. Designers should check that the operating conditions in their circuit match the operating conditions when relying on the quoted parameters.

**Table 5. Operating and AC measurement conditions**

| Parameter | Conditions | Unit |
|---|---|---|
| $V_{DD}$ supply voltage | 2.25 to 3.6 | V |
| $V_{DD}$ EEPROM programming supply voltage | 2.25 to 3.6 | V |
| $AV_{DD}$ reference voltage | 4.5 to 20 | V |
| Ambient operating temperature ($T_A$) | –40 to 85 | °C |

**Table 6. Capacitances**

| Symbol | Parameter[1][2] | | Min | Max | Unit |
|---|---|---|---|---|---|
| $C_b$ | Bus capacitive load | | | 400 | pF |
| $C_{SDA}$ | Capacitance on SDA | | | 10 | pF |
| $C_S$ | Capacitance on SCL | WP = 0 | | 10 | pF |
| | | WP = 1 | | 22 | pF |

1. Effective capacitance measured with power supply at 3V. Sampled only, not 100% tested.
2. At 25°C, f = 1MHz.

**Table 7. DC and AC characteristics**

| Sym | Description | Test Condition(1) | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $V_{DD}$ | Supply voltage | | 2.25 | | 3.6 | V |
| | EEPROM programming supply voltage | | 2.25 | | 3.6 | V |
| $I_{DD}$(2) | $V_{DD}$ supply current | | | | 50 | µA |
| $AV_{DD}$ | Analog supply voltage | $V_{DD}$ = 2.6V to 3.6V | 4.5 | | 20 | V |
| | | $V_{DD}$ = 2.25V to 3.6V | 4.5 | | 13 | V |
| $I_{AVDD}$(3) | $AV_{DD}$ supply current | | | | 25 | µA |
| $SET_{VR}$ | SET voltage resolution | | | 7 | | Bits |
| $SET_{DN}$ | SET differential nonlinearity | Monotonic over temperature | | | ±1 | LSB |
| $SET_{ZSE}$ | SET zero scale error | | | | ±2 | LSB |
| $SET_{FSE}$ | SET full scale error | | | | ±8 | LSB |
| $I_{SET}$(4) | SET current | Through $R_{SET}$ | | | 120 | µA |
| $SET_{ER}$ | SET external resistance | To GND, $AV_{DD}$ = 20V | 10 | | 200 | kΩ |
| | | To GND, $AV_{DD}$ = 4.5V | 2.25 | | 45 | kΩ |
| $AV_{DD}$ to SET | $AV_{DD}$ to SET voltage attenuation(5) | | | 20 | | V/V |
| $OUT_{ST}$ | OUT settling time | | | 8 | | µs |
| $V_{OUT}$ | OUT voltage | | $V_{SET}$ + 0.5V | | 13 | V |
| $SET_{VD}$ | SET voltage drift(5) | T = 25°C to 55°C | | <10 | | mV |
| $V_{IH}$ | SDA, SCL, $\overline{WP}$ input logic high | | $0.7V_{DD}$ | | | V |
| $V_{IL}$ | SDA, SCL, $\overline{WP}$ input logic low | | | | $0.3V_{DD}$ | V |
| | SDA, SCL hysteresis(5) | | | $0.22V_{DD}$ | | V |
| $I_{IL(WPN)}$ | $WP_N$ input current | | 15 | 25 | 35 | µA |
| $V_{OL(s)}$ | SDA, SCL output logic low | At 3mA | | | 0.4 | V |

1. Valid for ambient operating temperature: $T_A$ = –40 to 85°C; $V_{DD}$ = 3V; $AV_{DD}$ = 10V; typical $T_A$ = 25°C; OUT = 1/2$AV_{DD}$; $R_{SET}$ = 24.9kΩ (except where noted).
2. Simulated maximum current draw when Programming EEPROM is 23mA; should be considered when designing a power supply.
3. Tested at $AV_{DD}$ = 20V.
4. A typical Current of 20µA is calculated using $AV_{DD}$ = 10V and $R_{SET}$ = 24.9kΩ. The maximum suggested SET current should be 120µA.
5. Simulated and determined via design and NOT directly tested.

**Figure 9. Bus timing requirements sequence**

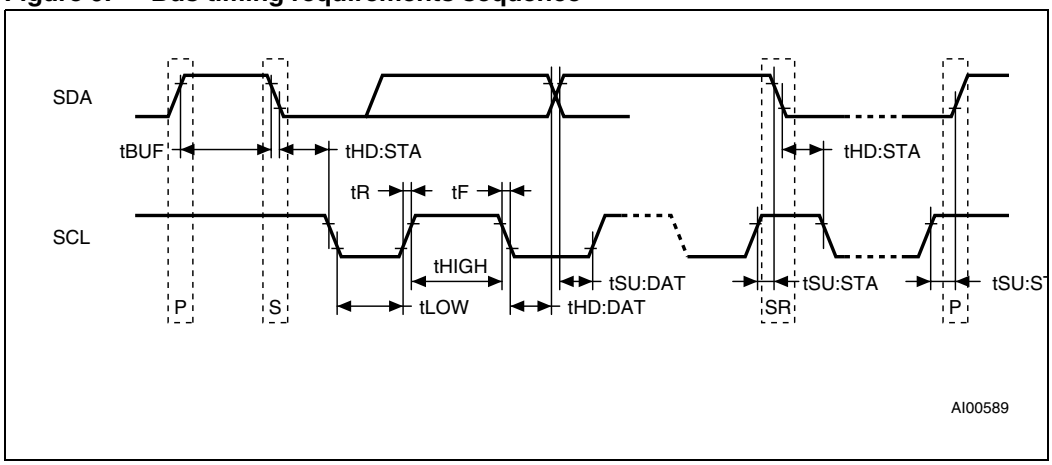



**Table 8. AC characteristics**

| Sym | Description | Test Condition(1) | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $f_{SCL}$ | SCL clock frequency | | 0 | | 400 | kHz |
| $t_{LOW}$ | Clock low period | | 1.3 | | | µs |
| $t_{HIGH}$ | Clock high period | | 0.6 | | | µs |
| $t_{SU:DAT}$ | Data setup time | | 100 | | | ns |
| $t_{HD:DAT}$ | Data hold time | | 0 | | 900 | ns |
| $t_R$ | SDA and SCL rise time | Dependent on load (see *Table 6 on page 14*) | | 20 + 0.1$C_b$ | 300 | ns |
| $t_F$ | SDA and SCL fall time | | | | 300 | ns |
| $t_{BUF}$ | Bus free time before new transmission can start | | 1.3 | | | µs |
| $t_{DSP}$ | $I^2C$ spike rejection filter pulse width | | 0 | | 50 | ns |
| $t_{SU:STA}$ | Repeated start condition setup time | | 0.6 | | | µs |
| $t_{HD:STA}$ | Repeated start condition hold time | | 0.6 | | | µs |
| $t_{SU:STO}$ | Stop condition setup time | | 0.6 | | | µs |
| $t_W$ | WRITE cycle time | | | | 100 | ms |

1. Valid for ambient operating temperature: $T_A$ = –40 to 85°C; $V_{DD}$ = 3.0V to 3.6V; $AV_{DD}$ = 10V; OUT = 1/2$AV_{DD}$; $R_{SET}$ = 24.9kΩ (except where noted, see *Figure 9*).

# 6 Typical operating characteristics

Typical operating characteristics for the STVM100 are $T_A$ = 25°C, $V_{DD}$ = 3V, $AV_{DD}$ = 10V, OUT = $1/2_{AVDD}$, and $R_{SET}$ = 24.9kΩ except where noted.

**Figure 10. $V_{DD}$ supply current v's $V_{DD}$**

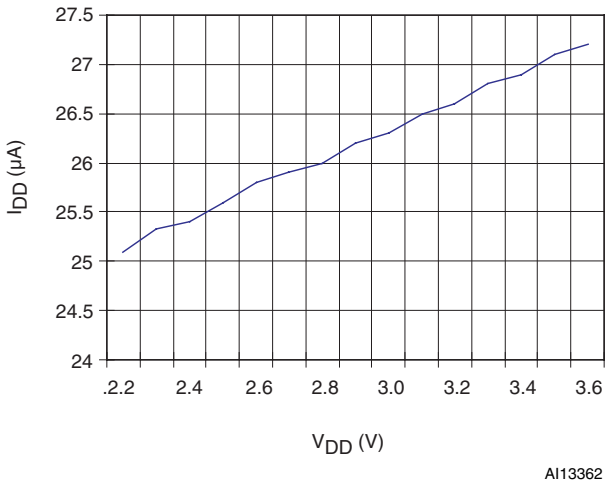



**Figure 11. $AV_{DD}$ supply current v's $AV_{DD}$**

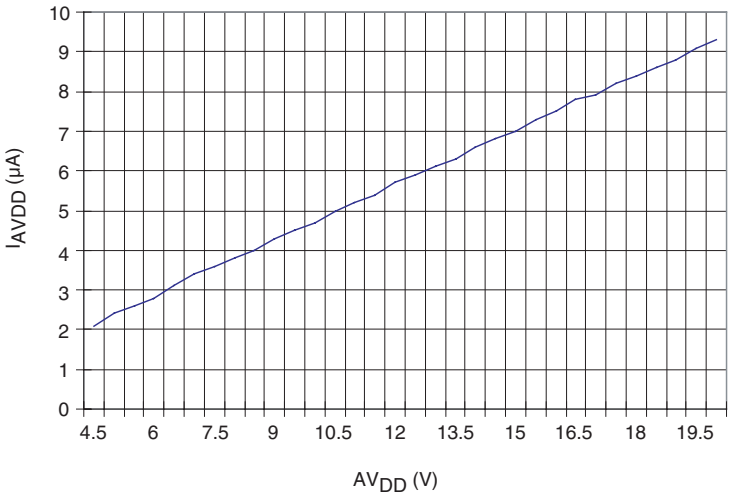


**Figure 12. $V_{DD}$ supply current v's temperature**

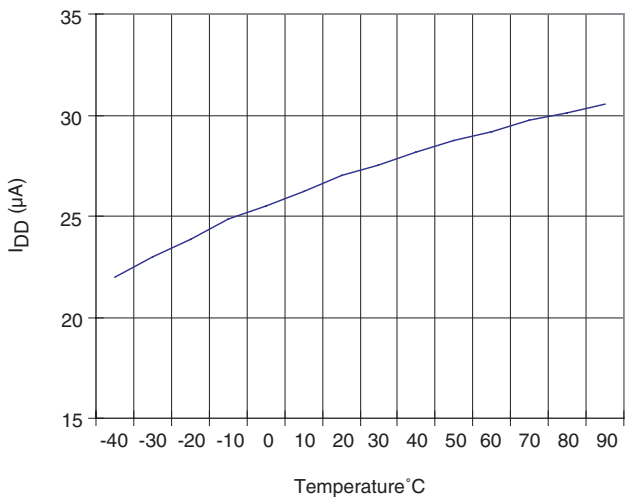



**Figure 13. $AV_{DD}$ supply current v's temperature**

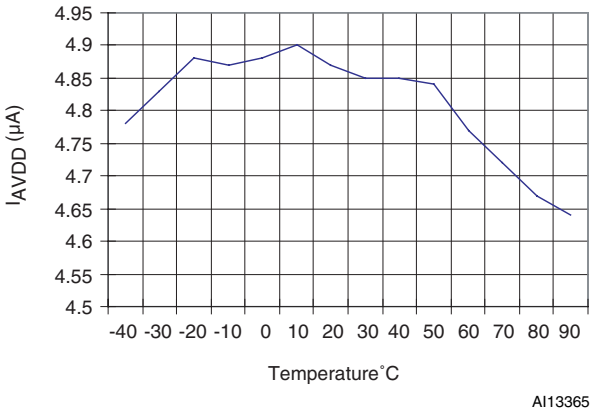


**Figure 14. $I_{OUT}$ error v's temperature (STVM100 at middle scale)**

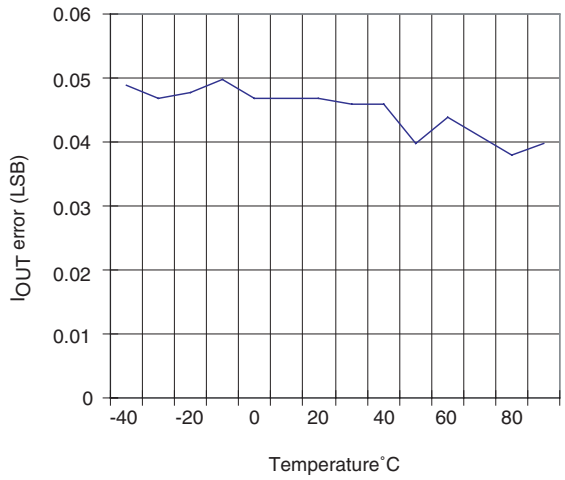



**Figure 15. Total unadjusted error v's DAC setting**

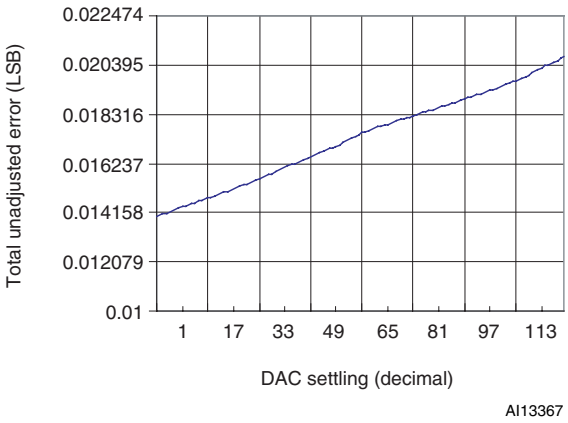


**Figure 16. Differential non-linearity v's DAC setting**

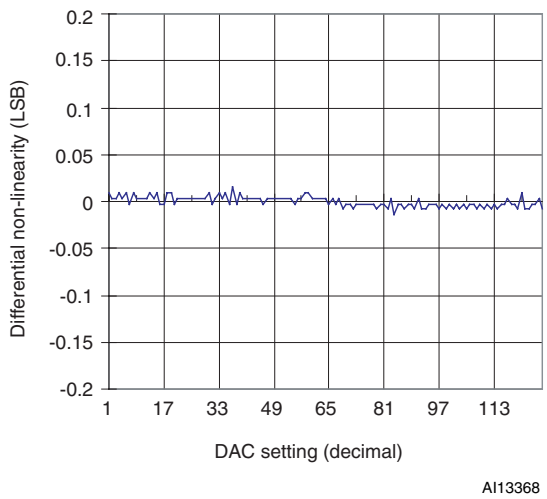



**Figure 17. Integral non-linearity v's DAC setting**

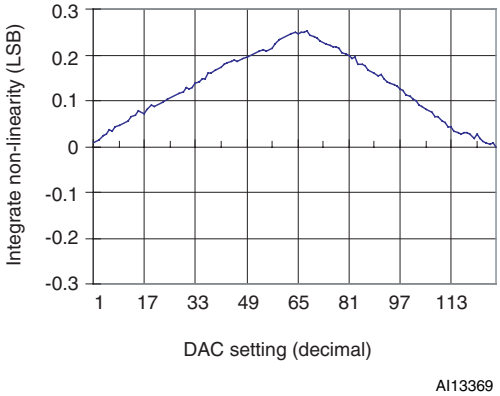
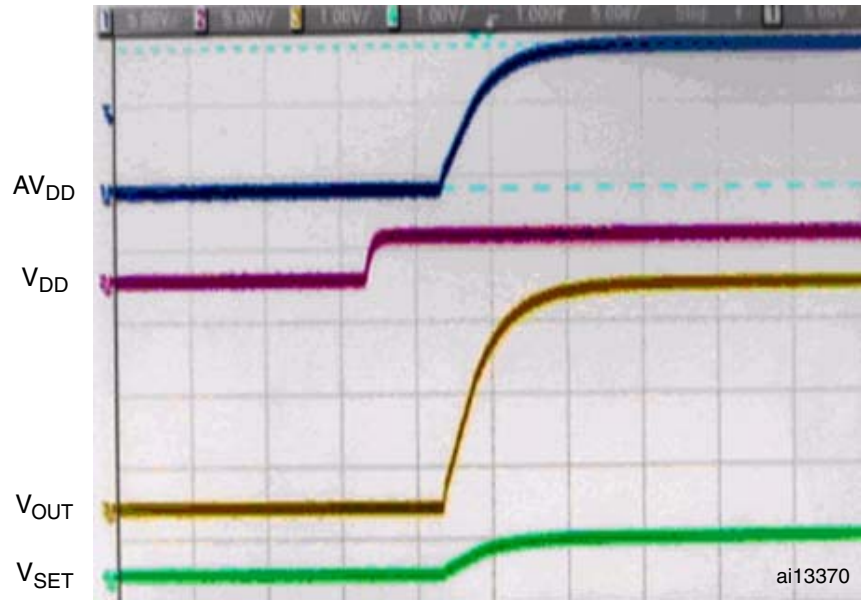
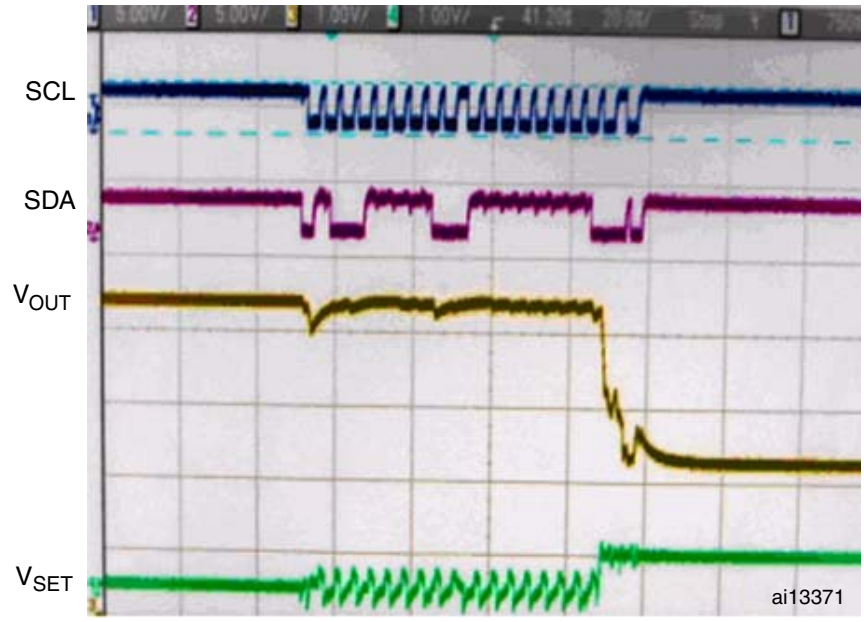


**Figure 18. $AV_{DD}$ power-up response**



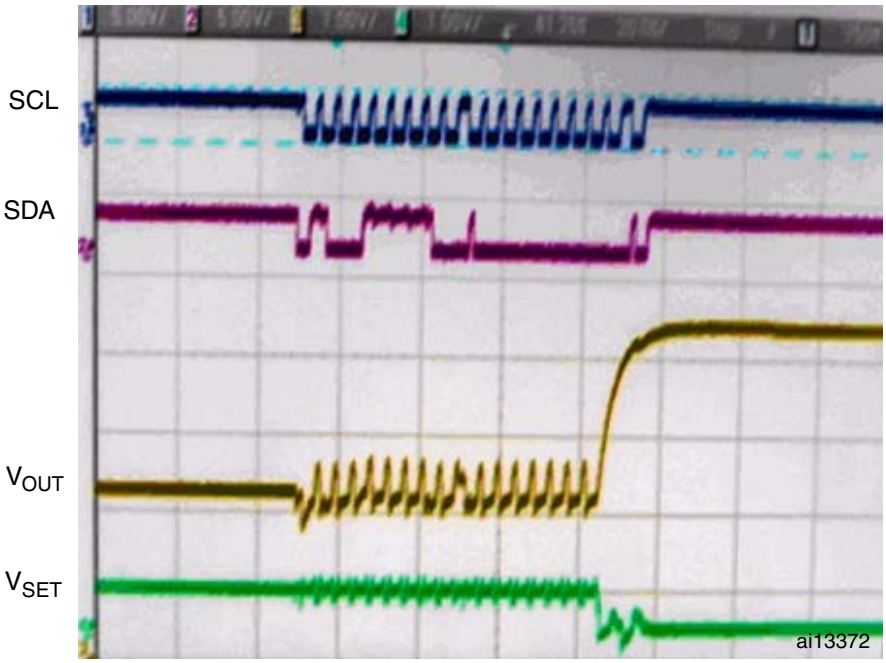

5ms/DIV
$AV_{DD}$: 5V/DIV, $V_{DD}$: 5V/DIV, $V_{OUT}$: 1V/DIV, $V_{SET}$: 1V/DIV

**Figure 19. Full scale-up response**




20µs/DIV
SCL: 5V/DIV, SDA: 5V/DIV, $V_{OUT}$: 1V/DIV, $V_{SET}$: 1V/DIV

**Figure 20. Full scale-down response**

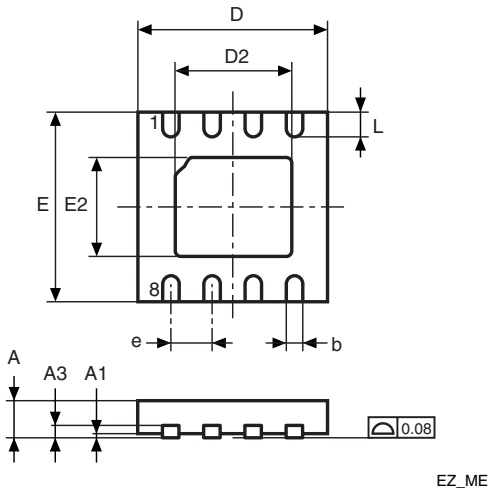



20µs/DIV
SCL: 5V/DIV, SDA: 5V/DIV, $V_{OUT}$: 1V/DIV, $V_{SET}$: 1V/DIV

# 7 Package mechanical

In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect. The category of second Level Interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: www.st.com.

**Figure 21. MLPD-DFN 3 x 3 x.75mm, pitch 0.65, package mechanical data**

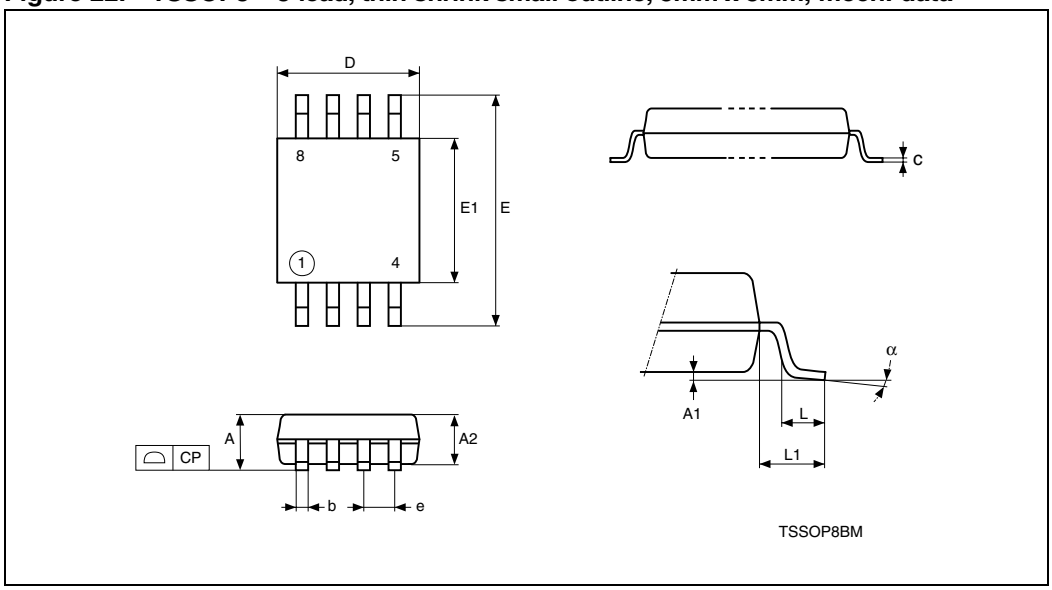



1. Drawing is not to scale.

**Table 9. MLPD-DFN 3 x 3 x .75mm, pitch 0.65, package mechanical data**

| Sym | mm | | | inches | | |
|---|---|---|---|---|---|---|
| | Typ | Min | Max | Typ | Min | Max |
| A | 0.75 | 0.70 | 0.80 | 0.0295 | 0.0276 | 0.0315 |
| A1 | 0.02 | 0.00 | 0.05 | 0.0008 | 0.0000 | 0.0020 |
| A3 | 0.20 | | | 0.0079 | | |
| b | 0.30 | 0.25 | 0.35 | 0.0118 | 0.0098 | 0.0138 |
| D | 3.00 | | | 0.1181 | | |
| D2 | 2.38 | 2.23 | 2.48 | 0.0937 | 0.0878 | 0.0976 |
| E | 3.00 | | | 0.1181 | | |
| E2 | 1.64 | 1.49 | 1.74 | 0.0646 | 0.0587 | 0.0685 |
| e | 0.65 | – | – | 0.0256 | – | – |
| L | 0.40 | 0.30 | 0.50 | 0.0157 | 0.0118 | 0.0197 |

**Figure 22. TSSOP8 – 8-lead, thin shrink small outline, 3mm x 3mm, mech. data**




*Note: Drawing is not to scale.*

**Table 10. TSSOP8 – 8-lead, thin shrink small outline, 3mm x 3mm, mech. data**

| Sym | mm | | | inches | | |
|---|---|---|---|---|---|---|
| | Typ | Min | Max | Typ | Min | Max |
| A | | | 1.100 | | | 0.0433 |
| A1 | | 0.050 | 0.150 | | 0.0020 | 0.0059 |
| A2 | 0.850 | 0.750 | 0.950 | 0.0335 | 0.0295 | 0.0374 |
| b | | 0.250 | 0.400 | | 0.0098 | 0.0157 |
| c | | 0.130 | 0.230 | | 0.0051 | 0.0091 |
| CP | | | 0.100 | | | 0.0039 |
| D | 3.000 | 2.900 | 3.100 | 0.1181 | 0.1142 | 0.1220 |
| e | 0.650 | – | – | 0.0256 | – | – |
| E | 4.900 | 4.6500 | 5.150 | 0.1929 | 0.1831 | 0.2028 |
| E1 | 3.000 | 2.900 | 3.100 | 0.1181 | 0.1142 | 0.1220 |
| L | 0.550 | 0.400 | 0.700 | 0.0217 | 0.0157 | 0.0276 |
| L1 | 0.950 | | | 0.0374 | | |
| α | | 0° | 6° | | 0° | 6° |
| N | 8 | | | 8 | | |

# 8 Part numbering

**Table 11. Ordering information scheme**

Example: STVM100 DC 6 F

**Device type**

STVM100, $V_{COM}$ calibrator with 7-bit DAC and $I^2C$ interface

**Package**

DC = TDFN8

DS = TSSOP8

**Temperature range**

6 = –40 to 85°C

**Shipping method**

E = ECOPACK package, tubes

F = ECOPACK package, tape & reel

For other options, or for more information on any aspect of this device, please contact the ST sales office nearest you.

# 9 Revision history

**Table 12. Revision history**

| Date | Revision | Changes |
|---|---|---|
| 09-May-2006 | 1 | Initial release. |
| 14-Jul-2006 | 2 | Graphical and textual updates |
| 08-Nov-2006 | 3 | Document status upgraded to Preliminary Data; changed the wording of Input function to include 'WRITE operations' instead of 'programming' in *Table 2: Pin names and functions*; deleted some bracketed text and modified the P bit function in *Section 2.2: Read mode*; ensured that all of *Equation 2* and *Equation 3* were visible; amalgamated 2 cells containing the same information ($V_{DD}$) in *Table 7: DC and AC characteristics*; deleted footnotes 2 and 3 of *Table 8: AC characteristics*; updated package mechanical information in *Figure 21*, *Table 9*, and *Table 10*. |
| 12-Feb-2007 | 4 | Reformatted Inside Cover Page according to new template; renamed section 1 *Device overview* and section 2 *Device operation*; deleted Signal names table; moved and renamed *Table 2: Pin names and functions*, added*Section 6: Typical operating characteristics* and *Figure 10* to *Figure 20*. |
| 20-Apr-2007 | 5 | Value added in *Section 2.3: Write mode*. |
| 24-Jul-2007 | 6 | Document status upgraded to full datasheet. |

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