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RoHS Compliant

# Touch Switch Module Specification

Model : TKU016CT-A100

Specification No.: DS-1980-0001-04

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**This product complies with RoHS Directive**
**Please contact our sales consultant for details and to confirm the current status**

## Contents

# 1 Touch Switch Module Handling and Usage Precautions

Please follow the appropriate product application notes and operation standards for proper usage, safe handling, and ideal performance.

### 【The Glass Touch Switch Panel】

| | |
|---|---|
| In the case of the Touch Switch panel's edges are not smooth, it requires careful handling to avoid injury. | Be careful to avoid breaking the Touch Switch panel as the resulting sharp glass particles may cause injury. |
| Do not intentionally destroy the Touch Switch panel. | Do not use with a sharp object as it will scratch and damage the panel surface. |
| To clean the surface of the Touch Switch panel, use a soft cloth and glass cleaner and do not use organic solvents, acids, or alkalis. | Touch switch panel surface is made only of glass. For washing, an acidic or slightly alkaline detergent for glass can also be used. |

### 【Cable Connection】

| | |
|---|---|
| Do not unplug the power and/or data cables from the Touch Switch module during operation, this may result in permanent damage to the module. | Sending input signals to the Touch Switch module when it is not powered can cause I/O port damage. |
| It is recommended to use a 30cm or shorter signal cable to prevent functional failures. | |

### 【Electrostatic Charge】

| |
|---|
| Touch Switch modules need electrostatic-free packaging and protection from electrostatic charges during handling and usage. |

### 【Structure】

| | |
|---|---|
| It is recommended to use UL-grade materials or components in conjunction with Touch Switch modules. | Bending and twisting causes stress and may break the Touch Switch panel and module. Please minimize chassis movement to accommodate for the 0.3mm attachment point gap. Failure to do so may result in panel damage. |
| Do not apply force to any FPC or cable running from the control board to the Touch Switch panel. | |

### 【Power】

| | |
|---|---|
| Apply regulated power to the Touch Switch module within the specified voltages to protect from failures. | Touch Switch modules may draw in-rush current exceeding twice the typical current at power-on, so a power supply with sufficient capacity and a quick-starting power regulator is recommended. |
| The Touch Switch module needs a specific voltage to operate properly. Please use a reliable power cable to avoid a voltage decrease. As a safety measure, a fuse or another type of over-current protection is recommended. | |

**【Implementation】**

| | |
|---|---|
| Avoid contact with metal. | If you would like to create a waterproof application, we recommend that a sturdy and durable sealing material is used between the panel's gasket area and the chassis. |

**【Storage and Operating Environment】**

| | |
|---|---|
| Please use our Touch Switch modules under the specified environmental conditions only.<br><br>Salty, sulfuric, and dusty environments may damage the module even during storage. | If used in a high temperature environment, there is a possibility that the Touch Switch panel surface may be hot.<br><br>There is a risk of burns and other injuries so be careful when touching the panel. |

**【Disposal】**

| | |
|---|---|
| Touch Switch uses materials that contain lead (the RoHS directive exempts these lead compounds for glass that is used with electronic devices). | When discarding the Touch Switch panel or Touch Switch module, please adhere to the applicable laws and regulations. |

**【Other Precautions】**

| | |
|---|---|
| Although the Touch Switch module is designed to be tolerant of electrical noise, please place an emphasis on noise reduction in your circuit design. | Do not reconstruct or repair the Touch Switch module without our authorization. We cannot assure the quality or reliability of unauthorized and reconstructed Touch Switch modules. |
| We do not authorize the use of any patents that may be inherent in these specifications. | Whole or partial copying of these specifications is not permitted without our approval. If necessary, please ask for our sales consultant for assistance. |
| This product is not designed for military, aerospace, medical or other life-critical applications.<br><br>If you choose to use this product for these applications, please ask us for prior consultation or we cannot accept responsibility for any problems that may occur. | |

# 2 General Description

## 2.1 Scope

This specification covers the operation and operating requirements of the Touch Switch Module TKU016CT-A100.

## 2.2 Construction

The module consists of a mutual-capacitive Touch Switch panel, LEDs for touch switch backlighting, touch controller, and all necessary control logic.

## 2.3 Outline

・Power supply: Single $5V_{DC}$ power supply

・Interface: Serial interfaces
Asynchronous serial interface/ $I^2C$ / SPI
Port
General-purpose port / Key scan (selectable)

・Function: Read Touch Switch ON/OFF
Touch operation setting
LED setting
Buzzer control
Program Macro function
Miscellaneous

- Applicable Touch Switch Module Reliability Specification : TT-99-3102
- Applicable Touch Switch Module Quality Specification : TT-98-3413
- Applicable Touch Switch Panel Quality Specification : TT-16-3301

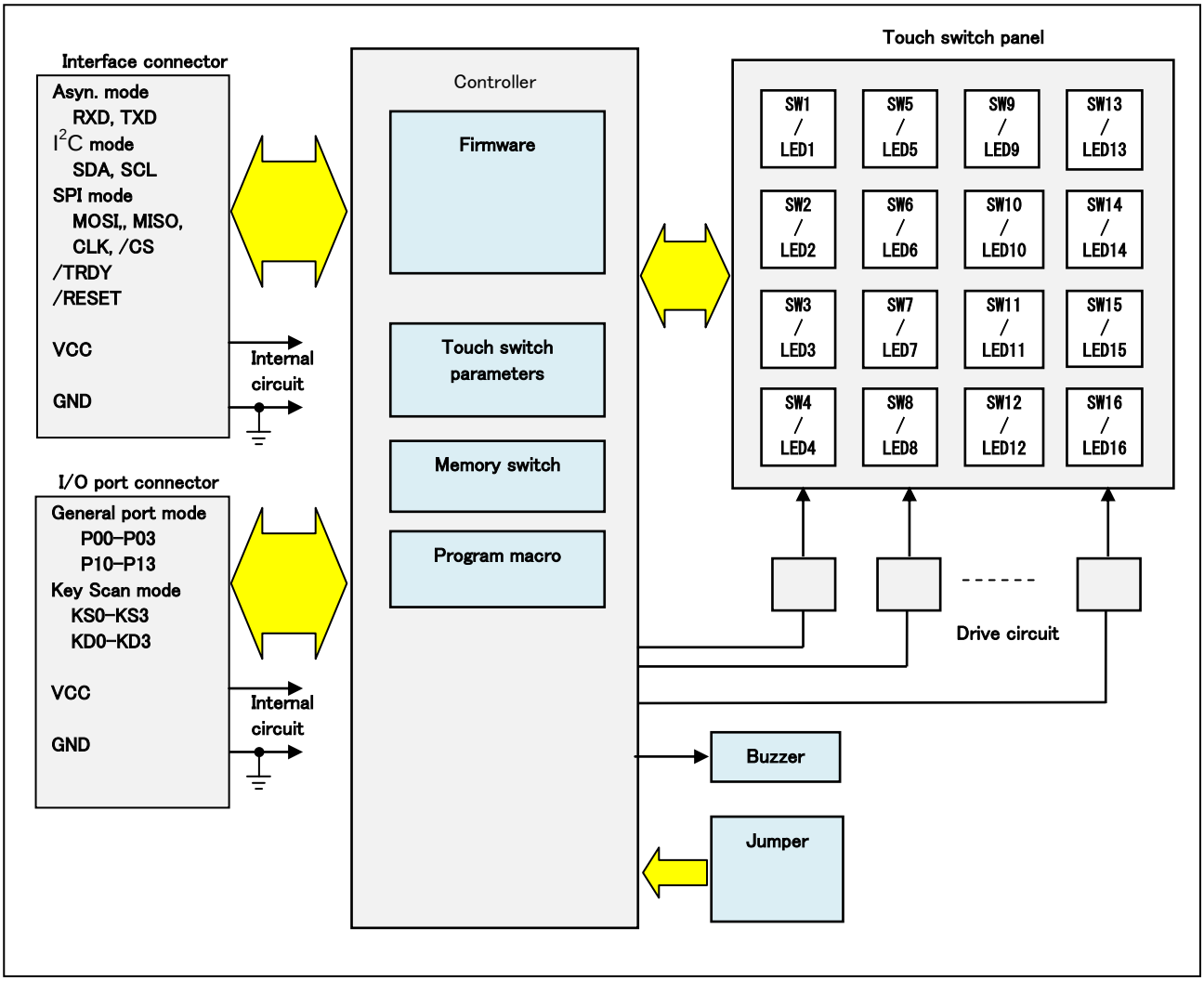
## 2.4 Weight

Approximately 78g

## 2.5 Block Diagram

Number of switches: 16

Number of LED groups: 16



# 3 Electrical Specifications

## 3.1 Absolute Maximum Ratings

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Condition |
|---|---|---|---|---|---|---|
| Power Supply Voltage | VCC | -0.3 | - | 6.0 | VDC | - |
| Logic Input Voltage (Pull Up Voltage) KD0-3, P10-P13 | VIN-S | -0.3 | - | 6.0 | VDC | - |
| Logic Input Voltage | VIN | -0.3 | - | 3.5 | VDC | Vcc > 3.3 |
| | | -0.3 | - | VCC | VDC | Vcc ≤ 3.3 |

## 3.2 Electrical Ratings

| Parameter | Symbol | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| Power Supply Voltage | VCC | 4.75 | 5.0 | 5.25 | VDC |

## 3.3 Electrical Characteristics

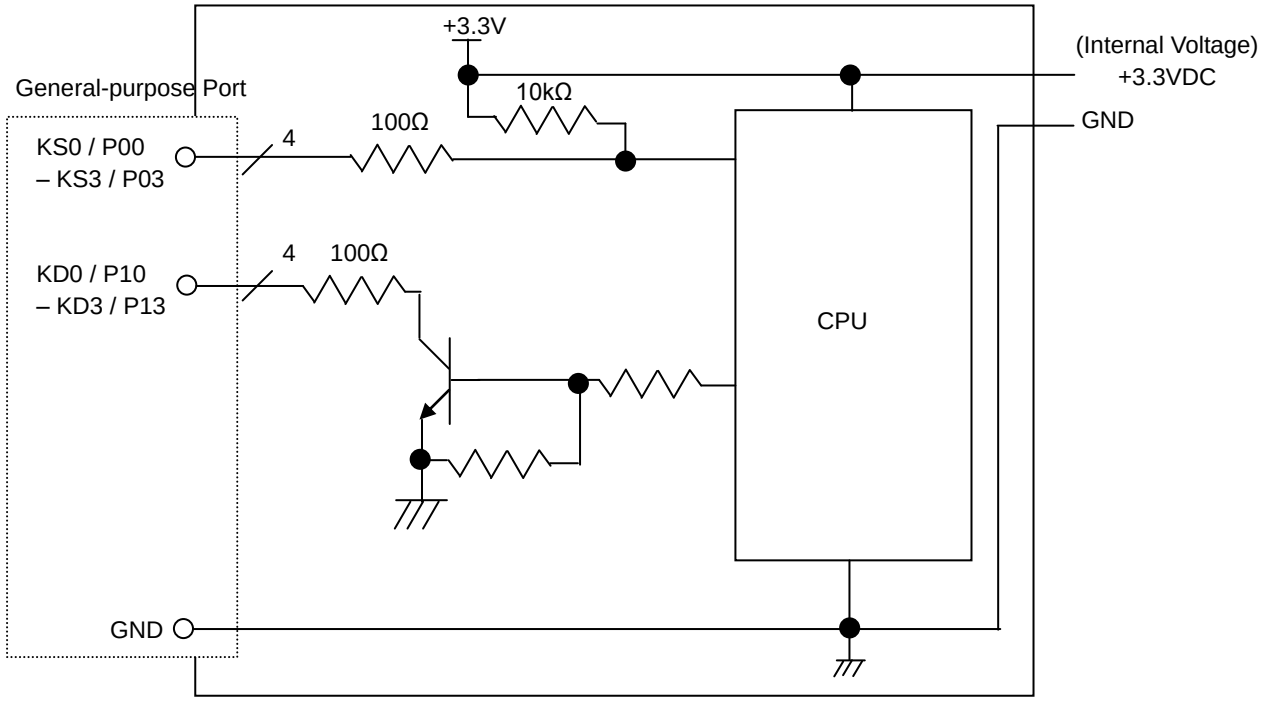
Measuring Conditions: Ambient temperature = 25 ºC, $V_{CC}$ = 5.0 $V_{DC}$

| Parameter | | | Symbol | Min. | Typ. | Max. | Unit | Condition |
|---|---|---|---|---|---|---|---|---|
| $I^2C$ interface | Logic Input Voltage SDA,SCL | "H" | IIH-1 | | - | 1.0 | µADC | VIN=3.3V |
| | | "L" | IIL-1 | - | - | -0.5 | mA | VIN=0V |
| | Logic Input Voltage /RESET | "H" | IIH-2 | | - | 2.0 | µADC | VIN=3.3V |
| | | "L" | IIL-2 | - | - | -0.5 | mA | VIN=0V |
| | Logic Input Voltage SDA,SCL | "H" | VIH-1 | 2.7 | - | - | VDC | - |
| | | "L" | VIL-1 | - | - | 0.6 | VDC | - |
| | Logic Input Voltage /RESET | "H" | VIH-2 | 2.7 | - | - | VDC | - |
| | | "L" | VIL-2 | - | - | 0.2 | VDC | - |
| | Logic Output Voltage SDA,SCL | "L" | VOL-1 | - | - | 0.8 | VDC | IOL= 2mA |
| | Logic Output Voltage /TRDY | "H" | VOH-2 | 2.4 | - | - | VDC | IOH=-0.5mA |
| | | "L" | VOL-2 | - | - | 0.9 | VDC | IOL= 1.0mA |
| Other interfaces | Logic Input Current RXD,MOSI,SCK,/CS | "H" | IIH-3 | - | - | 1.0 | µADC | VIN=3.3V |
| | | "L" | IIL-3 | - | - | -0.5 | mADC | VIN=0V |
| | Logic Input Current /RESET | "H" | IIH-4 | - | - | 2.0 | µADC | VIN=3.3V |
| | | "L" | IIL-4 | - | - | -0.5 | mADC | VIN=0V |
| | Logic Input Voltage RXD,MOSI,SCK,/CS | "H" | VIH-3 | 2.7 | - | - | VDC | - |
| | | "L" | VIL-3 | - | - | 0.6 | VDC | - |
| | Logic Input Voltage /RESET | "H" | VIH-4 | 2.7 | - | - | VDC | - |
| | | "L" | VIL-4 | - | - | 0.2 | VDC | - |
| | Logic Output Voltage TXD,MISO,/TRDY | "H" | VOH-3 | 2.4 | - | - | VDC | IOH= -0.5mA |
| | | "L" | VOL-3 | - | - | 0.9 | VDC | IOL= 1.0mA |
| I/O Port | Logic Input Current KS0-KS3, P00-P03 | "H" | IIH-5 | - | - | 1.0 | µADC | VIN=3.3V |
| | | "L" | IIL-5 | - | - | -0.5 | mADC | VIN=0V |
| | Logic Input Voltage KS0-KS3, P00-P03 | "H" | VIH-5 | 2.7 | - | - | VDC | - |
| | | "L" | VIL-5 | - | - | 0.6 | VDC | - |
| | Logic Input Voltage KD0-KD3, P10-P13 | "H" | VOH-4 | Open Collector | | | | |
| | | "L" | VOL-4 | - | - | 0.5 | VDC | IOL = 1mA |
| | Output allowable current KD0-KD3, P10-P13 (per pin) | "H" | IiOH-1 | Open Collector | | | | |
| | | "L" | IiOL-1 | - | - | 3 | mADC | - |
| Internal Pull-up Resistor RXD,TXD,MOSI,MISO,SCK, /CS,SDA,SCL, /TRDY,/RESET, KS0-KS3, P00-P03 | | | Rp | - | 10 | - | kΩ | - |

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Condition |
|---|---|---|---|---|---|---|
| Power Supply Current 1 | ICC-1 | - | 520 | 610 | mADC | All LED ON (Brightness level 100%)<br>Buzzer ON |
| Power Supply Current 2 | ICC-2 | - | 260 | 310 | mADC | All LED ON (Brightness level 50%)<br>Buzzer OFF |
| Power Supply Current 3 | ICC-3 | | 30 | 45 | mADC | All LED OFF<br>Buzzer OFF |
| Power Consumption | | | 2.6 | 3.1 | W | All LED ON (Brightness level 100%)<br>Buzzer ON |

・A quick-rise type power supply (<100ms) is recommended.
・At power-on, inrush current can be approximately twice the current in the above table.

## 3.4 General-purpose Port




・For electrical characteristics, refer to 3.3 Electrical Characteristics.
・For controlling, refer to 8.1.20 General-purpose Port Input and 8.1.21 General-purpose Port Output commands.

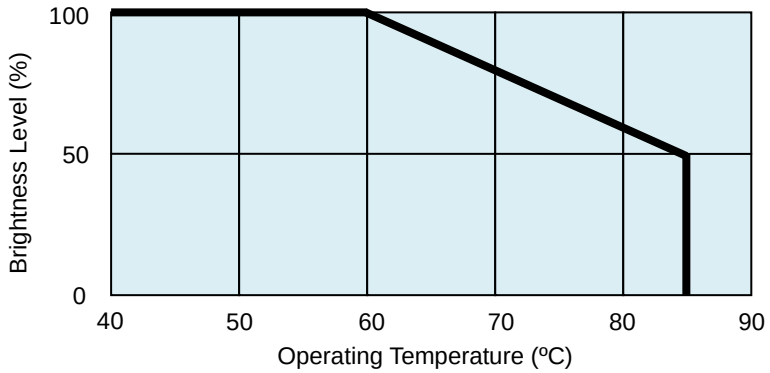
# 4 Optical Specifications (Backlight LED)

LED color: White

Luminance: LED backlighting is visible when ambient light is less than 500 lux.
(Provided there is no light reflection on the Touch Switch glass.)

# 5 Environmental Specifications

Operating temperature : −40 to +60 ºC (Brightness Level 100%)
: −40 to +85 ºC (Brightness Level 50%)




| | |
|---|---|
| Storage temperature | : −40 to +85 ºC |
| Operating humidity | : 20 to 80% RH (non-condensing) |
| Storage humidity | : 20 to 80% RH (non-condensing) |
| Vibration (non-operating) | : 10-55-10Hz, all amplitude 1mm, X-Y-Z, 30 minutes |
| Shock (non-operating) | : 392m/s$^2$ (40G), 9ms, X-Y-Z, 3 times each direction |

# 6 Touch Switch Specifications

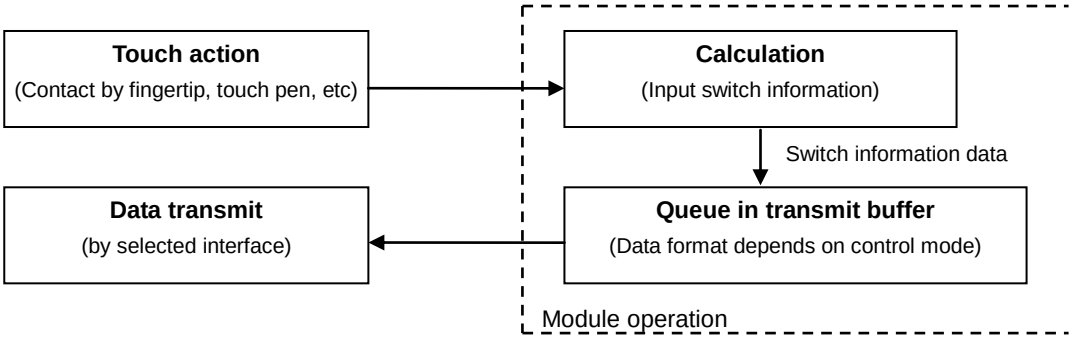
## 6.1 General Description

Detection method: Mutual Capacitive sensing

Construction: Glass substrate + Aluminum thin film wiring

## 6.2 Basic Operation

The Touch Switch module features a Touch-Switch panel for handling input by fingertip or touch pen, etc. The switch information data is stored into the module's transmit buffer.



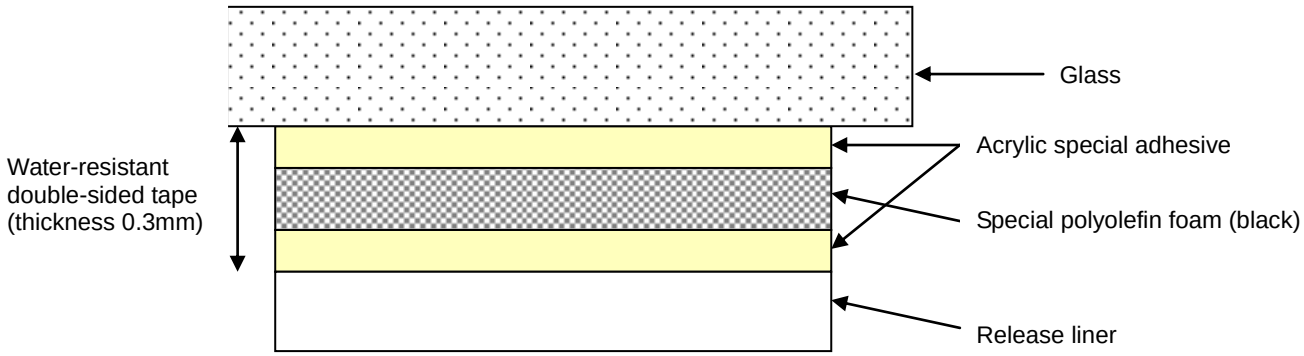

Note: Switch status information can be sent to the host in response to a touch status read command, or it can be sent automatically whenever touch status changes. Current touch status can also be read within a Program Macro, and via the Key Scan interface (if Key Scan mode is enabled).

## 6.3 Cautions

・When mounting the module in the end product stage, adjust settings while checking the actual operation sensitivity.

・The Touch-Switch cable (FPC) significantly impacts the operation of the Touch-Switch, so the mounting design should ensure that the FPC does not directly contact the device. Do not hold the Touch-Switch panel cable (FPC), and avoid any assembly or operation that would apply stress to the cable.

・The structure of the waterproof adhesive tape, which runs around the edge on the reverse side of the glass, is shown below.




・Moisture, oil and dust on the waterproof adhesive tape can cause peeling. Please keep the surface clean.

・Release liner should be peeled off just before installation into the equipment.

・Touch sensor initialization occurs immediately after the following events. The touch switch surface should not be touched during this initialization time (approximately 3 seconds).

Applicable events: Power-on, /RESET release, User Setup Mode End command, Restart Touch Operation command.

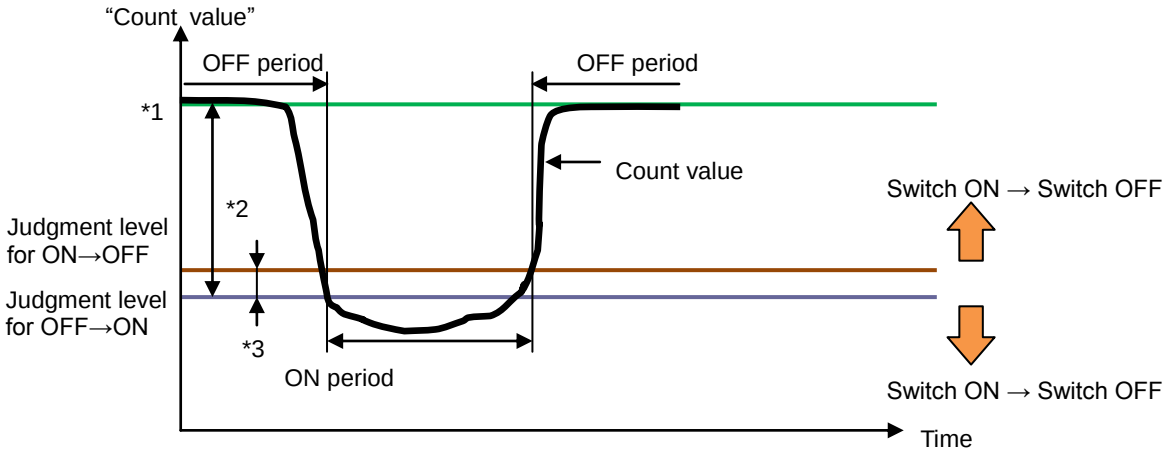
## 6.4 Touch-Switch Control

### 6.4.1 Basic Function

・The Touch-Switch module uses the static-capacitive method, wherein ON and OFF are determined by monitoring changes in the measured capacitance. “**Count value”** represents the measured capacitance, which is used for touch detection as explained below.

・**ON / OFF determination**

1. When finger (or equivalent conductor) is not near the Touch-Switch, OFF state is maintained.
2. When finger approaches the Touch-Switch, “Count value” decreases.
3. If “Count value” falls below the “**Judgment level for OFF→ON”**, Touch-Switch turns ON.
   * If touch parameter **mon** (Continuous touch ON time limit) is set to greater than zero, the ON time is subject to the set limit. If the limit is reached, the Reference value is adjusted equal to the Count value, forcing an OFF judgement.
4. When finger moves away from the Touch-Switch, “Count value” increases.
5. If “Count value” exceeds the “**Judgment level for ON→OFF”**, Touch-Switch turns OFF.

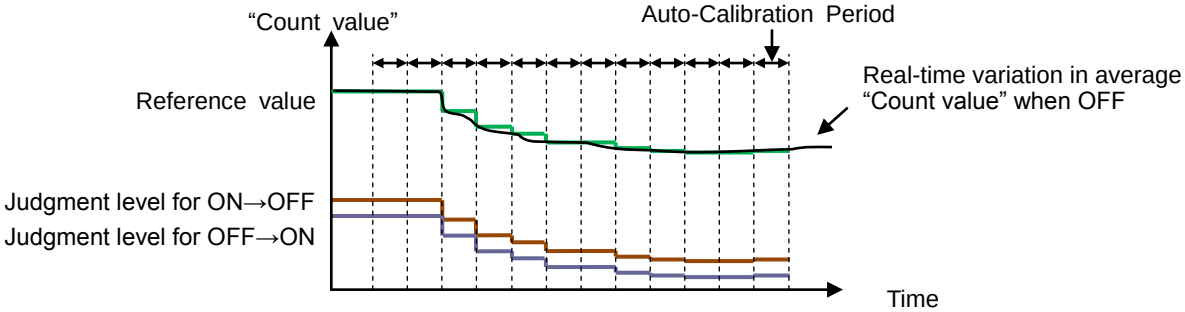



*1 **Reference value:** Average “Count value” at OFF determination time
*2 **Threshold value:** The threshold value for OFF → ON (relative to “Reference value”)
*3 **Hysteresis value:** The margin value for ON → OFF (relative to “Threshold value”)

・Judgement levels are calculated as follows:
**Judgment level for OFF→ON** = “Reference value” - ( ( “Threshold value” × “Threshold level” ) + “Offset” )
**Judgment level for ON→OFF** = **Judgment level for OFF→ON** + “Hysteresis value”

### 6.4.2 Auto-calibration

・When **Auto-calibration function** is ON, if the average of “Count value” changes, due to changes in the surrounding environment, etc., the “Reference value” will continue to change to follow it. The ON and OFF judgement levels will likewise change in synchronization with the “Reference value”. This enables consistent ON/OFF touch detection, unaffected by environmental changes. Auto-calibration can also be disabled by command.




*: The “Reference value” will re-adjust each Auto-calibration period. The “Threshold value” and the “Hysteresis value” are relative values, so each “Judgment level” for ON/OFF will continue to remain at the same relative level, in synchronization with the “Reference value”.

### 6.4.3 Touch-Switch control commands

Touch-Switch operation is controlled by commands.

・Reading of Touch-Switch ON / OFF state and the Count-Level / Touch-Level

(1) **Reading of Touch-Switch ON / OFF state**

Two commands can be used to read the ON / OFF state of the Touch-Switches – **"All Touch-Switch Status Read"** and **"Individual Touch-Switch Status Read"**.
The module sends the corresponding data (ON: "1", OFF: "0") to the host (refer to the command details for the data format). In addition, the **"Touch-Switch Status Read mode setting"** command is used to set whether touch data is sent only in response to the above commands, or is automatically sent whenever touch status changes are detected by the module. The **"Touch-Level Order Switch Read"** command reports currently-touched switches in touch-level order, enabling appropriate priority handling.

○**Detailed explanation pages**

| Section | Heading |
|---|---|
| 8.1.1 | All Touch-Switch Status Read |
| 8.1.2 | Individual Touch-Switch Status Read |
| 8.1.6 | Touch-Switch Status Read Mode Setting |
| 8.1.3 | Touch-Level Order Switch Read |

(2) **Reading of Count-Level / Touch-Level**

The current (real-time) count level and touch level for the Touch-Switches can be read out using the **"All Touch-Switch Count-Level Read"** and **"All Touch-Switch Touch-Level Read"** commands.
**"Count-Level"** is the "Count value" expressed as a ***CntLevel***. **"Touch-Level"** is the "Count value" expressed as a normalized value in the range 00h to F8h (upper 5 bits only (32 steps)), with 00h corresponding to Reference value and 80h corresponding to Threshold value. Both values are independent of the Touch-Switch ON / OFF state. Count value changes for each switch can be monitored, allowing the host to determine ON/OFF status.

○**Detailed explanation pages**

| Section | Heading |
|---|---|
| 8.1.4 | All Touch-Switch Count-Level Read |
| 8.1.5 | All Touch-Switch Touch-Level Read |

・Adjustment of internal parameters

A number of internal parameters determine the basic Touch-Switch operation. The parameters can be set, read and saved by commands.

○**Detailed explanation pages**

| Section | Heading |
|---|---|
| 8.1.25 | Touch Parameter Setting |
| 8.1.26 | Touch Parameter Send |
| 8.1.27 | Touch Parameter Save |

| Parameter | Symbol | All Switches Common Setting | Individual Switch Setting | Effective Range | Default | Condition |
|---|---|---|---|---|---|---|
| Threshold Level | thr | ✓ | ✓ | 0 to 31 | 7 (100%) | 0 (12.5%: sensitive) to 31 (400%: insensitive) |
| Offset | offs | ✓ | ✓ | 0 to 250 | 0 | Offset for Threshold |
| Hysteresis | hys | ✓ | ✓ | 1 to 250 | 20 | ON→OFF Change value |
| Sampling ON Number | son | ✓ | - | 1 to 250 | 3 | ON determination in "son" times continuous ON detection |
| Sampling OFF Number | soff | ✓ | - | 1 to 250 | 3 | OFF determination in "soff" times continuous OFF detection |
| Auto Calibration period | clb | ✓ | - | 1 to 250 | 10 | 0：Calibration OFF<br>1 to 250：clb × approx. 20ms |
| Threshold Reference | thrVL | - | ✓ | 1 to 60000 | private | Switch individual Setting |
| | thrVH | - | ✓ | | private | |

Parameter Valid: ✓ Parameter Invalid：-

For parameters valid for both All Switches Common Setting and Individual Switch Setting, the order of priority is as follows:

| Priority | Referenced content |
|---|---|
| 1st | Individual Switch Setting Parameter |
| 2nd | All Switches Command Setting Parameter |
| 3rd | Default Setting Parameter |

# 7 Interface

## 7.1 Type of interface

Asynchronous serial, SPI, and $I^2C$ (all CMOS-level) are supported, selected by jumpers.

**Refer to 9 Jumper.**

## 7.2 Basic function

- Data received is stored in the internal receive buffer, and processed in order of receipt.
- MBUSY signal should be monitored if using SPI at high speed.
- When data is in the transmit buffer, /TRDY = READY.
- User Setup Mode End and Touch Operation Re-start commands cause an internal re-initialization, during which data is unable to be received for approximately 100ms.
- For commands that transmit data (response data), that data should be read before sending the next command.

MBUSY signal change timing:

| MBUSY | BUSY ("1") | READY ("0") |
|---|---|---|
| Condition | Data in receive buffer / Internal BUSY* | No data in receive buffer |

* Internal BUSY: Initialization, FROM definition commands, etc.

/TRDY signal change timing:

| /TRDY | EMPTY ("H") | READY ("L") |
|---|---|---|
| Condition | No data in transmit buffer | Data in transmit buffer |

Buffer Capacity:

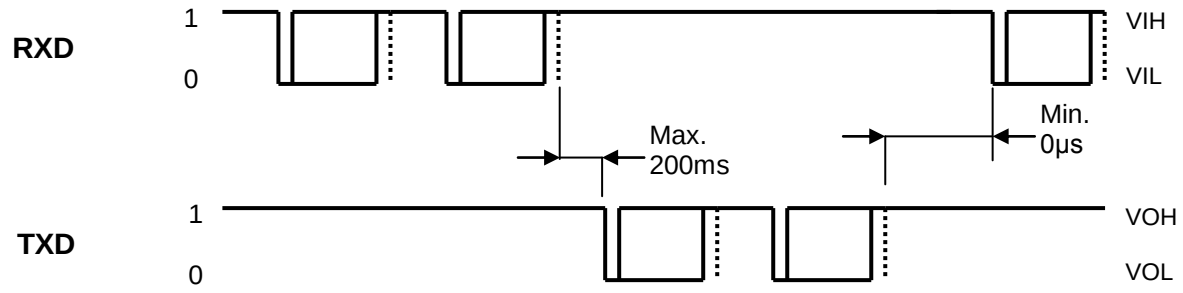
| | |
|---|---|
| Receive buffer | 63 bytes |
| Transmit buffer | 63 bytes |

### 7.2.1 Asynchronous serial interface

Interface conditions:

| | |
|---|---|
| Baud rate | 9600 to 115200bps (set by Jumper)<br>**Default setting: 38400bps** |
| Parity | None |
| Format | Start (1 bit) + Data (8 bit) + Stop (1 bit) |
| Communication control signal | - |

Timing



### 7.2.2 SPI

Interface conditions:

・ Touch switch module operates as SPI slave; data is sent and received in response to host (master) operations. /CS = High → Low → High is one command sequence.

| 1st byte | Operation mode |
|---|---|
| 44h | Data write (Host → Module) |
| 54h | Data read (Host → Module) |
| 58h | Status read |

**[Data write]**

・ When 44h is input as the first byte, the module receives as data the 2nd and subsequent bytes.

| | 1st byte | 2nd byte | 3rd byte | --- | n byte |
|---|---|---|---|---|---|
| MOSI | 44h | Data(1) | Data(2) | --- | Data(n-1) |
| MISO | - | - | - | --- | - |

**[Data read]**

・ When 54h is input as the first byte, the module outputs valid data on the 3rd and subsequent bytes.

・ The host must read the number of bytes reported by the immediately preceding Status Read command. **(The number of bytes reported by the Status read command will be transmitted, with any unread bytes discarded.)**

| | 1st byte | 2nd byte | 3rd byte | --- | n byte |
|---|---|---|---|---|---|
| MOSI | 54h | - | - | --- | - |
| MISO | - | 00h | Data(1) | --- | Data(n-2) |

**[Status read]**

・ When 58h is input as the first byte, the module outputs status data. **For the 3rd and any subsequent bytes, the most recent status data is provided.**

| | 1st byte | 2nd byte | 3rd byte | --- | n byte |
|---|---|---|---|---|---|
| MOSI | 58h | - | - | --- | - |
| MISO | - | Status | Status | --- | Status |

**Status bit assignment**

| bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 | bit 0 |
|---|---|---|---|---|---|---|---|
| MBUSY | 0 * | TL(bit 5) | TL(bit 4) | TL(bit 3) | TL(bit 2) | TL(bit 1) | TL(bit 0) |

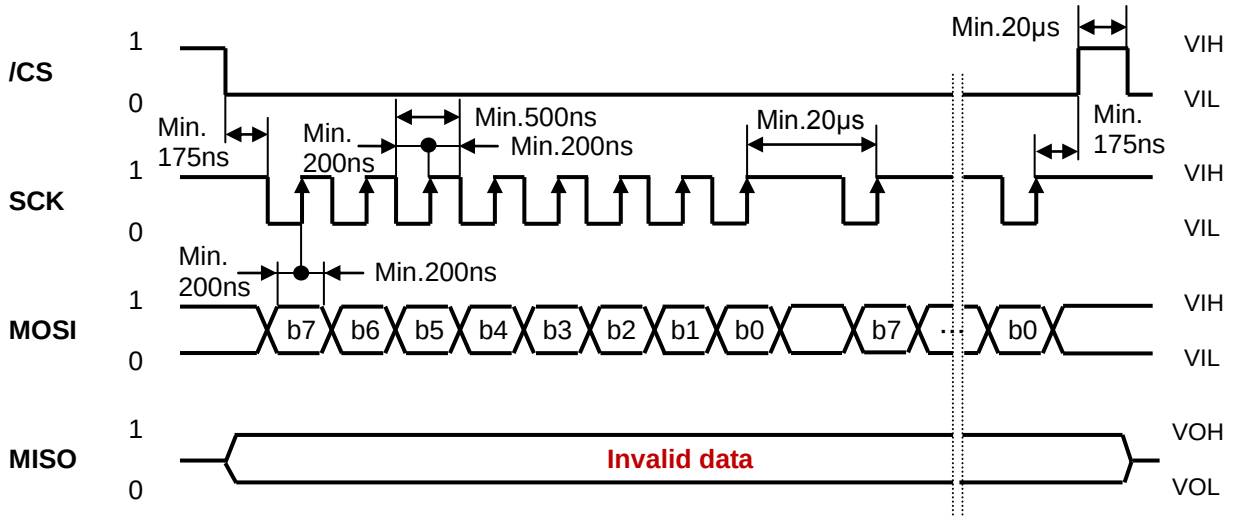
・ MBUSY: MBUSY signal status (MBUSY = 0: Low(READY), MBUSY = 1: High(BUSY))

・ TL: Number of Transmit data bytes available (maximum 63 bytes)

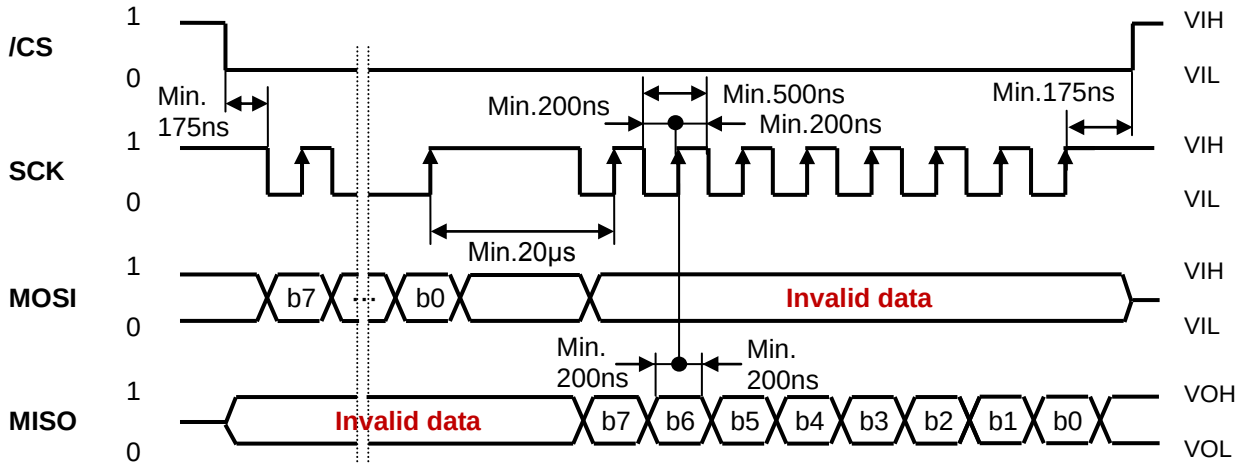
*: If bit 6 = 1, the Status data is invalid.

○Timing

**[Write operation] Data write**




**[Read operation] Data read / Status read**



### 7. 2. 3 I²C interface

Interface conditions:

・ Touch switch module operates as I²C slave, sending and receiving data in response to host (master) operation.

| | |
|---|---|
| Clock frequency | Max.400kHz |
| Format | Conforms to the I²C standard |
| Slave address | 08h to 77h (set by Jumper and Memory SW)<br>**Default setting: 50h** |
| Supported functions | ACK response, Clock stretch |
| Communication control signals | MBUSY, /TRDY |

**Note: If Clock stretch is applied during processing of a command, the host (master) will not be able to send or receive any more data until command processing has finished.**

**・In addition to the configured Slave address, the Touch-Switch module also responds to the General call address (00h), however "second byte" functions (06h and 04h) are not supported (the second, and any subsequent bytes, are treated as ordinary data).**

・If /TRDY = EMPTY, FFh is transmitted from the VFD module in response to a read sequence.

**[Data write sequence]**

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S (Sr) | Slave Address | | | R/*W | ACK | Data | | | ACK | ··· | Data | | | ACK | P |
| | b7 | ... | b1 | b0 | | b7 | ... | b0 | | | b7 | ... | b0 | | |

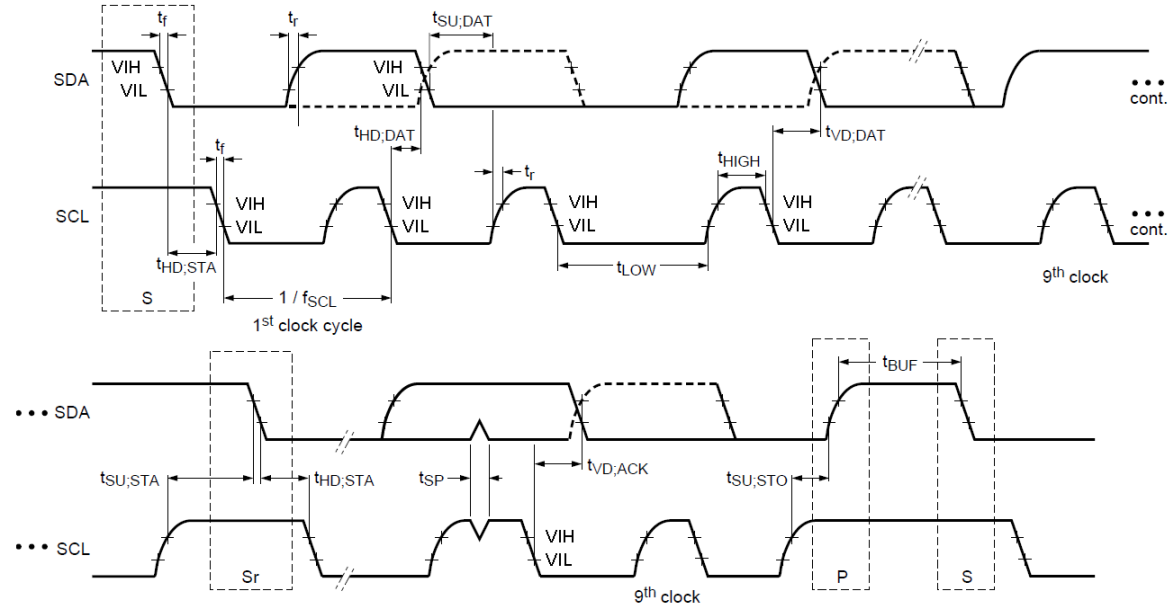
**[Data read sequence]**

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S (Sr) | Slave Address | | | R/*W | ACK | Data | | | ACK | ··· | Data | | | NACK | P |
| | b7 | ... | b1 | b0 | | b7 | ... | b0 | | | b7 | ... | b0 | | |

The host is transmitter, Touch-Switch module is receiver

The host is receiver, Touch-Switch module is transmitter

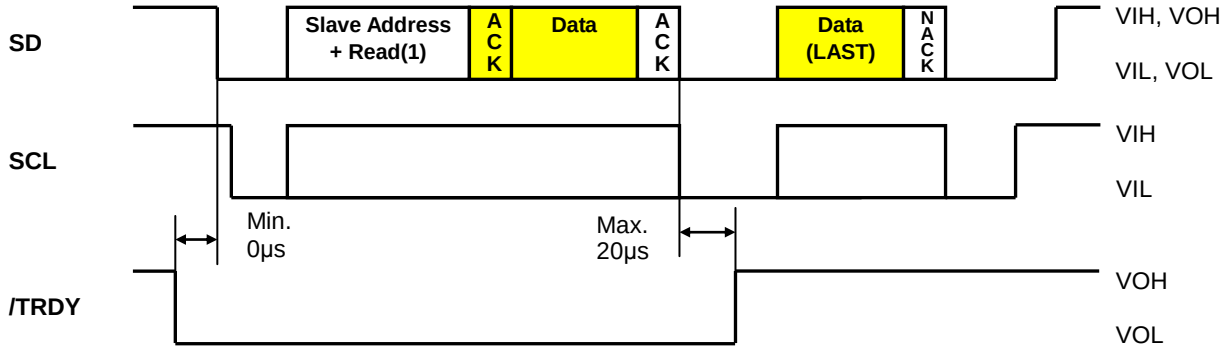
Timing



| Parameter | Symbol | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| Pulse width of spikes that must be suppressed by the input filter | $t_{SP}$ | - | 0 | - | 50 | ns |
| SCL clock frequency | $f_{SCL}$ | - | 0 | - | 400 | kHz |
| (Repeat)Start condition hold time | $t_{HD;STA}$ | - | 0.6 | - | - | µs |
| SCL LOW time | $t_{LOW}$ | - | 1.3 | - | - | µs |
| SCL HIGH time | $t_{HIGH}$ | - | 0.6 | - | - | µs |
| Repeat Start condition setup time | $t_{SU;STA}$ | - | 0.6 | - | - | µs |
| Data hold time | $t_{HD;DAT}$ | - | 10 | - | - | ns |
| Data setup time | $t_{SU;DAT}$ | - | 100 | - | - | ns |
| SCL, SDA rise time | $t_r$ | - | 20 | - | 300 | ns |
| SCL, SDA fall time | $t_f$ | $V_{IN}$=5.5V | 20 | - | 300 | ns |
| Stop condition setup time | $t_{SU;STO}$ | - | 0.6 | - | - | µs |
| Stop condition - Start condition bus idle time | $t_{BUF}$ | - | 20 | - | - | µs |
| Data valid time | $t_{VD;DAT}$ | - | - | - | 0.9 | µs |
| Data valid acknowledge valid time | $t_{VD;ACK}$ | - | - | - | 0.9 | µs |

***: When selecting the external resistor(s), ensure the requirements in the above table are satisfied. (Refer to 3.3 Electrical Characteristics, for internal pull-up resistor details)**

**/TRDY timing**



## 7.3 Key Scan interface

General-purpose port interface can be set to Key Scan mode by Memory SW setting. In this mode, an external host can input a scanning signal pattern into KS0 – KS3 to scan the columns, successively reading-off the touch status for the four switches in the column from KD0 – KD3. The Touch-Switch module effectively emulates a mechanical switch matrix.

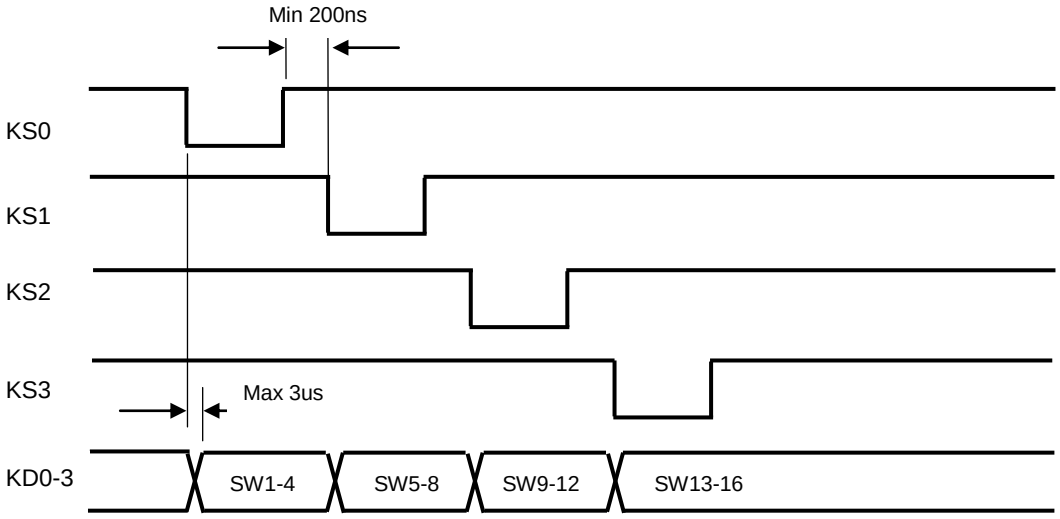
When “L” level is input to one of KS0 – KS3, the corresponding switch ON/OFF status is output on KD0 – KD3.

| | KS0=L Input | KS1=L Input | KS2=L Input | KS3=L Input |
|---|---|---|---|---|
| KD0 Output | SW1 | SW5 | SW9 | SW13 |
| KD1 Output | SW2 | SW6 | SW10 | SW14 |
| KD2 Output | SW3 | SW7 | SW11 | SW15 |
| KD3 Output | SW4 | SW8 | SW12 | SW16 |

KDn Output SWx = ON : L Output

SWx = OFF : Hi-Z Output

When KS0 – KS3 is set to “H” level, KD0 – KD3 maintain the previous output state.



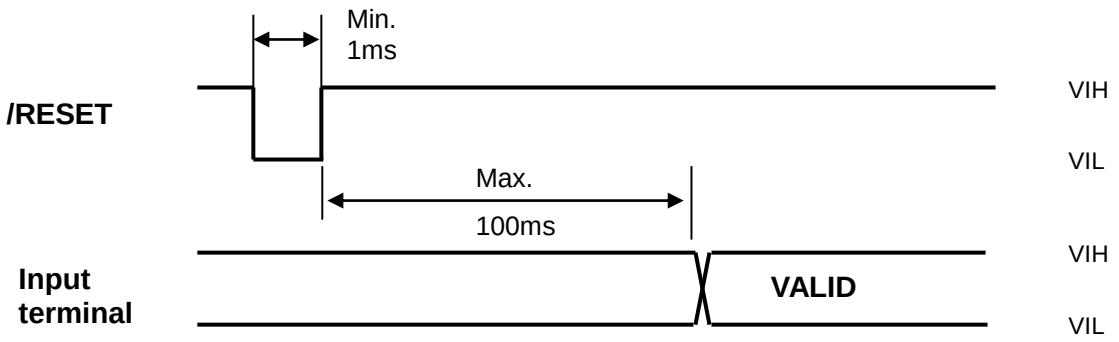

Note:

External pull-up resistors required for KD0 – KD3. Rise time depends on the value of the pull-up resistor.

If KS0 – KS3 is “L” level during power-on or reset, output to KD0 – KD3 does not become active until KS0 – KS3 are first set to “H” level.

## 7.4 Reset timing

Reset pulse (active low) should be longer than 1ms.
The module sets the MBUSY line upon receipt of /RESET signal and clears the line when ready to receive data.



# 8 Function

## 8.1 Commands

This section describes the operation of each command.

### 8.1.1 All Touch-Switch Status Read [Only valid in Manual transmit mode]

【Code】

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| RX | 1Fh | 4Bh | 10h | | | | |
| TX | | | | 10h | n | d(1) | d(2) |

**n** : Number of data bytes
n = 02h
**d** : Switch ON/OFF status

| | bit7 | bi6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 |
|---|---|---|---|---|---|---|---|---|
| d1 | SW16 | SW15 | SW14 | SW13 | SW12 | SW11 | SW10 | SW9 |
| d2 | SW8 | SW7 | SW6 | SW5 | SW4 | SW3 | SW2 | SW1 |

SWn = 0 : Not touched
SWn = 1 : Touched

【Function】 Sends ON/OFF status for all Touch-Switches

### 8.1.2 Individual Touch-Switch Status Read [Only valid in Manual transmit mode]

【Code】

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| RX | 1Fh | 4Bh | 11h | sn | | | |
| TX | | | | | 11h | sn | d |

**sn** : Switch No.
sn = 00h (SW1) to 0Fh (SW16)
**d** : Switch ON/OFF status
d = 00h : Not touched
d = 01h : Touched

【Function】 Sends ON/OFF status for an individual Touch-Switch

### 8.1.3 Touch-Level Order Switch Reading

【Code】

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| RX | 1Fh | 4Bh | 12h | | | | | |
| TX | | | | 12h | sn(1) | sn(2) | sn(3) | sn(4) |

**sn(x)** : Switch No.
sn(x)= 00h (SW1) to 0Fh(SW16), FFh (untouched)

| | sn(1) | sn(2) | sn(3) | sn(4) |
|---|---|---|---|---|
| Touch-Level | 1st | 2nd | 3rd | 4th |

【Function】 Sends ON-determined switch numbers in Touch-Level order.
Sends FFh if no (more) switches currently ON.
Example: If 3 switches (1st : SW1, 2nd : SW2, 3rd : SW16) are ON (touched)
Transmit: 12h 00h(SW1) 01h(SW2) 0FH(SW16) FFh(OFF)
For situations where high sensitivity setting, or water drops, etc cause switches not actually touched to also register ON, this command can be used to obtain only the required switch number(s).

### 8.1.4 All Touch-Switch Count-Level Read

【Code】

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | --- | 21 |
|---|---|---|---|---|---|---|---|---|---|
| RX | 1Fh | 4Bh | 14h | | | | | --- | |
| TX | | | | 14h | In | cl(1) | cl(2) | --- | cl(16) |

**In : 10h (fixed)**
**cl(x)** : Count-level for each switch = 00h to 1Fh

【Function】 Sends the count-level for all Touch-Switches.
Count level is a value converted from the internal count value.
**Levels are reported regardless of ON/OFF determined status of the switches.**

### 8.1.5 All Touch-Switch Touch-Level Read

【Code】

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | --- | 21 |
|---|---|---|---|---|---|---|---|---|---|
| RX | 1Fh | 4Bh | 15h | | | | | --- | |
| TX | | | | 15h | In | tl(1) | tl(2) | --- | tl(16) |

**In : 10h (fixed)**
**tl(x) :** Touch-Level for each switch = 00h to FFh

【Function】 Sends the current touch-level (normalized, with respect to the threshold value) for all Touch-Switches.
Touch-level 80h corresponds approximately to the threshold value.
Touch-level returns to 00h when released.

### 8.1.6 Touch-Switch Status read Mode Setting

【Code】

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| RX | 1Fh | 4Bh | 18h | m |
| TX | | | | |

**m :** operating mode
m = 00h: Manual transmit mode (Send only in response to read command)
m = 01h: Automatic transmit mode 1 (All Touch-Switch status)
m = 02h: Automatic transmit mode 2 (Individual Touch-Switch status)

【Default】 m = 00h or Memory SW setting
【Function】 Set read mode of Touch-Switch status

## 8.1.7 All LED Control

【Code】

| | 1 | 2 | 3 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|
| **RX** | **1Fh** | **4Bh** | **20h** | **pm1** | **pm2** | **d(1)** | **d(2)** |
| **TX** | | | | | | | |

**pm1 : LED brightness control / transition time**

| | bit7 | bi6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 |
|---|---|---|---|---|---|---|---|---|
| pm1 | br | | | | tm | | | |

br : LED brightness control

| br | LED brightness | br | LED brightness |
|---|---|---|---|
| 0 | 0% | 8 | 45% |
| 1 | 10% | 9 | 50% |
| 2 | 15% | 10 | 55% |
| 3 | 20% | 11 | 60% |
| 4 | 25% | 12 | 70% |
| 5 | 30% | 13 | 80% |
| 6 | 35% | 14 | 90% |
| 7 | 40% | 15 | 100% |

tm : transition time

tm = 0 : Immediate

tm = 1 to 15 : tm * approx.10ms / step

**pm2 : control mode / data length**

| | **bit7** | **bi6** | **bit5** | **bit4** | **bit3** | **bit2** | **bit1** | **bit0** |
|---|---|---|---|---|---|---|---|---|
| **pm2** | **md** | | | | **ln** | | | |

md : control mode

md = 0 : All LED mode

md = 1 : LED selection mode

ln : data length

ln = 2 : 2 bytes (fixed)

**d(x)** : LED control

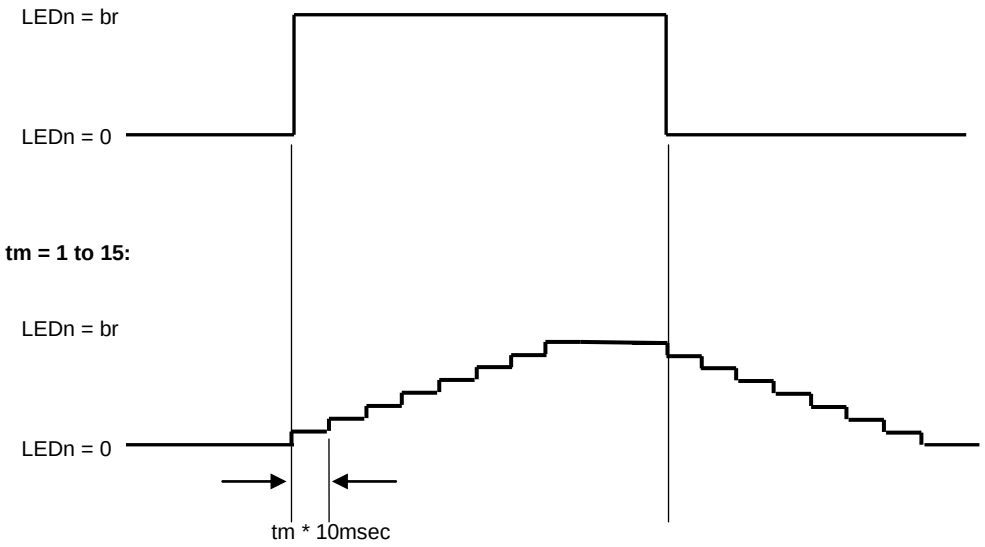
| | **bit7** | **bi6** | **bit5** | **bit4** | **bit3** | **bit2** | **bit1** | **bit0** |
|---|---|---|---|---|---|---|---|---|
| **d(1)** | **LED16** | **LED15** | **LED14** | **LED13** | **LED12** | **LED11** | **LED10** | **LED9** |
| **d(2)** | **LED8** | **LED7** | **LED6** | **LED5** | **LED4** | **LED3** | **LED2** | **LED1** |

| control mode | LEDn=0 | LEDn=1 |
|---|---|---|
| md = 0 (All LED mode) | OFF (0%) | OFF/ON (br) |
| md = 1 (LED selection mode) | No change | OFF/ON (br) |

【Function】 Control multiple LEDs at once.
LEDs change to brightness “br” with a transition time period specified by “tm”.
Each LED changes brightness in fixed steps from it's current brightness level to the specified level, which means that different LEDs may reach their specified brightness at different times.
The control mode determines which LEDs are affected (ie, all LEDs, or only selected LEDs).

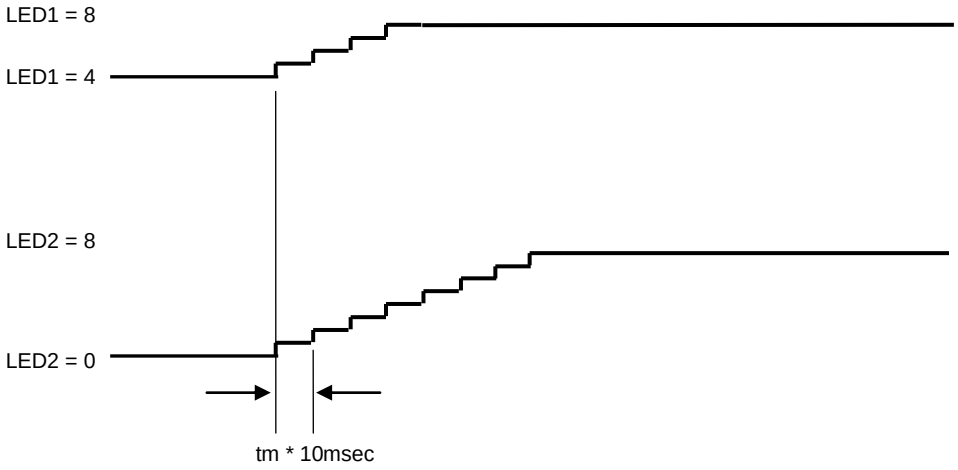
**LED brightness change timing (1)**

**tm = 0:**




**LED brightness change timing (2)**

br = 8:



### 8.1.8 Individual LED Control

【Code】

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **RX** | **1Fh** | **4Bh** | **21h** | **ln** | **pm1** |
| **TX** | | | | | |

**ln** : LED No.
ln = 00h (LED1) to 0Fh (LED16)

**pm1 : LED brightness control / change time**

| | bit7 | bi6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 |
|---|---|---|---|---|---|---|---|---|
| pm1 | br | | | | tm | | | |

br : LED brightness control

| br | LED brightness | br | LED brightness |
|---|---|---|---|
| 0 | 0% | 8 | 45% |
| 1 | 10% | 9 | 50% |
| 2 | 15% | 10 | 55% |
| 3 | 20% | 11 | 60% |
| 4 | 25% | 12 | 70% |
| 5 | 30% | 13 | 80% |
| 6 | 35% | 14 | 90% |
| 7 | 40% | 15 | 100% |

**tm** : transition time
tm = 0 : Immediate
tm = 1 to 15 : tm * approx.10ms / step

【Function】 Control specified individual LED
LED brightness changes to brightness “br” with a transition time specified by “tm”.
LED brightness changes in fixed steps from its current brightness, so total transition time depends on the current brightness level.

### 8.1.9 Fixed Buzzer Sound Output Control

【Code】

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| **RX** | **1Fh** | **4Bh** | **30h** | **bt** |
| **TX** | | | | |

**bt** : buzzer output time
bt = 0 : Stop buzzer output
bt = 1 to 100 : bt * approx. 20ms

【Function】 Output buzzer sound for specified time
The pitch of the buzzer sound is “C6” (approximately 1047Hz).
When this command is input during buzzer sound output, outputting buzzer sound is interrupted and the new command is executed.

### 8. 1. 10 Buzzer Sound Pitch Control

【Code】

| | 1 | 2 | 3 | 4 | 5 | 6 | --- | (n*2+3) | (n*2+4) |
|---|---|---|---|---|---|---|---|---|---|
| RX | 1Fh | 4Bh | 31h | n | bf(1) | bt(1) | --- | bf(n) | bt(n) |
| TX | | | | | | | | | |

**n** : number of buzzer notes
n = 1 to 64

**bf(x)** : buzzer note pitch (frequency accuracy: ±3%)
Buzzer note pitch (scale) values are listed below. If buzzer note pitch is any other value, a rest is inserted for the specified time.

| | C | C# | D | D# | E | F | F# | G | G# | A | A# | B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| octave 4 | 40h | 41h | 42h | 43h | 44h | 46h | 47h | 48h | 49h | 4Ah | 4Bh | 4Ch |
| octave 5 | 50h | 51h | 52h | 53h | 54h | 56h | 57h | 58h | 59h | 5Ah | 5Bh | 5Ch |
| octave 6 | 60h | 61h | 62h | 63h | 64h | 66h | 67h | 68h | 69h | 6Ah | 6Bh | 6Ch |
| octave 7 | 70h | - | - | - | - | - | - | - | - | - | - | - |

**bt(x)** : buzzer sound output time
bt(x) = 0 : buzzer output invalid
bt(x) = 1 to 100 : bt(x) * approximately 20ms

【Function】 Output buzzer sounds with seleced note/octave and duration
If this command is executed during buzzer sound output, the buzzer sound is interrupted and the new buzzer sound starts immediately.

### 8. 1. 11 Transmit data control

【Code】

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| RX | 1Fh | 4Bh | F0h | md |
| TX | | | | |

**md** : Transmit data enable/disable
md = 0 : Disable
md = 1 : Enable
Default: md = 1 (Enable)

【Function】 Enables or disables writing of transmit data to the internal transmit buffer.
When disabled, transmit data destined for the host (response data, etc) is discarded and not actually placed in the internal transmit buffer for transmission.
This command is for use with a Program Macro that will read and process response data from the Work Memory, and response data does not need to be sent to the host.

### 8. 1. 12 User Setup Mode Start

【Code】

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| RX | 1Fh | 28h | 65h | 01h | 49h | 4Eh | | | | |
| TX | | | | | | | 28h | 65h | 01h | 00h |

【Function】 Start User setup mode and send the response data
This command is only valid in Normal mode.

### 8. 1. 13 User Setup Mode End

【Code】

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| RX | 1Fh | 28h | 65h | 02h | 4Fh | 55h | 54h |
| TX | | | | | | | |

【Function】 End User setup mode and restart

### 8. 1. 14 Status Send 1

【Code】

| | 1 | 2 | 3 | 4 | 5 | 6 | --- | (x + 5) |
|---|---|---|---|---|---|---|---|---|
| RX | 1Fh | 4Bh | 40h | n | | | | |
| TX | | | | | 40h | d(1) | --- | d(x) |

n: Information type
n = 02h: Firmware version information
n = 30h: Product type information
n = 40h: Switch number information
n = 41h: Buzzer fitted / not fitted information

【Function】 Send the product status information
Sent data length depends on the Information type.

| n: Information type | Data length | Contents |
|---|---|---|
| 02h | d(1) to d(5) : 5 bytes | 20h to 7Fh : 【example】”1.00 “ |
| 30h | d(1) to d(7) : 7 bytes | 20h to 7Fh : 【example】”TKU-STD” |
| 40h | d(1) : 1 byte | 01h to FFh : 【example】10h |
| 41h | d(1) : 1 byte | 00h = Buzzer not fitted, 01h = Buzzer fitted 【example】01h |

### 8. 1. 15 Memory SW setting 1

【Code】

| | 1 | 2 | 3 | 4 | 5 | --- | 19 | 20 |
|---|---|---|---|---|---|---|---|---|
| RX | 1Fh | 4Bh | 51h | msw(0) | msw(1) | --- | msw(15) | |
| TX | | | | | | | | 51h |

msw(0) to msw(15): Memory switch setting value
msw(x) = FFh: No change

【Function】 Set Memory SW value
Set values are stored into flash memory, and used on next startup.
This command is only valid in User Setup Mode.

### 8. 1. 16 Memory SW data send 1

【Code】

| | 1 | 2 | 3 | 4 | 5 | 6 | --- | 20 |
|---|---|---|---|---|---|---|---|---|
| RX | 1Fh | 4Bh | 52h | | | | | |
| TX | | | | 52h | msw(0) | msw(1) | --- | msw(15) |

msw(0) to msw(15): Memory switch contents (refer to 10.3 Memory Switch (MSW) for details)

【Function】 Send Memory SW values

### 8. 1. 17 Status Send 2

【Code】

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | --- | (x + 8) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| RX | 1Fh | 28h | 65h | 40h | n | | | | | | |
| TX | | | | | | 28h | 65h | 40h | d(1) | --- | d(x) |

n: Information type
n = 02h: Firmware version information
n = 30h: Product type information
n = 40h: Switch number information
n = 41h: Buzzer fitted / not fitted information

【Function】 Send the product status information
Sent data length depends on the Information type.

| n: Information type | Data length | Contents |
|---|---|---|
| 02h | d(1) to d(4) : 4 bytes | 20h to 7Fh:【example】"1.00 " |
| 30h | d(1) to d(15) : 15 bytes | 20h to 7Fh:【example】"TKU-STD _ _ _ _ _ _ " |
| 40h | d(1) to d(3) : 3 bytes | 20h to 7Fh:【example】16 switches = "016" |
| 41h | d(1) to d(3) : 3 bytes | 20h to 7Fh:【example】Buzzer not fitted = "000"<br>Buzzer fitted = "001" |

### 8. 1. 18 Memory Switch Setting 2

【Code】

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| RX | 1Fh | 28h | 65h | 03h | n | d |
| TX | | | | | | |

n: Memory switch number (refer to 10.3 Memory Switch (MSW) for details)
n = 0 (MSW1) to 63 (MSW63)
d: Set value (refer to 10.3 Memory Switch (MSW) for details)
d = FFh: No change

【Function】 Set Memory SW value
Set values are stored into flash memory, and used on next startup.
This command is only valid in User Setup Mode.

### 8. 1. 19 Memory Switch Data Send 2

【Code】

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| RX | 1Fh | 28h | 65h | 04h | n | | | | |
| TX | | | | | | 28h | 65h | 04h | d |

n: Memory switch number (refer to 10.3 Memory Switch (MSW) for details)
n = 0 (MSW1) to 63 (MSW63)
d: Memory switch content

【Function】 Send memory switch value

### 8.1.20 General-purpose Port Input

【Code】

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| RX | 1Fh | 28h | 70h | 20h | n | | | | |
| TX | | | | | | 28h | 70h | 20h | d |

n: Port number
n = 00h: Port0 (P00 to P03)
d: Port output value

| | bit7 | bi6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 |
|---|---|---|---|---|---|---|---|---|
| d | 0 | 0 | 0 | 0 | P03 | P02 | P01 | P00 |

d bit value “0” = Input Low level
d bit value “1” = Input High level

【Function】 Send data at input ports

### 8.1.21 General-purpose Port Output

【Code】

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| RX | 1Fh | 28h | 70h | 10h | n | d |
| TX | | | | | | |

n: Port number
n = 01h: Port1 (P10 to P13)
d: Port output value

| | bit7 | bi6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 |
|---|---|---|---|---|---|---|---|---|
| d | 0 | 0 | 0 | 0 | P13 | P12 | P11 | P10 |

d bit value “0” = OPEN (Hi-Z)
d bit value “1” = Output Low level

【Function】 Control general-purpose port output
Since Port1 is an open collector output, attach a pull-up resistor on the host side as necessary.
Note that logic level is inverted.

### 8.1.22 RAM Program Macro Define / Delete

【Code】

| | 1 | 2 | 3 | 4 | 5 | --- | (p + 4) |
|---|---|---|---|---|---|---|---|
| RX | 1Fh | 3Ah | pL | pH | d(1) | --- | d(p) |
| TX | | | | | | | |

pL: RAM Program Macro data length, lower byte
pH: RAM Program Macro data length, upper byte
(pL + pH * 256) = 0 to 256
d: RAM Program Macro data

【Function】 Define or delete RAM Program Macro
(pL + pH * 100h) > 0000h: Supplied data “d” is stored as Program Macro.
(pL + pH * 100h) = 0000h: Program Macro is deleted.
If Program Macro data length “p” is outside the definable area, the command is cancelled, and the following data is treated as standard data.
**Program Macro details: Refer to "Program Macro" Software specification.**

### 8.1.23 Program Macro Execution

【Code】

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| RX | 1Fh | 5Eh | a | t1 | t2 |
| TX | | | | | |

a: Program Macro definition number
a = 80h: RAM Program Macro
a = 81h: FROM Program Macro
t1: Reserved
t1 = 0 to 255
t2: Reserved
t1 = 0 to 255

【Function】 Execute contents of Program Macro definition number “a”.
If Program Macro “a” is not defined, or if “a” is outside the definable area, the entire command (up to t2) is ignored.
Program Macro execution operation follows the Program Macro script specification.
Program Macro execution is stopped by END command specified within Program Macro definition.

### 8.1.24 FROM Program Macro Define / Delete

【Code】

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | --- | (p + 9) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RX | 1Fh | 28h | 65h | 12h | a | pL | pH | t1 | t2 | d(1) | --- | d(p) |
| TX | | | | | | | | | | | | |

a: Program Macro definition number
a = 01h: FROM Program Macro
pL: FROM Program Macro data length, lower byte
pH: FROM Program Macro data length, upper byte
pL + pH * 256 = 0 to 4096
t1: Reserved
t1 = 0 to 255
t2: Reserved
t1 = 0 to 255

【Function】 Define or delete FROM Program Macro
(pL + pH × 100h) > 0000h: Supplied data “d” is stored as Program Macro.
(pL + pH × 100h) = 0000h: Program Macro is deleted.
If program macro data length “p” is outside the definable area, the command is cancelled, and the following data is treated as standard data.
**This command is only valid in User Setup Mode.**
Do not define any of the following commands in a Macro;
Program Macro Execution, RAM Program Macro Define / Delete, User Setup Mode Start.
Program Macro details: Refer to "Program Macro" Software specification.

## 8.1.25 Touch Parameter Setting

【Code】

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RX | 1Fh | 4Bh | 54h | sn | d(1) | d(2) | d(3) | d(4) | d(5) | d(6) | d(7) | d(8) | |
| TX | | | | | | | | | | | | | 54h |

sn: Switch number

sn = 00h (SW1) to 0Fh (SW16) : Individual switch setting

sn = FEh : All switch setting 2

sn = FFh : All switch setting

If sn = 00h to 0Fh or FFh:

d(1) / thr: Threshold level

thr = 0 to 31 : Threshold level (thr + 1) × 12.5%

thr = 0 : 12.5%

thr = 7 : 100%

thr = 31 : 400%

d(2) / offs: Threshold offset

d(3) / hys: Hysteresis

d(4) / son: Sampling time setting (ON decision)

d(5) / soff: Sampling time setting (OFF decision)

d(6) / clb: Auto-callibration period setting

clb = 0 to 250

clb = 0 : Auto calibration OFF

clb = 1 to 250 : clb × approximately 20ms

d(7) / thrVL: Threshold reference, lower byte

d(8) / thrVH: Threshold reference, upper byte

| Parameter | All switch setting FFh | Individual switch setting 00h to 0Fh | Effective range | No change | Default |
|---|---|---|---|---|---|
| thr | ✓ | ✓ | 0 to 31 | 255 (FFh) | 7 |
| offs | ✓ | ✓ | 0 to 250 | 255 (FFh) | 0 |
| hys | ✓ | ✓ | 1 to 250 | 255 (FFh) | 20 |
| son | ✓ | - | 1 to 250 | 255 (FFh) | 3 |
| soff | ✓ | - | 1 to 250 | 255 (FFh) | 3 |
| clb | ✓ | - | 1 to 250 | 255 (FFh) | 10 |
| thrVL<br>thrVH | - | ✓ | 1 to 60000 | 65535 (FFFFh) | Private |

Parameter Valid: ✓ Parameter Invalid : -

If sn = FEh:

d(1) / mon: Continuous touch ON time limit

mon = 0 to 250

mon = 0 : No continuous touch time limit

mon = 1 to 250 : Continuous touch ON time limited to: mon × approximately 20ms

d(2) to d(8) / rsv: Reserved

Set these parameters to FFh (no change)

d(8) / thrVH: Threshold reference, upper byte

| Parameter | Effective range | No change | Default |
|---|---|---|---|
| mon | 0 to 250 | 255 (FFh) | 0 |
| rsv | - | 255 (FFh) | Private |

【Function】 Set various parameters for Touch-Switch

Parameter settings may be applicable for all switches, or individual switches, as shown above.

Parameter settings are effective immediately.

Use the Touch Parameters Save command to store the parameters to non-volatile memory if necessary.

### 8.1.26 Touch Parameters Send

【Code】

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RX | 1Fh | 4Bh | 55h | sn | | | | | | | | | |
| TX | | | | | 55h | d(1) | d(2) | d(3) | d(4) | d(5) | d(6) | d(7) | d(8) |

sn: Switch number
sn = 00h (SW1) to 0Fh (SW16) : Individual switch setting
sn = FEh : All switch setting 2
sn = FFh : All switch setting
d(1) to d(8): Various parameters (refer to 8.1.25 Touch Parameter Setting).

【Function】 Send various touch switch parameters

### 8.1.27 Touch Parameters Save

【Code】

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| RX | 1Fh | 4Bh | 56h | md | |
| TX | | | | | 56h |

md: Mode
md = 5Ah : Save current parameters to memory
md = A5h : Save default parameters to memory

【Function】 Save Touch-Switch parameters to memory
**This command is only valid in User Setup Mode.**

### 8.1.28 Restart Touch Operation

【Code】

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| RX | 1Fh | 4Bh | 57h | 5Ah | |
| TX | | | | | 57h |

【Function】 Restart Touch-Switch operation with parameters re-loaded from memory.

## 8.2 Initial State

The module's initial state is as follows:

| Item | Initial state |
|---|---|
| LED | All LEDs off |
| Buzzer | Buzzer sound output off |
| Touch Switch | Switch OFF state |
| Other | Initial values, subject to Jumper and MSW settings |

# 9 Jumper

| No. | Function | Condition |
|---|---|---|
| J0 | Baud rate select / $I^2C$ slave address select | OPEN |
| J1 | | OPEN |
| J2 | Serial interface select | OPEN |
| J3 | | OPEN |
| J4 | Reserved | OPEN |
| JT | Operation mode select | OPEN |

## 9.1 Serial Interface Select

| J2 | J3 | Condition |
|---|---|---|
| — | OPEN | Asynchronous serial interface |
| OPEN | SHORT | $I^2C$ interface |
| SHORT | SHORT | SPI |

## 9.2 $I^2C$ Slave Address Select

$I^2C$ address setting is set by a combination of Memory SW and Jumper.

| J0 | J1 | Slave address |
|---|---|---|
| OPEN | OPEN | 50h *1 |
| SHORT | OPEN | 51h *1 |
| OPEN | SHORT | 70h *1 |
| SHORT | SHORT | MSW14 setting *2 |

*1: The module also responds on the General call address (00h).

*2: Response to General call address can be disabled (see below).

| **MSW14** | **Condition** |
|---|---|
| 08h to 77h | Slave address is set 08h to 77h.<br>The module also responds to the General call address |
| 88h to F7h | Slave address is set 08h to 77h (lower 7 bits).<br>**No response to general call address** |
| Out of range | Slave address is set to 71h.<br>The module also responds to the General call address |

## 9.3 Baud Rate Select

| J0 | J1 | Condition |
|---|---|---|
| OPEN | OPEN | 38400bps |
| SHORT | OPEN | 19200bps |
| OPEN | SHORT | 9600bps |
| SHORT | SHORT | 115200bps |

## 9.4 Operation Mode Select

| JT | Operation mode |
|---|---|
| OPEN | Normal mode |
| SHORT | Test mode (Factory use only) |

# 10 Connector

## 10.1 Serial Interface (CN2)

* IC: Leave unconnected

### 10.1.1 Asynchronous Serial Interface mode

| Pin No. | Signal | Function | Direction |
|---|---|---|---|
| 1 | VCC | Power supply | Input |
| 2 | RXD | Data receive | Input |
| 3 | GND | Ground | Input |
| 4 | IC | Internal connection | - |
| 5 | IC | Internal connection | - |
| 6 | /RESET | Reset | Input |
| 7 | IC | Internal connection | - |
| 8 | TXD | Data send | Output |
| 9 | IC | Internal connection | - |

### 10.1.2 SPI mode

| Pin No. | Signal | Function | Direction |
|---|---|---|---|
| 1 | VCC | Power supply | Input |
| 2 | MOSI | Data receive | Input |
| 3 | GND | Ground | Input |
| 4 | IC | Internal connection | - |
| 5 | SCK | Serial clock | Input |
| 6 | /RESET | Reset | Input |
| 7 | /CS | Chip select | Input |
| 8 | MISO | Data send | Output |
| 9 | IC | Internal connection | - |

### 10.1.3 I2C mode

| Pin No. | Signal | Function | Direction |
|---|---|---|---|
| 1 | VCC | Power supply | Input |
| 2 | SDA | Serial data | Input/Output |
| 3 | GND | Ground | Input |
| 4 | IC | Internal connection | - |
| 5 | SCL | Serial clock | Input/Output |
| 6 | /RESET | Reset | Input |
| 7 | IC | Internal connection | - |
| 8 | IC | Internal connection | - |
| 9 | /TRDY | Transmit ready | Output |

## 10.2 I/O Port Interface (CN1)

| Pin No. | Signal | Function | Direction |
|---|---|---|---|
| 1 | KS0 / P00 | Key scan select / General-purpose input port | Input |
| 2 | KS1 / P01 | Key scan select / General-purpose input port | Input |
| 3 | KS2 / P02 | Key scan select / General-purpose input port | Input |
| 4 | KS3 / P03 | Key scan select / General-purpose input port | Input |
| 5 | KD0 / P10 | Key scan data / General-purpose output port | Output |
| 6 | KD1 / P11 | Key scan data / General-purpose output port | Output |
| 7 | KD2 / P12 | Key scan data / General-purpose output port | Output |
| 8 | KD3 / P13 | Key scan data / General-purpose output port | Output |
| 9 | VCC | Power supply | Input |
| 10 | GND | Ground | Input |

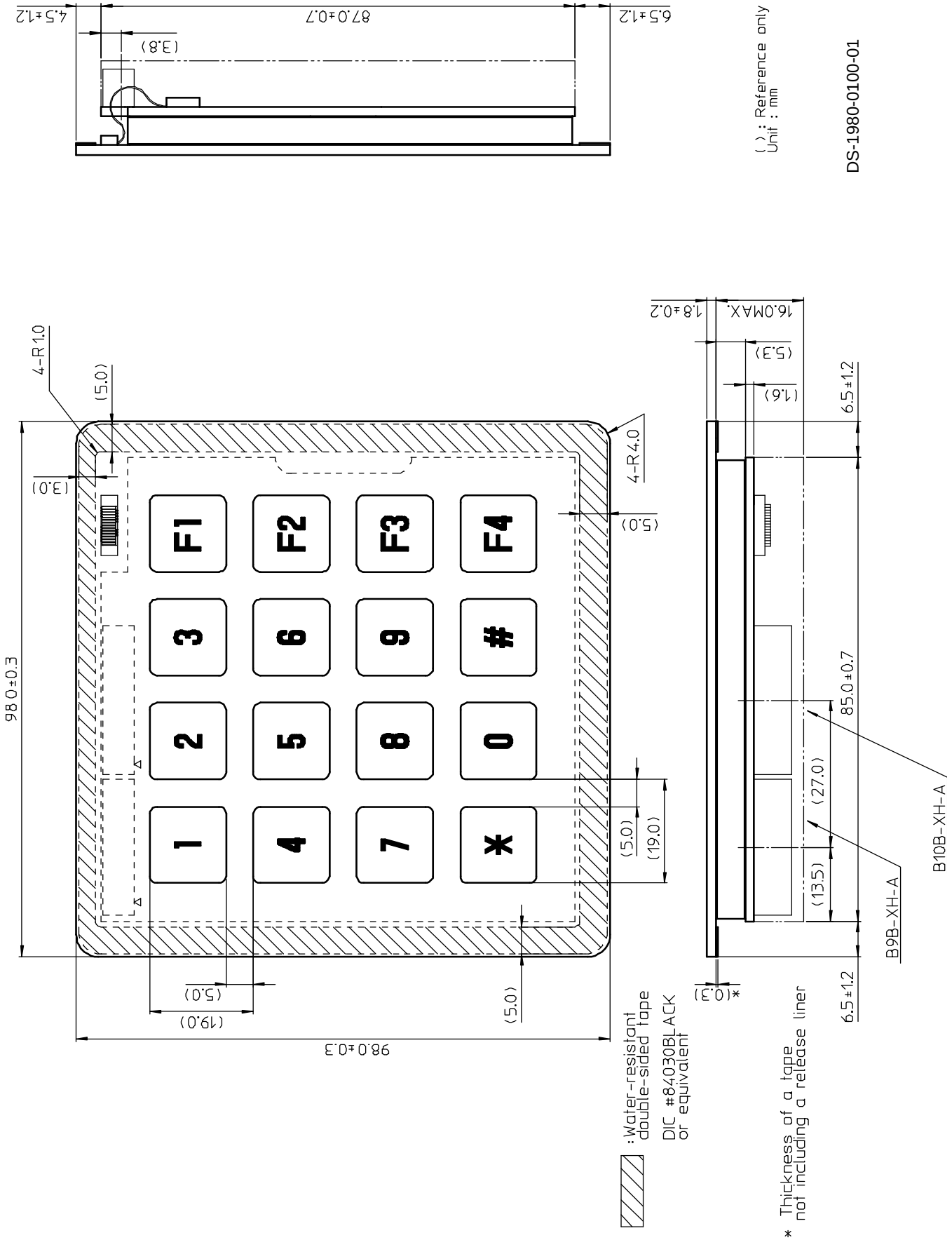
## 10.3 Memory Switch (MSW)

| MSW No. | Function | Valid range | Default value |
|---|---|---|---|
| MSW0 to 3 | Reserved | - | - |
| MSW4 | Touch-Switch read setting | 00h：Manual transmit mode<br>01h：Auto transmit mode<br>All touch-switch status read<br>02h：Auto transmit mode<br>Individual touch-switch status read | 00h |
| MSW5 to 12 | Reserved | - | - |
| MSW13 | Port setting | 00h: Key Scan mode<br>01h: General-purpose port mode | 00h |
| MSW14 | $I^2C$ Slave address | 08h to 77h: Slave address (08h to 77h)<br>(Module also responds on the General call address)<br>88h to F7h: Slave address (08h to 77h)<br>(Module does not respond on General call address) | 71h |
| MSW15 to 18 | Reserved | - | - |
| MSW19 | Power-on Program<br>Macro automatic execution | 00h：No start<br>81h：Program Macro start | 00h |
| MSW20 to 63 | Reserved | - | - |

* Setting and reading MSW16 to MSW63 is only possible using the Memory Switch Setting 2 and Memory Switch Data Send 2 commands respectively.

* Module operates with default value if Memory SW value is outside the valid range.

## 11 Physical Dimensions



## Revision

| Specification No. | Date | Revision |
|---|---|---|
| DS-1980-0001-00 | Sep. 29, 2016 | Initial issue |
| DS-1980-0001-01 | Oct. 4, 2016 | 2.3 Outline<br>Applicable Touch Switch Module reliability specification<br>TT-12-3301A → TT-12-3102<br>Applicable Touch Switch Module quality specification<br>TT-12-3401A → TT-12-3401<br>6.3 Cautions<br>Separator → Release liner<br>7.3 Key Scan interface<br>Key scan timing corrected<br>8.1.3 Touch-Level Order Switch Reading<br>Example sentence corrected<br>8.1.7 All LED Display Control → All LED Control<br>8.1.8 Individual LED Display Control → Individual LED Control<br>11 Physical Dimensions<br>DS-1980-0100-00 → DS-1980-0100-01<br>Comment changed<br><br>Other minor changes |
| DS-1980-0001-02 | Oct. 31, 2016 | 2.3 Outline<br>Applicable Touch Switch Module reliability specification<br>TT-12-3102 → TT-99-3102<br>Applicable Touch Switch Module quality specification<br>TT-12-3401 → TT-98-3413<br>Applicable Touch Switch specification<br>T.B.D. → TT-16-3301<br>3.3 Electrical Characteristics<br>Corrected signals |
| DS-1980-0001-03 | Feb. 3, 2017 | 1 Touch Switch Module Handling and Usage Precautions<br>The item positon change and sentences correction<br>7.2.1 Asynchronous serial interface<br>Communication control signal changed<br>/TRDY removed<br>8.1.10 Buzzer Sound Pitch Control<br>Octave number and terminology correction<br>10.1.1 Asynchronous Serial Interface mode<br>Signal name of Pin No9 changed<br>/TRDY → IC<br>10.1.2 SPI mode<br>Signal name of Pin No9 changed<br>/TRDY → IC<br>10.2 I/ Port Interface (CN1)<br>Additional connector number<br>Correction other minor errors |
| DS-1980-0001-04 | Feb. 6, 2017 | 10.1.2 SPI mode<br>Pin No.7 function correction |