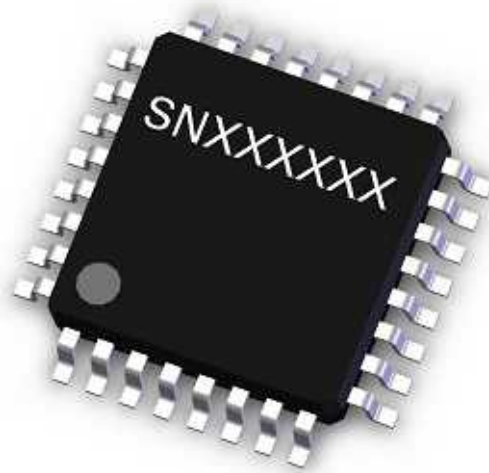




TYPE: B6TS-08LF
TOUCH-SENSING IC

USER MANUAL



Introduction

Thank you very much for purchasing the touch sensor.

The touch sensor is a product that has been developed based on our advanced technology and rich experience.

This user manual describes the information necessary for use of the sensor, such as its functions, capabilities and proper usage.

When using the touch sensor, please keep the following in mind:

- Only specialists with knowledge of electricity must handle the touch sensor.
- Please read and understand the contents of this manual thoroughly to use the touch sensor appropriately.
- Keep this manual handy to refer to it again later on specific problems.

Points to note when using the touch sensor

- Although OMRON makes constant efforts to improve the quality and reliability of its semiconductor products, products such as this touch sensor may malfunction or break.

Before using the touch sensor, please contact OMRON's business development personnel, if necessary, to confirm product specifications, while also paying attention to using the sensor with a sufficient margin allowed for its ratings and capabilities, and taking safety measures such as installing safety circuits to minimize hazards in the unlikely event that a failure of the sensor might occur.

- Basically, this product is not designed and manufactured for use in equipment or systems operated under potentially hazardous conditions. If you intend to use the touch sensor with any of the following systems, facilities or equipment, be sure to consult OMRON sales personnel or an agent or dealership first:
 - (A) Atomic power control equipment, incineration facilities, railroads, aircraft, vehicle equipment, medical appliances, amusement machines, safety devices, and facilities that must comply with the regulations of administrative agencies and their respective industries.
 - (B) Systems, machines and devices that are potentially hazardous to humans and property.
 - (C) Other usages that require a high degree of safety.

The technical information contained in this manual is prepared only to describe typical performances and application examples of the product. Application of the products based on the information does not infer the grant of any OMRON or third party intellectual property, right or license.

1. Preventing malfunction caused by contact with an electric conductor other than a human finger with the touch electrode

Because this product measures the electrostatic capacitance of the detector (electrode), the product may operate if something other than a human finger is brought into contact with the electrode. Therefore, a fail-safe design is required for use of the product so that it does not cause any functional or safety problem even on such occasions. Substances, etc., that may cause a malfunction if they are present near to or on the detector are:

- Water, metal, animals, other conductive materials

2. Preventing operational error

Because this product detects human touch, it may operate if the detector (electrode) is touched only lightly or if somebody remains nearby. When incorporating this product into a device, check the detection range thoroughly, and employ measures to prevent the device from malfunctioning caused by operational error. Especially, if the device is used where children may come into contact with it, provide some safety measure such as a child safety lock.

3. Preventing the entry of water or corrosive gases

If water or a corrosive gas enters the operating part of the sensor (electrode), in the event of a short circuit or corrosion of the electrode, the sensor may malfunction or its detection sensitivity may be lowered. If the product is supposed to be used in an environment where this may occur, employ some structure to prevent the entry of water or gas, and check to be sure in actual operation that the device is protected securely against such an event.

4. Preventing malfunction caused by noise

The product may malfunction if subjected to excessive noise.
Check to be sure that no safety problems are caused by excessive noise.

5. Preventing direct touching of the electrode

Do not employ any structure that exposes the surface of the touch electrode to the air and allows somebody to touch the metal part of the touch electrode directly. Otherwise, the safety of the product may be impaired, accumulated electrostatic charges may damage the product, or the electrode may corrode. Adopt a structure that covers the surface of the touch electrode with nonconductive material and does not allow anybody to touch the metal part of the electrode directly.

The recommended thickness for the nonconductive material is:

Resin material (dielectric constant of 2 to 3): no more than 2mm

Glass material (dielectric constant of about 5): no more than 4mm

6. Configurable data

When setting data with commands, consider the environment and conditions for using the touch sensor (e.g., location and circuit configuration) to determine proper values which may not cause functional or safety problems.

Proper usage

1. Method of transportation and storage

- (1) Do not drop or apply any shock to the touch sensor because it is a precision device.
If the sensor is thrown or dropped, it may break.
- (2) When carrying or storing the touch sensor, keep its packaging properly oriented.
If the packaging is placed upside down or tilted, the sensor may be subjected to some undue force and may break.
- (3) Store the touch sensor under the following conditions to prevent the package from absorbing moisture:
Otherwise, the sensor may break when the package is mounted.
<Storage conditions>
 - A. Before opening the moisture-proof pack (aluminum laminate pack):

[Temperature, humidity]	-65 - 150°C, -80% or less RH
[Term of validity]	One year

 When the sensor is used after a long period of storage, make sure that no damage, dirt, or rust is present on the pack.
 - B. After opening the moisture-proof pack (aluminum laminate pack):
Until the package is mounted, the following conditions are recommended for storage of the package:
(In accordance with MSL3/JEDEC-STD-020)

[Temperature, humidity]	30°C 60% RH
[Term of validity]	168 hours
 - C. Temporary storage after opening the moisture-proof pack:
After opening the moisture-proof pack, it is recommended to store any parts remaining in the same package after mounting due to your manufacturing quantity reason in a desiccator (device to keep temperature constant and humidity as low as 20% or less RH), or return them into the moisture-proof pack then seal the pack immediately after using them.
Do not use or store the touch sensor where it will be subject to corrosive gases such as hydrosulfuric gas or salt air, or exposed to oil or direct sunlight.
- (4) Do not use or store the touch sensor where it will be subject to corrosive gases such as hydrosulfuric gas or salt air, or exposed to oil or direct sunlight.
- (5) Where either of the following conditions [1] or [2] is applicable, baking the sensor package in the following manner is recommended in order to remove moisture:
The tray used in the moisture-proof pack can be stored in a high-temperature chamber because it is heat-resistant. However, place the tray on a flat base such as a level block, and then cool it down on the base to prevent deformation after baking.
[1] The above storage conditions A-C are exceeded.
[2] The color of the 30% RH detection part of the indicator changes to lavender or pink.

<Baking method>

[Temperature]	125°C
[Time]	6 hours
[Number of times]	Up to three (Cumulative time limit: 72 hours)

2. Measures against electrostatic charges during handling

Keep the relevant electric equipment, work-bench and worker at the same potential.

Lay a conductive mat with a surface resistance of 10 kΩ - 10 MΩ on the work-bench, and ground the mat.

The user must make sure that there is no electric leakage from the electric equipment to ground. The electric leakage must be limited by the use of a resistor of about 1 MΩ for safety. All safety regulations must be observed. Any electric leakage from the electric equipment is undesirable from the viewpoint of worker safety.

Check to be sure that there is no electric leakage from the tester, curve tracer, oscilloscope, or the like, and then ground the equipment. Any electric leakage can break the CMOS IC.

The same precautions apply to soldering irons.

3. Recommended soldering Conditions

Recommended soldering conditions (Pb free)

Temperature conditions for mounting the IC chip

When mounting the IC chip at a high temperature by using reflow soldering, the melting temperature of the solder depends on the mounting board and paste adhesive materials of the mounting board and the paste adhesive.

Referring to the mounting temperature profile shown in the following figure, choose the optimum soldering temperature within the profile.

(1) Reflow method (infrared light reflow and air reflow)

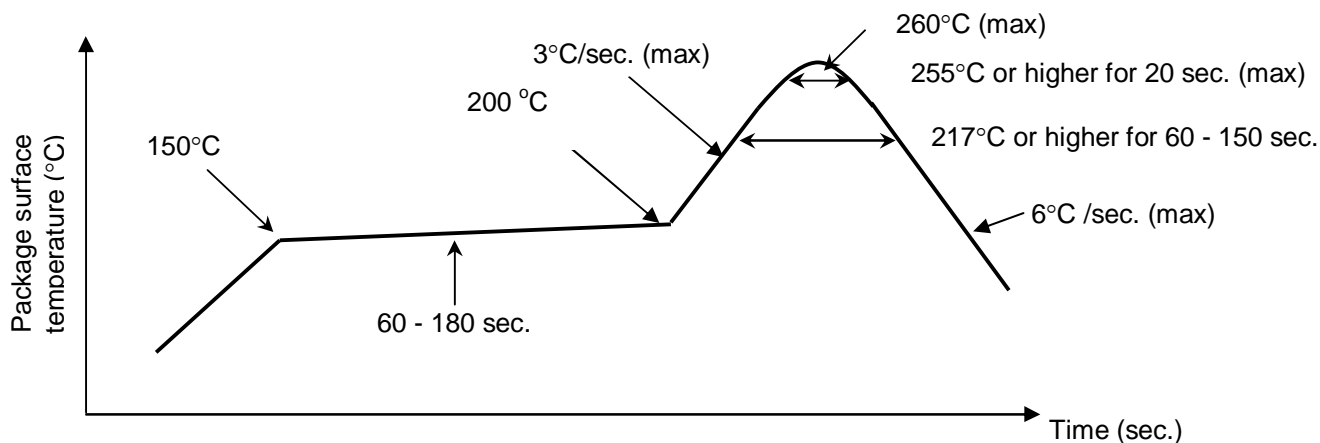


Figure 1. Reflow Method - Temperature Profile

(2) Wave soldering method (called known as flow soldering or dip soldering)

Wave soldering method using Pb-free solder is not recommended.

(3) Soldering iron (manual soldering)

Solder using a soldering iron for semiconductor devices under the following conditions:

[Iron tip temperature]	350±5°C
[Soldering time]	No longer than 5 sec/pin

4. Recommended wash conditions

The wash conditions compliant to MIL-STD-883C are recommended.

When using rosin flux wash, check the following items:

- (1) Amount of contamination containing residual ions (or no ions)
- (2) Administrative directions and regulations
- (3) Melting resistance of parts

5. Handling after mounting parts on PCB

When dividing a PCB on which ICs are mounted, do not apply any excessive force to the ICs. Otherwise, the internal IC chips may be broken.

6. Applied voltages and currents

- (1) Do not apply to any pin any voltage or current that exceeds the absolute maximum ratings.
- (2) Use the device within the recommended specifications to enhance the quality of the device.
- (3) Do not apply any forward bias to any of the pins.
Otherwise, excessive forward current may cause thermal breakdown of the IC.
- (4) Do not connect any output pin directly to power. If any output pin is directly connected to low-impedance power, the internal wiring may melt down or break thermally due to excessive current.

CONTENT

1. Overview
2. Pin connections
3. Operation mode
4. Measurement
5. Serial communication
6. Commands
7. Teaching
8. Electrical characteristics
9. Appearance and dimensions

1. Overview

This chip is a sensor IC to detect micro capacitances and can be used in touch sensors. Internally, the chip employs the CMOS process and is contained in a 32-pin TQFP plastic package. The IC has 8 independent measurement pins, of which each can measure capacitance independently. On/Off- or serial communication output can be selected as the output mode. The IC is provided with an EEPROM that can store operation mode.

2. Pin connections

2.1 Pin arrangement diagram

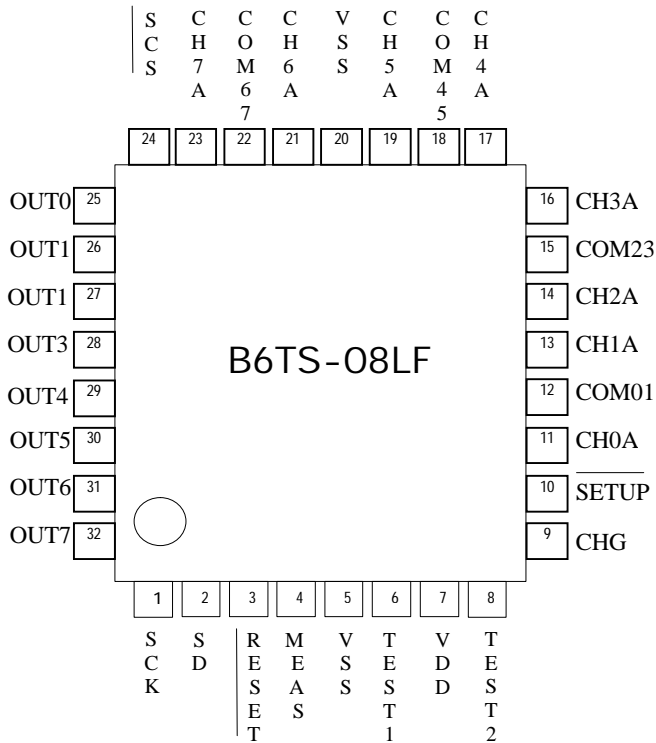


Figure 2. Pin assignment

Note: Pins TEST1 (6-pin) and TEST2 (8-pin) are used for testing during manufacture of the IC. During normal operation of the IC, connect them to Vdd through a pull-up resistor.

2.2 Pin functions

Table 1. Pin functions

Pin No.	Designation	Input/Output	Function
11 13 14 16 17 19 21 23	CH0A CH1A CH2A CH3A CH4A CH5A CH6A CH7A	I/O	Connect these pins to the touch electrode through the measurement pins (channels 8 to 0).
12 15 18 22	COM01 COM23 COM45 COM67	I/O	Common-use measurement pins (channels 8 - 0) Common-use measurement pins for two channels each Connect these pins to charge capacitors through resistors.

Pin No.	Designation	Input/ Output	Function
7	V _{dd}	I	Power Supply Input (3.0 - 5.5V)
5 20	V _{ss}	I	Ground
9	CHG	O	An output pin which indicates the operation status. [Normal measurement mode] Outputs measurement results. [Serial communication mode] - Measurement termination output Two output modes are available: 1. High-signal output every time a measurement finishes. 2. High-signal output when the condition changes in any one of the channels (touch→no touch, no touch→touch). [Setup mode] When setup mode is entered, CHG pin goes high. However, when EEPROM write command is received and data is being written in EEPROM, CHG pin remains low.
2	SD	I/O	Serial communication data I/O
1	SCK	I	Serial communication clock input
24	SCS	I	Serial communication mode chip select input
10	SETUP	I	Setup mode. Low input to this pin moves the chip into setup mode. (Connect to V _{dd} through a pull-up resistor) In addition, insert 0.01uF ceramic capacitor between this terminal and V _{SS} .
4	MEAS	I	Initiation of measurement. Capacitance measurement is initiated by inputting high to this pin. While low is input to this pin, the chip is held in standby status.
6	TEST1	I	(Connect to V _{dd} through a pull-up resistor)
8	TEST2	I	(Connect to V _{dd} through a pull-up resistor)
3	RESET	I	Reset signal input. Inputting low to this pin resets the chip.
25	OUT0	O	Output pin for Ch0 (can be set to active Low or active High).
26	OUT1	O	Output pin for Ch1 (can be set to active Low or active High).
27	OUT2	O	Output pin for Ch2 (can be set to active Low or active High).
28	OUT3	O	Output pin for Ch3 (can be set to active Low or active High).
29	OUT4	O	Output pin for Ch4 (can be set to active Low or active High).
30	OUT5	O	Output pin for Ch5 (can be set to active Low or active High).
31	OUT6	O	Output pin for Ch6 (can be set to active Low or active High).
32	OUT7	O	Output pin for Ch7 (can be set to active Low or active High).

2.3 Example of circuit

Note 1: Connect R_r , C_r , R_c , and C_c to each touch electrode, as shown in the diagram below. Refer to the design tool (B6TWorkbench – Circuit Constants) for recommended values.

* Reference values: $R_r=10k\Omega$, $R_c=3.9k\Omega$, $C_c=0.1\mu F$, $C_r=15pF$ (Cr_0, Cr_1)
 $18pF$ (Cr_2, Cr_4)
 $22pF$ (Cr_3, Cr_5-7)

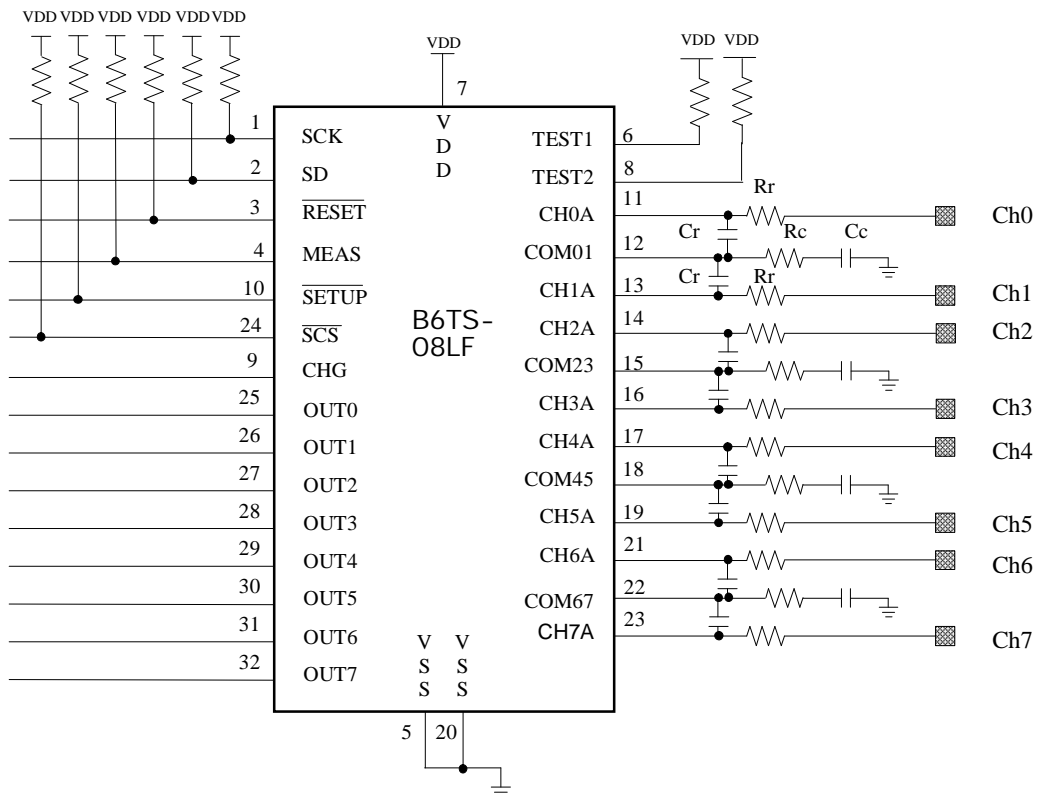


Figure 3. Example of circuit

Note 2: Connect a bypass capacitor of about $0.1\mu F$ between V_{dd} and V_{ss} using wires as short as possible.

Note 3: Connect a bypass capacitor of about $0.01\mu F$ between $/SETUP$ pin and V_{ss} .

3. Operation mode

This chip has three operating modes. Each mode is selected by the MEAS pin and /SETUP pin.

- (1) Normal measurement mode ----- Normal operation mode to detect touch/no-touch. Serial communication- and On/Off output mode can be selected.
- (1-1) On/off output mode ----- OUT0 - OUT7 pins are used. Touch/no-touch detection results are output from the respective channels with low/high signal.
- (1-2) Serial communication output ----- Measured results are transmitted in serial with a 3-wire SPI function using SCK, SD and SCS signals.
- (2) Setup mode ----- Chip operation is set to serial communication.

Table 2. Operation mode

/SETUP pin	MEAS pin	Operation mode
HIGH	HIGH	Normal measurement mode
HIGH	LOW	Standby - without executing measurements
LOW	HIGH	Teaching mode
LOW	LOW	Setup mode

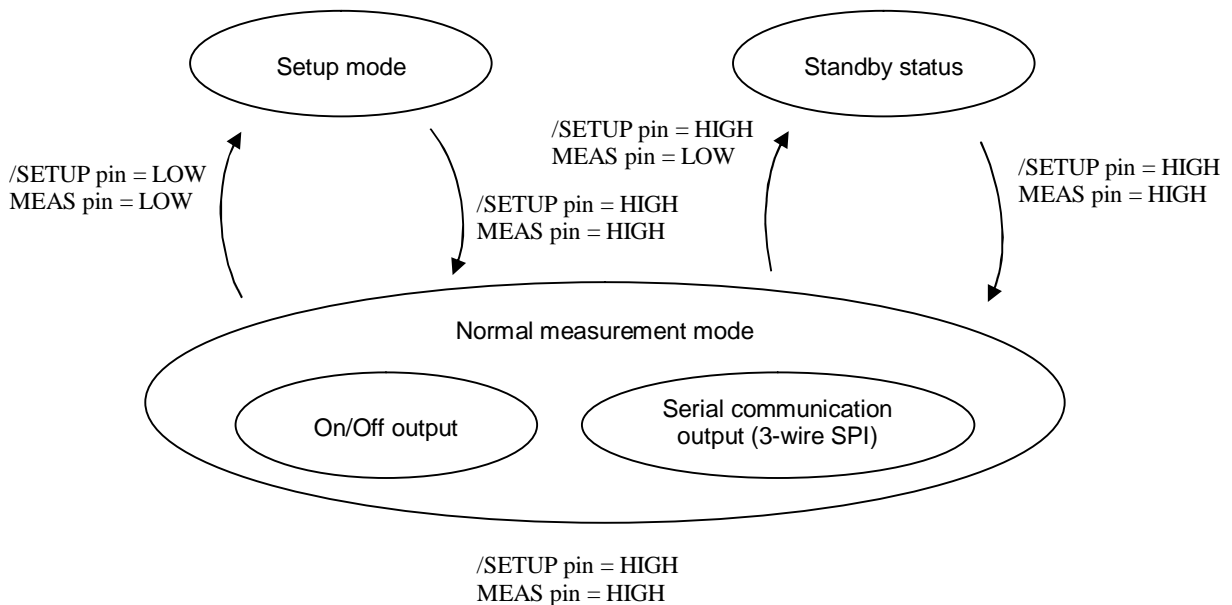


Figure 4. State transition diagram

4. Measurement

The chip measures the discharge of the charge stored in the charge capacitor. When a finger is placed close to the touch electrode, the electrostatic capacitance of the electrode increases and the discharge time for the charge becomes shorter. The chip has a built-in counter to measure the discharge period. Whether the sensor has been touched or not is judged according to whether the length of the discharge period exceeds a specified value or not. Hereafter, the length of the discharge period is referred to as the measured value.

The measured value when the sensor is not touched is called the reference value. The change of the measured value which allows a judgment that the sensor is touched is called judging change, and the change of the measured value when returning from on status is called hysteresis. These 3 parameters define the switching characteristics of each touch channel and can be set for each channel independently.

The relationships between the measured value and the above values are as follows:

$$\begin{aligned} [\text{Measured value}] < [\text{Reference value}] - [\text{Judging change}] &\rightarrow \text{Touch} \\ [\text{Measured value}] > [\text{Reference value}] - [\text{Judging change}] + \text{Hysteresis} &\rightarrow \text{Touch to no touch} \end{aligned}$$

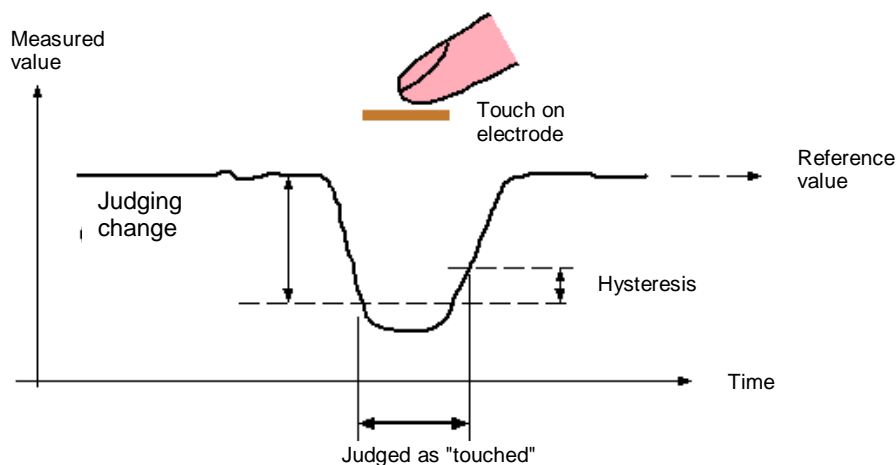


Figure 5. State of touch

Even in the no touched state, the measured value changes according to variation in the environment (output drift). The chip is provided with an automatic drift-compensation function, which can cancel mild changes of the measured value due to variation in the environment. The drift compensation function can be enabled or disabled in setup mode.

5. Serial communication

It is possible to read out measured values and set the operation mode by sending/receiving data to/from this chip through serial communication.

Serial communication is performed with the three-wire SPI using SCS (chip select), SCK (transfer clock), and SD (data transmission and reception: host → B6TS, B6TS → host).

5.1 SPI communication

The SPI communication method works as follows:

(Refer to “8. Electrical specifications” for specific communication timing, etc.)

- Operation in SPI slave mode
 - Supply SCS (chip select) and SCK (transfer clock) from an external source.
- SCK (transfer clock) is set to high during idling. The data is latched at the rising edge of the clock.
- The data (SD) is in MSB first format.

This chip sends/receives data using 4 bytes, consisting of a command byte, dummy bytes, and 2 data bytes.

Command: 1 byte (MSB 1 bit is used for the read/write flag.)

Dummy data: 1 byte (0x00 or 0x80 is set when accessing to commands 0x00 - 0x7F or 0x80 - 0xFF respectively.)

Data: 2 bytes

Read (Data direction: B6T→Host)

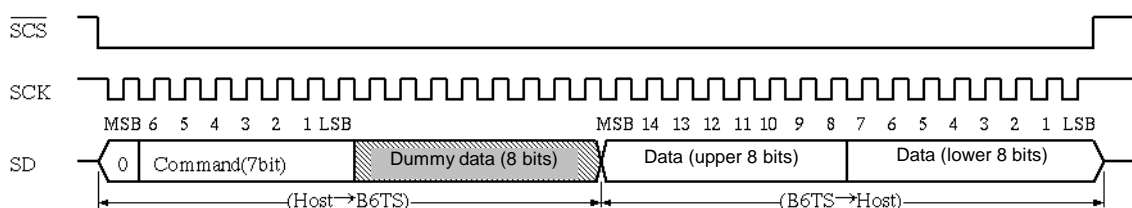


Figure 6. In case of “Read command”

Write (Data direction: Host→B6T)

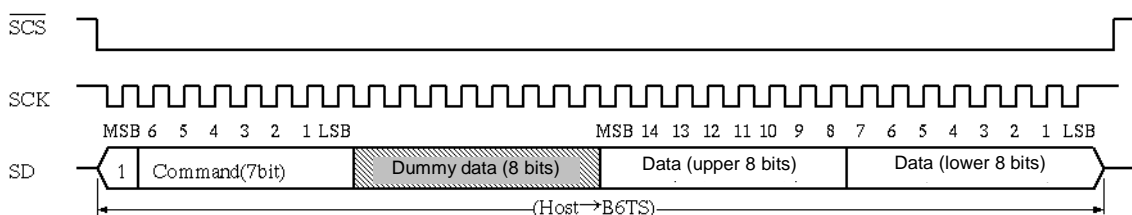


Figure 7. In case of “Write command”

If data communication is performed during normal measurement mode, the measurement operation stops while the data is communicated.

Measurement will restart after communication completes (when measurement has been interrupted, values from the last measurement are read).

*If SCS is disabled while data is being transmitted or received, data transmitted or received by B6T up to that moment is lost.

*I/O of the SD pin toggles according to the data direction. Be sure to change the host pin I/O according to the SD pin direction.

5.2 Command access

- Access to commands 0x00 - 0x7F.
 - For read operation: Command Code. + dummy data (0x00)
 - For write operation: Command Code. + 0x80 + dummy data (0x00) + data (upper 8 bits) + data (lower 8 bits)

* For write accesses, transmit each command ORed with 0x80.

6. Commands

The commands and data used in serial communication are listed below:

The data comprises read only data (read) and read/write data (read/write). If a write command is applied to read only data, the operation will be invalid.

Some data is not accessible in some operation modes. If inaccessible data is read out, the read data is indefinite. If inaccessible data is written, the data is ignored.

Command code (Designation)	Main function	Read/write restriction	Access limit	
			Normal measurement mode (in serial communication mode)	Setup mode
0x00(ID) - 0x25(CHYS7)	Measured data	Read only	Accessible	Accessible
0x39(CHEN) - 0x67(RHYS7)	Parameter setting	Read/write	Inaccessible	

When writable data are written in this chip, the built-in register corresponding to each command is rewritten. Then, if the normal measurement mode is entered, the chip can be operated with the written parameters (mode, etc.). In this case, because only the built-in register is rewritten, the value in each register returns to its original value (value stored in EEPROM) when power is turned off and on again.

To store the built-in register value in EEPROM, an EEPROM write command (0x3F) must be received. When an EEPROM write command is received, the content of the register is stored in EEPROM.

6.1 List of commands

Table 3. List of command

Command code	Desig- nation	Description	Access limit			Note
			Read (R)/Write (W)	Normal measurement mode	Setup mode	
0x00	ID	Chip ID	R			0x0281 for this chip
0x01	BDATA	Detected result of each channel	R			1 channel 1 bit
0x02	DCH0	Ch0 measured value	R			
0x03	DCH1	Ch1 measured value	R			
0x04	DCH2	Ch2 measured value	R			
0x05	DCH3	Ch3 measured value	R			
0x06	DCH4	Ch4 measured value	R			
0x07	DCH5	Ch5 measured value	R			

Command code	Designation	Description	Access limit			Note
			Read (R)/Write (W)	Normal measurement mode	Setup mode	
0x08	DCH6	Ch6 measured value	R			
0x09	DCH7	Ch7 measured value	R			
0x0A : 0x0D	(System reservation)					
0x0E	CREF0	Current Ch0 reference value	R			Result of drift compensation is reflected.
0x0F	CTHR0	Current Ch0 judging change	R			Result of drift compensation is reflected.
0x10	CHYS0	Current Ch0 hysteresis value	R			Result of drift compensation is reflected.
0x11	CREF1	Current Ch1 reference value	R			Result of drift compensation is reflected.
0x12	CTHR1	Current Ch1 judging change	R			Result of drift compensation is reflected.
0x13	CHYS1	Current Ch1 hysteresis value	R			Result of drift compensation is reflected.
0x14	CREF2	Current Ch2 reference value	R			Result of drift compensation is reflected.
0x15	CTHR2	Current Ch2 judging change	R			Result of drift compensation is reflected.
0x16	CHYS2	Current Ch2 hysteresis value	R			Result of drift compensation is reflected.
0x17	CREF3	Current Ch3 reference value	R			Result of drift compensation is reflected.
0x18	CTHR3	Current Ch3 judging change	R			Result of drift compensation is reflected.
0x19	CHYS3	Current Ch3 hysteresis value	R			Result of drift compensation is reflected.
0x1A	CREF4	Current Ch4 reference value	R			Result of drift compensation is reflected.
0x1B	CTHR4	Current Ch4 judging change	R			Result of drift compensation is reflected.
0x1C	CHYS4	Current Ch4 hysteresis value	R			Result of drift compensation is reflected.
0x1D	CREF5	Current Ch5 reference value	R			Result of drift compensation is reflected.
0x1E	CTHR5	Current Ch5 judging change	R			Result of drift compensation is reflected.
0x1F	CHYS5	Current Ch5 hysteresis value	R			Result of drift compensation is reflected.
0x20	CREF6	Current Ch6 reference value	R			Result of drift compensation is reflected.
0x21	CTHR6	Current Ch6 judging change	R			Result of drift compensation is reflected.

Command code	Designation	Description	Access limit			Note
			Read (R)/Write (W)	Normal measurement mode	Setup mode	
0x22	CHYS6	Current Ch6 hysteresis value	R			Result of drift compensation is reflected.
0x23	CREF7	Current Ch7 reference value	R			Result of drift compensation is reflected.
0x24	CTHR7	Current Ch7 judging change	R			Result of drift compensation is reflected.
0x25	CHYS7	Current Ch7 hysteresis value	R			Result of drift compensation is reflected.
0x26 : 0x35	(System reservation)					
0x36	MSA	Max successive On count	R/W			
0x37	DCI	Drift compensation interval	R/W			
0x38	BPOL	On/Off output polarity select	R/W			
0x39	CHEN	Channel measurement enable	R/W			
0x3A	TCAL	Teaching count number	R/W			
0x3B	TOG	Toggle action	R/W			
0x3C	ACD	Judging count	R/W			
0x3D	SLP	Sleep time	R/W			
0x3E	MODE	Operation mode	R/W			
0x3F	ROMSTR	EEPROM write	R/W			Writing into ROM with dummy write
0x40	REF0	Ch0 reference value	R/W			
0x41	THR0	Ch0 judging change	R/W			
0x42	HYS0	Ch0 hysteresis	R/W			
0x43	RTHR0	Ch0 On-judgment ratio	R/W			Used in teaching
0x44	RHYS0	Ch0 hysteresis ratio	R/W			Used in teaching
0x45	REF1	Ch1 reference value	R/W			
0x46	THR1	Ch1 judging change	R/W			
0x47	HYS1	Ch1 hysteresis	R/W			
0x48	RTHR1	Ch1 On-judgment ratio	R/W			Used in teaching
0x49	RHYS1	Ch1 hysteresis ratio	R/W			Used in teaching
0x4A	REF2	Ch2 reference value	R/W			
0x4B	THR2	Ch2 judging change	R/W			
0x4C	HYS2	Ch2 hysteresis	R/W			
0x4D	RTHR2	Ch2 On-judgment ratio	R/W			Used in teaching

Command code	Designation	Description	Access limit			Note
			Read (R)/Write (W)	Normal measurement mode	Setup mode	
0x4E	RHYS2	Ch2 hysteresis ratio	R/W			Used in teaching
0x4F	REF3	Ch3 reference value	R/W			
0x50	THR3	Ch3 judging change	R/W			
0x51	HYS3	Ch3 hysteresis	R/W			
0x52	RTHR3	Ch3 On-judgment ratio	R/W			Used in teaching
0x53	RHYS3	Ch3 hysteresis ratio	R/W			Used in teaching
0x54	REF4	Ch4 reference value	R/W			
0x55	THR4	Ch4 judging change	R/W			
0x56	HYS4	Ch4 hysteresis	R/W			
0x57	RTHR4	Ch4 On-judgment ratio	R/W			Used in teaching
0x58	RHYS4	Ch4 hysteresis ratio	R/W			Used in teaching
0x59	REF5	Ch5 reference value	R/W			
0x5A	THR5	Ch5 judging change	R/W			
0x5B	HYS5	Ch5 hysteresis	R/W			
0x5C	RTHR5	Ch5 On-judgment ratio	R/W			Used in teaching
0x5D	RHYS5	Ch5 hysteresis ratio	R/W			Used in teaching
0x5E	REF6	Ch6 reference value	R/W			
0x5F	THR6	Ch6 judging change	R/W			
0x60	HYS6	Ch6 hysteresis	R/W			
0x61	RTHR6	Ch6 On-judgment ratio	R/W			Used in teaching
0x62	RHYS6	Ch6 hysteresis ratio	R/W			Used in teaching
0x63	REF7	Ch7 reference value	R/W			
0x64	THR7	Ch7 judging change	R/W			
0x65	HYS7	Ch7 hysteresis	R/W			
0x66	RTHR7	Ch7 On-judgment ratio	R/W			Used in teaching
0x67	RHYS7	Ch7 hysteresis ratio	R/W			Used in teaching
0x68 : 0x7F	(System reservation)					

6.2 Description of commands

6.2.1 ID: Chip ID (read only)

Used as ID of the chip. The data is fixed to 0x0281.

Command code	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0x00	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1

6.2.2 BDATA: Detection result of touch/no-touch for each channel (read only)

Measurement result for each channel is indicated by 1/0.

1: Off (no-touch), 0: On (touch)

Command code	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0x01	1	1	1	1	1	1	1	1	Ch7	Ch6	Ch5	Ch4	Ch3	Ch2	Ch1	Ch0

6.2.3 DCHx: Measured value for each channel (read only)

Measured value for each channel is indicated by an unsigned 16-bit integer.

Command code	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0x02..0x09	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0

Channel 0 (DCH0) Command code 0x02

Channel 1 (DCH1) Command code 0x03

Channel 2 (DCH2) Command code 0x04

Channel 3 (DCH3) Command code 0x05

Channel 4 (DCH4) Command code 0x06

Channel 5 (DCH5) Command code 0x07

Channel 6 (DCH6) Command code 0x08

Channel 7 (DCH7) Command code 0x09

6.2.4 CREFx: Current reference value for each channel (read only)

Current reference value for each channel is indicated by an unsigned 16-bit integer.

Command code	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0x0E..0x23	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0

Channel 0 (CREF0) Command code 0x0E

Channel 1 (CREF1) Command code 0x11

Channel 2 (CREF2) Command code 0x14

Channel 3 (CREF3) Command code 0x17

Channel 4 (CREF4) Command code 0x1A

Channel 5 (CREF5) Command code 0x1D

Channel 6 (CREF6) Command code 0x20

Channel 7 (CREF7) Command code 0x23

6.2.5 CTHR_x: Current judging change for each channel (read only)

Current judging change for each channel is indicated by an unsigned 16-bit integer.

<i>Command code</i>	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0x0F..0x24	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0

Channel 0 (CTHR0)	Command code 0x0F
Channel 1 (CTHR1)	Command code 0x12
Channel 2 (CTHR2)	Command code 0x15
Channel 3 (CTHR3)	Command code 0x18
Channel 4 (CTHR4)	Command code 0x1B
Channel 5 (CTHR5)	Command code 0x1E
Channel 6 (CTHR6)	Command code 0x21
Channel 7 (CTHR7)	Command code 0x24

6.2.6 CHYS_x: Current hysteresis for each channel (read only)

Current hysteresis for each channel is indicated by an unsigned 16-bit integer.

<i>Command code</i>	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0x10..0x25	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0

Channel 0 (CHYS0)	Command code 0x10
Channel 1 (CHYS1)	Command code 0x13
Channel 2 (CHYS2)	Command code 0x16
Channel 3 (CHYS3)	Command code 0x19
Channel 4 (CHYS4)	Command code 0x1C
Channel 5 (CHYS5)	Command code 0x1F
Channel 6 (CHYS6)	Command code 0x22
Channel 7 (CHYS7)	Command code 0x25

6.2.7 MSA: Max successive On count (read/write enabled only in setup mode)

Drift compensation will be effective when On status is successive at MSA × 64 times measurement because of reading that condition as Off status.

In fact, On status will change to Off status after On status is successive at MSA × 64 times. Only the lower-order 8 bits are valid. If the other bits are written to, they are ignored.

<i>Command code</i>	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0x36	1	1	1	1	1	1	1	1	D7	D6	D5	D4	D3	D2	D1	D0

6.2.8 DCI: Drift compensation interval (read/write enabled only in setup mode)

Drift compensation is effective every 2^{DCI} measurement.

Only the lower-order 3 bits are valid. If the other bits are written to, they are ignored.

<i>Command code</i>	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0x37	1	1	1	1	1	1	1	1	1	1	1	1	1	D2	D1	D0

6.2.9 BPOL: On/Off output pole (read/write enabled only in setup mode)

Set the output polarity logic of On/Off output signal.

1:High Active (OUTx terminal is HIGH when touched)

0:Low Active (OUTx terminal is LOW when touched)

Only the lower-order 8 bits are valid. If the other bits are written to, they are ignored.

Command code	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0x38	1	1	1	1	1	1	1	1	Ch7	Ch6	Ch5	Ch4	Ch3	Ch2	Ch1	Ch0

6.2.10 CHEN: Measurement enable for each channel (read/write enabled only in setup mode)

Enable / Disable measurement per channel

1: measurement executed, 0: not executed

Only the lower-order 4 bits are valid. If the other bits are written to, they are ignored.

Command code	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0x39	1	1	1	1	1	1	1	1	Ch7	Ch6	Ch5	Ch4	Ch3	Ch2	Ch1	Ch0

6.2.11 TCAL: Teaching measurement count (read/write enabled only in setup mode)

Defines the termination of the teaching algorithm if not 3 touch events per channel were found with this time.

Only the lower-order 8 bits are valid. If the other bits are written to, they are ignored.

Command code	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0x3A	1	1	1	1	1	1	1	1	D7	D6	D5	D4	D3	D2	D1	D0

6.2.12 TOG: Toggle action (read/write enabled only in setup mode)

Selects momentary or latching output mode. This output takes effect on the signals output from OUT0 - 7 and BDATA command data.

1: Toggle mode off (momentary action: turned on only during a touch event)

0: Toggle mode on (alternate action: turned on with the first touch event and off with the next touch event)

Only the lower-order 8 bits are valid. If the other bits are written to, they are ignored.

Command code	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0x3B	1	1	1	1	1	1	1	1	Ch7	Ch6	Ch5	Ch4	Ch3	Ch2	Ch1	Ch0

6.2.13 ACD: Judging count (read/write enabled only in setup mode)

After ACD value + 1 consecutive measurements a touch event(or no-touch event) is judged and the output state is changed. This takes effect on the output signals from OUT0 - 7 and BDATA command data.

For example, with ACD = 2, after three consecutive measurements are judged as a touch event(or no-touch event), the output state changes.

D7 - D0 : ACDOn (Default: 0010b)

Sets the cumulative judgment count for touch Off to On transition.

D15 - D8 : ACDOff (Default: 0010b)

Sets the cumulative judgment count for touch On to Off transition.

Command code	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0x3C	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0

6.2.14 SLP: Sleep time (read/write enabled only in setup mode)

Defines the duty cycle between one measurement and the next measurement (operate time and sleep time).

Sleep mode is activated for SLP value $\times 10\text{mS}$ (Typ)

When SLP is set to "0", measurements are made consecutively without sleep time.

Only the lower-order 8 bits are valid. If the other bits are written to, they are ignored.

Command code	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0x3D	1	1	1	1	1	1	1	1	D7	D6	D5	D4	D3	D2	D1	D0

6.2.15 MODE: Operation mode (read/write enabled only in setup mode)

Select active mode.

Only the bits described are valid.

If the other bits are written to, they are ignored.

Command code	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0x3E	TS	TER	1	1	1	1	1	1	1	1	1	1	DCF	DC	CHG	1

TS: Teaching start

0: Teaching mode is entered when "0" is written in this bit.

1: During read out this bit is always "1"

TER: Teaching error flag

Set/reset according to result of teaching.

Is set to "1" when teaching finishes normally.

If a teaching error occurs, this bit is set to "0".

This flag is not cleared automatically. To clear this flag, write "1" to this bit.

DC: Drift compensation

Enable/disable the drift compensation function.

1: Drift compensation is enabled. 0: Drift compensation is disabled.

DCF: Drift compensation type

Sets the target for drift compensation.

0: Only the reference value is corrected. The On-judgment variation quantity and hysteresis are not corrected.

1: All values are compensated (default).

CHG: CHG pin function

The signal is specified from the CHG pin in normal measurement mode (serial communication mode).

With this pin set to "1", when on/off changes in any channel (when any channel is touched (comes into on state) or changes from touch to no-touch (goes to off state)), the signal is high.

When this pin is set to "0", the signal is high every time a measurement finishes.

6.2.16 ROMSTR: EEPROM write (only write is enabled in setup mode)

When this command is issued by setting the data to 0x5354, all the parameter data are written to the built in EEPROM

If the data is different than 0x5354, this command is ignored.

Until this command is issued, the written data is stored in RAM.

During write to the EEPROM, the CHG pin remains low.

Command code	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0x3F	0	1	0	1	0	0	1	1	0	1	0	1	0	1	0	0

6.2.17 REFx: Reference value for each channel (read/write enabled only in setup mode)

The reference value for each channel can be set with an unsigned 16-bit integer.

Can only be changed in setup mode or rewrite automatically by teaching.

It is not changed by drift compensation.

Command code 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0

0x40..0x63	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
------------	-----	-----	-----	-----	-----	-----	----	----	----	----	----	----	----	----	----	----

Channel 0 (REF0) Command code 0x40

Channel 1 (REF1) Command code 0x45

Channel 2 (REF2) Command code 0x4A

Channel 3 (REF3) Command code 0x4F

Channel 4 (REF4) Command code 0x54

Channel 5 (REF5) Command code 0x59

Channel 6 (REF6) Command code 0x5E

Channel 7 (REF7) Command code 0x63

6.2.18 THRx: Defines the threshold to judge a touch event (read/write enabled only in setup mode)

signal change or Threshold to judge a touch event for each channel can be set with an unsigned 16-bit integer.

Can only be changed in setup mode or rewrite automatically by the teaching function.

It is not changed by drift compensation.

Command code 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0

0x41..0x64	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
------------	-----	-----	-----	-----	-----	-----	----	----	----	----	----	----	----	----	----	----

Channel 0 (THR0) Command code 0x41

Channel 1 (THR1) Command code 0x46

Channel 2 (THR2) Command code 0x4B

Channel 3 (THR3) Command code 0x50

Channel 4 (THR4) Command code 0x55

Channel 5 (THR5) Command code 0x5A

Channel 6 (THR6) Command code 0x5F

Channel 7 (THR7) Command code 0x64

6.2.19 HYSx: Hysteresis for each channel (read/write enabled only in setup mode)

Hysteresis for each channel can be set with an unsigned 16-bit integer.

Can only be changed in setup mode or rewrite automatically by the teaching function.

It is not changed by drift compensation.

Command code 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0

0x42..0x65	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
------------	-----	-----	-----	-----	-----	-----	----	----	----	----	----	----	----	----	----	----

Channel 0 (HYS0) Command code 0x42

Channel 1 (HYS1) Command code 0x47

Channel 2 (HYS2) Command code 0x4C

Channel 3 (HYS3) Command code 0x51

Channel 4 (HYS4) Command code 0x56

Channel 5 (HYS5) Command code 0x5B

Channel 6 (HYS6) Command code 0x60

Channel 7 (HYS7) Command code 0x65

6.2.20 RTHR_x: On-judgment ratio for each channel (read/write enabled only in setup mode)

Used in teaching.

Sets the ratio of the quantity of judging change (THR_x) to the measured value observed in teaching with an unsigned 4-bit integer. (Refer to "7. Teaching" for details)

Only the lower-order 4 bits are valid. If the other bits are written to, they are ignored.

If the measured value changes by ΔA due to a touch during teaching, the quantity of judging change that is newly set in teaching (THR_x) is calculated as:

$$\text{Quantity of judging change (THR}_x) = \Delta A \times (\text{on-judgment ratio (RTHR}_x) + 81) / 16$$

For example, if RTHR_x = 10, the quantity of judging change (THR_x) is:

$$\text{THR}_x = \Delta A \times (10 + 1) / 16 \cong \Delta A \times 0.69 \text{ (about 70\% of } \Delta A)$$

<i>Command code</i>	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0x43..0x66	1	1	1	1	1	1	1	1	1	1	1	1	D3	D2	D1	D0

Channel 0 (RTHR0) Command code 0x43

Channel 1 (RTHR1) Command code 0x48

Channel 2 (RTHR2) Command code 0x4D

Channel 3 (RTHR3) Command code 0x52

Channel 4 (RTHR4) Command code 0x57

Channel 5 (RTHR5) Command code 0x5C

Channel 6 (RTHR6) Command code 0x61

Channel 7 (RTHR7) Command code 0x66

6.2.21 RHYS_x: Hysteresis ratio for each channel (read/write enabled only in setup mode)

Used in teaching.

Sets the ratio of hysteresis (HYS_x) to the measured value observed in teaching with an unsigned 4-bit integer. (Refer to "7. Teaching" for details)

Only the lower-order 4 bits are valid. If the other bits are written to, they are ignored.

If the measured value changes by ΔA due to a touch during teaching, the new hysteresis that is set in teaching (HYS_x) is calculated as:

$$\text{Hysteresis (HYS}_x) = \Delta A \times (\text{Hysteresis ratio (RHYS}_x) / 16)$$

For example, if RHYS_x = 2, hysteresis (HYS_x) is:

$$\text{HYS}_x = \Delta A \times 2 / 16 \cong \Delta A \times 0.13 \text{ (about 13\% of } \Delta A)$$

<i>Command code</i>	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0x44..0x67	1	1	1	1	1	1	1	1	1	1	1	1	D3	D2	D1	D0

Channel 0 (RHYS0) Command code 0x43

Channel 1 (RHYS1) Command code 0x49

Channel 2 (RHYS2) Command code 0x4E

Channel 3 (RHYS3) Command code 0x53

Channel 4 (RHYS4) Command code 0x58

Channel 5 (RHYS5) Command code 0x5D

Channel 6 (RHYS6) Command code 0x62

Channel 7 (RHYS7) Command code 0x67

* Refer to "6.1 List of commands" for the command code corresponding to each channel.

6.3 Default parameters in the EEPROM (shown in the Workbench monitor)

Setup parameters

Device: B6TS-08LF

Read from file Write to file close

Read from B6TS Write to B6TS

General settings(MODE)

Output mode(CON)

Serial

On/Off

CHG active (CHG)

Every Measurement

On/Off

Drift compensation(DC,DCF)

Disable

REFx only

All

Drift correction interval(DCI)

= Times

Max successive ON count(MSA)

= Times

Teaching measurement count(TCAL)

= Times

Judging count(ACD)

OFF->ON

= Times

ON->OFF

= Times

Sleep time(SLP)

= mS

channel	0	1	2	3
Enable(CHEN)/Latching(TOG)	momentar: ▾	momentar: ▾	momentar: ▾	momentar: ▾
Pole(BPOL)	Low Activ ▾	Low Activ ▾	Low Activ ▾	Low Activ ▾
Reference value(REFx)	<input type="text" value="300"/>	<input type="text" value="300"/>	<input type="text" value="300"/>	<input type="text" value="300"/>
Judging change(THRx)	<input type="text" value="30"/>	<input type="text" value="30"/>	<input type="text" value="30"/>	<input type="text" value="30"/>
Hysteresis(HYSx)	<input type="text" value="5"/>	<input type="text" value="5"/>	<input type="text" value="5"/>	<input type="text" value="5"/>
On judging ratio(RTHRx)	<input type="text" value="9"/>	<input type="text" value="9"/>	<input type="text" value="9"/>	<input type="text" value="9"/>
Hysteresis ratio(RHYSx)	<input type="text" value="1"/>	<input type="text" value="1"/>	<input type="text" value="1"/>	<input type="text" value="1"/>
On/Off threshold	<input type="text" value="270"/>	<input type="text" value="270"/>	<input type="text" value="270"/>	<input type="text" value="270"/>

channel	4	5	6	7
Enable(CHEN)/Latching(TOG)	momentar: ▾	momentar: ▾	momentar: ▾	momentar: ▾
Pole(BPOL)	Low Activ ▾	Low Activ ▾	Low Activ ▾	Low Activ ▾
Reference value(REFx)	<input type="text" value="300"/>	<input type="text" value="300"/>	<input type="text" value="300"/>	<input type="text" value="300"/>
Judging change(THRx)	<input type="text" value="30"/>	<input type="text" value="30"/>	<input type="text" value="30"/>	<input type="text" value="30"/>
Hysteresis(HYSx)	<input type="text" value="5"/>	<input type="text" value="5"/>	<input type="text" value="5"/>	<input type="text" value="5"/>
On judging ratio(RTHRx)	<input type="text" value="9"/>	<input type="text" value="9"/>	<input type="text" value="9"/>	<input type="text" value="9"/>
Hysteresis ratio(RHYSx)	<input type="text" value="1"/>	<input type="text" value="1"/>	<input type="text" value="1"/>	<input type="text" value="1"/>
On/Off threshold	<input type="text" value="270"/>	<input type="text" value="270"/>	<input type="text" value="270"/>	<input type="text" value="270"/>

Figure 8. Default parameters in the EEPROM

7. Teaching

7.1 Outline of teaching

Such parameters as the quantity of judging change can be set automatically through actual touches on the electrode. This operation is called "Teaching".

When teaching, the reference value (REFx), quantity of judging change (THRx) and hysteresis (HYSx) are updated appropriately, and stored in the EEPROM built into the chip.

Before performing a teaching operation, some preparation is required. The processing flow is as follows 7.2.

During teaching, serial communication is not available. However, checking the CHG pin allows status to be checked.

Once teaching mode is entered, any input other than /RESET is invalid until the measurement finishes and the chip comes out of teaching mode. Be aware that serial communication cannot be performed concurrently.

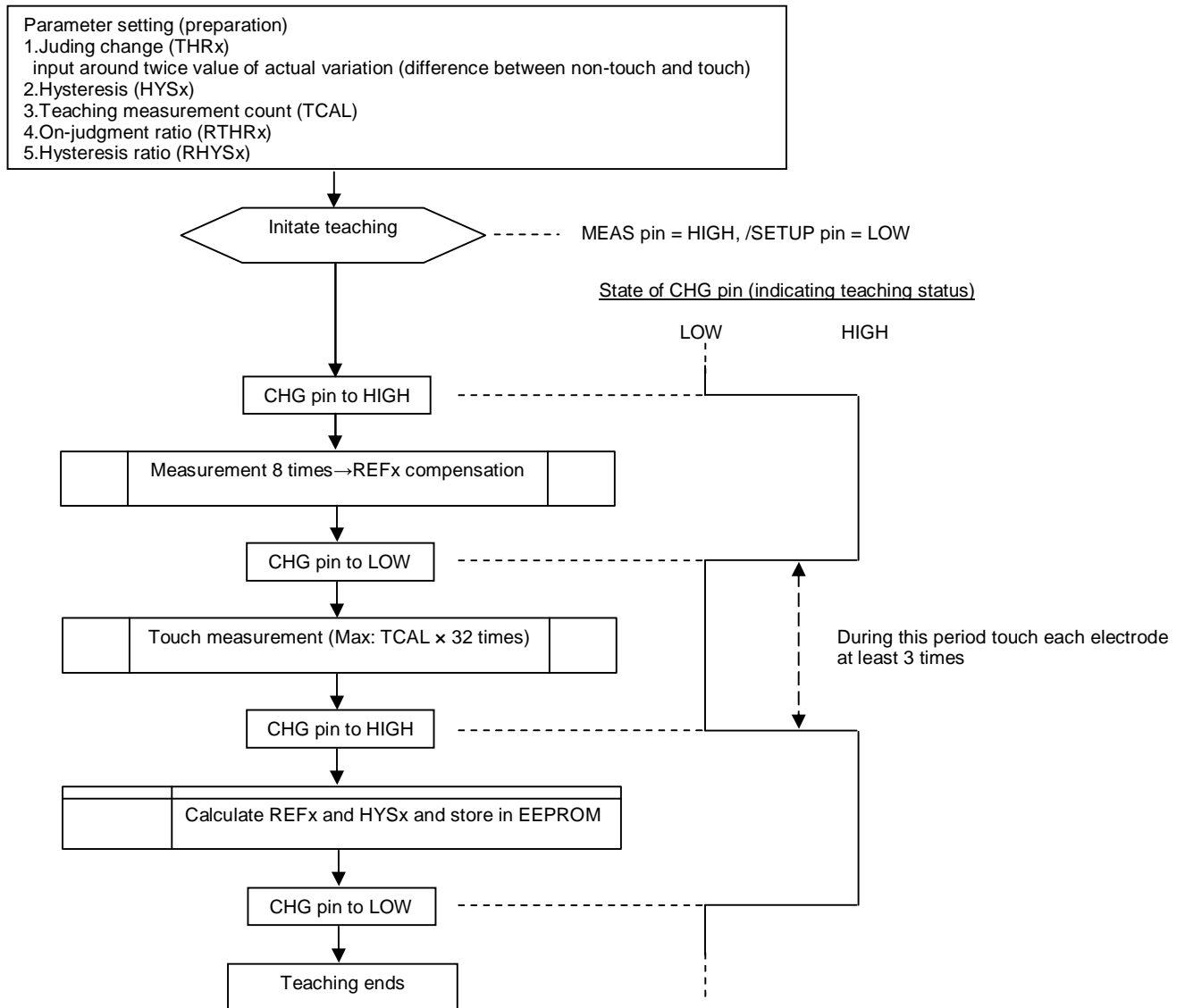


Figure 9. teaching flow

7.2 Preparation for teaching

To perform teaching, this chip must be brought into setup mode and some parameters must be set. The parameters (commands) associated with teaching are as follows:

7.2.1 Teaching measurement count (Refer to "6.2.8 TCAL: Teaching measurement count")

During teaching, measurement is executed x number of times where x is the value of this parameter $\times 32$. (Hereafter, this is referred to as the teaching measurement count)

It takes 30–100 msec for one teaching measurement (depending on external circuit constants), and if this parameter is set to 10, the touches must be executed within 10-30 seconds.

Unless each electrode is touched three times within the number of teaching measurements after starting teaching, the teaching is regarded as faulty, and none of the parameters are updated.

However, when this parameter is set to "0", only the reference value (REFx) is updated. In this case, no touching is required, and the teaching is not regarded as faulty even if no touches are executed.

7.2.2 On-judgment ratio (refer to "6.2.15 THR_x: On-judgment ratio for each channel")

This parameter contains the quantity of variation of the measured value that will allow judgment of a touch (approximate value).

To distinguish between variation of the measured value caused by a noise or the like and variation caused by touching during teaching, this parameter must be set to an approximate value.

If variation of half of this set value occurs during teaching, the electrode is judged touched. Therefore, an approximate value for variation likely to have been caused by touch may be entered.

7.2.3 Hysteresis ratio (Refer to "6.2.16 HYS_x: Hysteresis ratio for each channel")

This parameter sets the hysteresis value in teaching (approximate value).

7.2.4 On-judgment ratio (Refer to "6.2.17 RTHR_x: On-judgment ratio for each channel") and

Hysteresis ratio (Refer to "6.2.17 RHYS_x: Hysteresis ratio for each channel")

These parameters set the ratios of the quantity of judging change (THR_x) and hysteresis (HYS_x) to the variation of the measured value caused by touch.

During teaching, each electrode must be touched three times or more. Then, the minimum value of the quantity of variation caused by touch is calculated for each electrode of the chip. (Minimum value of quantity of variation)

The new quantity of judging change and the new hysteresis are calculated using the minimum value of quantity of variation ΔA as:

$$\text{Quantity of judging change (THR}_x\text{)} = \Delta A \times (\text{On-judgment ratio (RTHR}_x\text{)} + 1) / 16$$

$$\text{Hysteresis (HYS}_x\text{)} = \Delta A \times (\text{Hysteresis ratio (RHYS}_x\text{)}) / 16$$

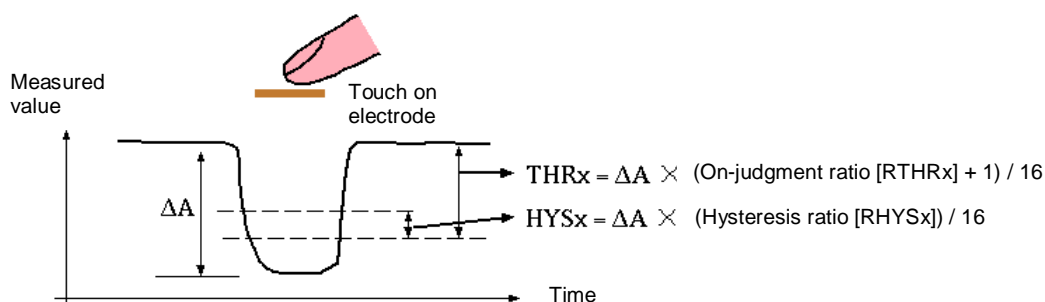


Figure 10. teaching parameter setting

7.3 Performing teaching

There are two ways to enter teaching mode:

- (1) /SETUP pin = low, and MEAS pin = high
- (2) Write "0" into bit15 (TS) using the MODE command in setup mode.

When entering teaching mode by method (1), set the /SETUP pin to high or the MEAS pin to low before teaching finishes. If /SETUP pin = high and the MEAS pin = low, teaching will commence again.

When entering teaching mode, the CHG pin changes to high, indicating entry to teaching mode.

Just after teaching has started, the chip calibrates the reference value (REFx) (the measured value with no-touch). The measurement is performed eight times for each electrode, and the average of the eight measured values is taken as REFx. After the calibration finishes, the CHG pin output changes to low. Do not touch the touch electrode until the CHG pin changes to low.

After REFx has been calibrated, the chip starts the teaching measurement count ((TCAL)×32 times). During this period, touch each electrode three times or more. The order for touching each of the electrodes is not defined. After the specified number of teaching measurements have finished, the CHG pin changes to high. However, if the number of touches (the number of times the chip recognizes a touch) reaches 32, the chip finishes measuring and changes the CHG pin to high, even if the teaching measurement count has not been reached. When touching the electrodes, do not touch two or more electrodes at the same time. If you do, teaching cannot be performed correctly. If more than one electrode is touched simultaneously in error, touch each of the electrodes touched simultaneously again. Touch all of the electrodes three times or more within the teaching measurement time.

After the touch measurements have finished, the chip updates the quantity of judging change (THR_x), and hysteresis (HYS_x) according to the calculation formula described in "7.2.4 On-judgment ratio and hysteresis ratio" (updates the values stored in the built-in ROM). After the values are updated, the CHG pin changes to low and teaching finishes.

7.4 Checking the result of teaching

When teaching finishes correctly, bit14 (TER bit) of the data, which can be read with the MODE command, changes to "1". If teaching is not completed normally because the specified number of touches are not executed within the teaching measurement time or for some other reason, the TER bit changes to "0" and the quantity of judging change (THR_x) and hysteresis (HYS_x) are not updated. (In this event, only the reference value (REFx) is updated.)

To reset the TER bit, set it to "1" using the MODE command, or perform teaching again (and finish the teaching operation normally).

8. Electrical characteristics

8.1 Absolute maximum ratings

Designation	Item	Condition	Rated value	Unit
V_{dd}	Supply voltage		-0.3 - 6.5	V
V_I	Input voltage		-0.3 - $V_{dd} + 0.3$	V
V_O	Output voltage		-0.3 - $V_{dd} + 0.3$	V
P_d	Power dissipation	$T_{opr}=25^{\circ}\text{C}$	500	mW
T_{opr}	Ambient operating temperature		-20 - 85	$^{\circ}\text{C}$
T_{stg}	Storage temperature		-65 - 150	$^{\circ}\text{C}$

8.2 Recommended operating conditions

Note 1: Unless otherwise specified, $V_{dd} = 3.0\text{-}5.5\text{V}$, $T_{opr} = -20 - 85^{\circ}\text{C}$

Designation	Item	Condition	Rated value			Unit
			Minimum	Standard	Maximum	
V_{dd}	Supply voltage		3.0		5.5	V
V_{IH}	High input voltage		$0.8V_{dd}$		V_{dd}	V
V_{IL}	Low input voltage		0		$0.2V_{dd}$	V
I_{OH}	High output current				40	mA
I_{OL}	Low output current				-40	mA

8.3 Electrical characteristics

Designation	Item	Condition	(Note 1)			Unit
			Minimum	Standard	Maximum	
V_{OH}	High Output voltage	$I_{OH}=-5\text{mA}$	$V_{dd}-0.2$		V_{dd}	V
V_{OL}	Low Output voltage	$I_{OL}=5\text{mA}$			2.0	V
I_{IH}	High Input current	$V_I=5\text{V}$ $V_{dd}=5\text{V}$			5	μA
I_{IL}	Low Input current	$V_I=0\text{V}$ $V_{dd}=5\text{V}$			-5	μA
I_{CC}	Supply current	Normal measurement mode		6.5		mA
		Sleep mode		1.2		mA
-	Number of times of EEPROM write	$T_{OPR}=0 - 60^{\circ}\text{C}$	10,000			Times
-	EEPROM write time	$V_{dd}=5\text{V}$, $T_{OPR}=25^{\circ}\text{C}$ (Note 2)		400		mS
-	EEPROM data retention period	$T_{OPR}=55^{\circ}\text{C}$	20			Years

Note 1: Unless otherwise specified, $V_{dd} = 3.0\text{-}5.5\text{V}$, $T_{opr} = -20 - 85^{\circ}\text{C}$

Note 2: The period following receipt of the EEPROM write command in setup mode until the data write finishes.

8.4 Necessary timing conditions

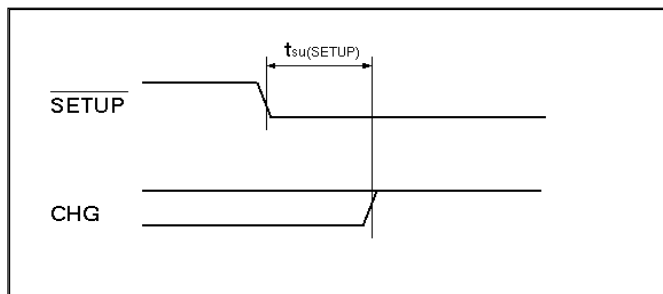
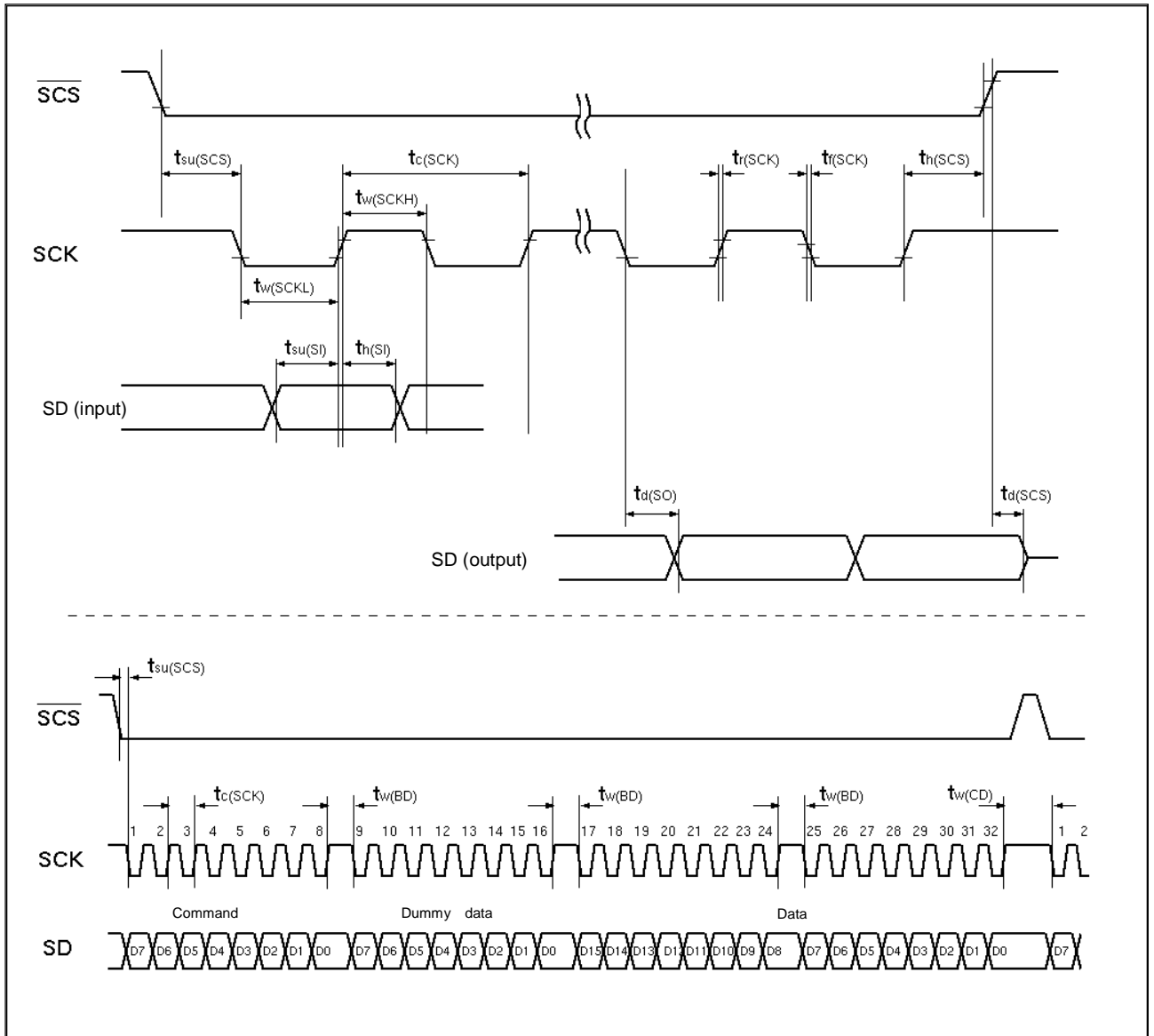


Figure 11. Timing conditions diagram

Table 4. Necessary timing conditions

Designation	Item	Condition	Rated value			Unit
			Minimum	Standard	Maximum	
$t_{c(SCK)}$	Serial communication clock cycle time		15			μ S
$t_{w(SCKH)}$	Serial communication clock high pulse width			0.4	0.6	μ S
$t_{w(SCKL)}$	Serial communication clock low pulse width			0.4	0.6	μ S
$t_{su(SCS)}$	/SCS setup time to CLK		320			nS
$t_{h(SCS)}$	/SCS hold time to CLK		320			nS
$t_{d(SO)}$	Serial communication output delay time				280	nS
$t_{su(SI)}$	Serial communication input setup time		120			nS
$t_{h(SI)}$	Serial communication input hold time		120			nS
$t_{w(BD)}$	Serial communication byte to byte interval		100			μ S
$t_{w(CD)}$	Serial communication command reception interval				400	μ S
$t_{w(CHG)}$	CHG pulse width (reference)	(Note 2)		20.5		mS
$t_{su(SETUP)}$	Mode shift delay time	(Note 3)			100	μ S
$t_{w(RESET)}$	Reset pulse width		500			μ S
$t_{h(PWON)}$	Power-on time	(Note 4)		250		ms

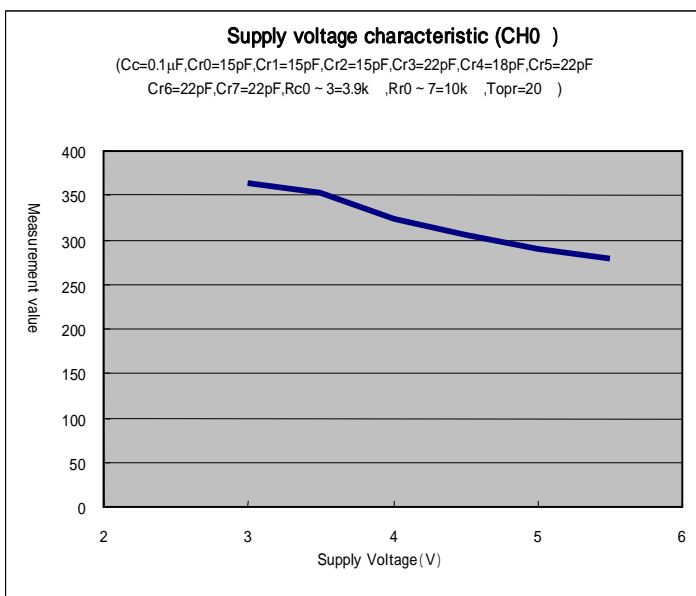
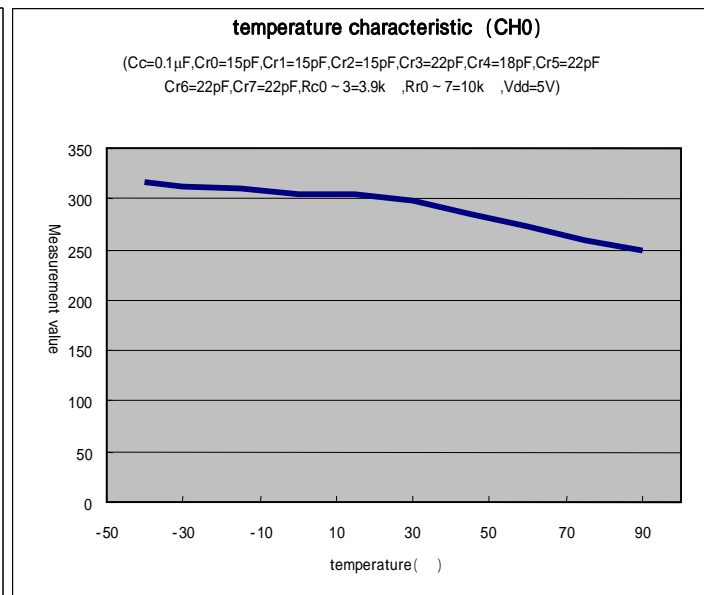
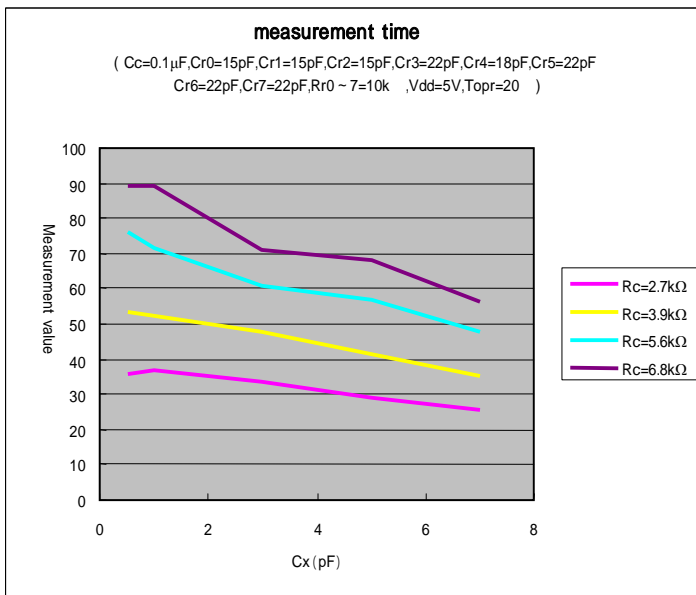
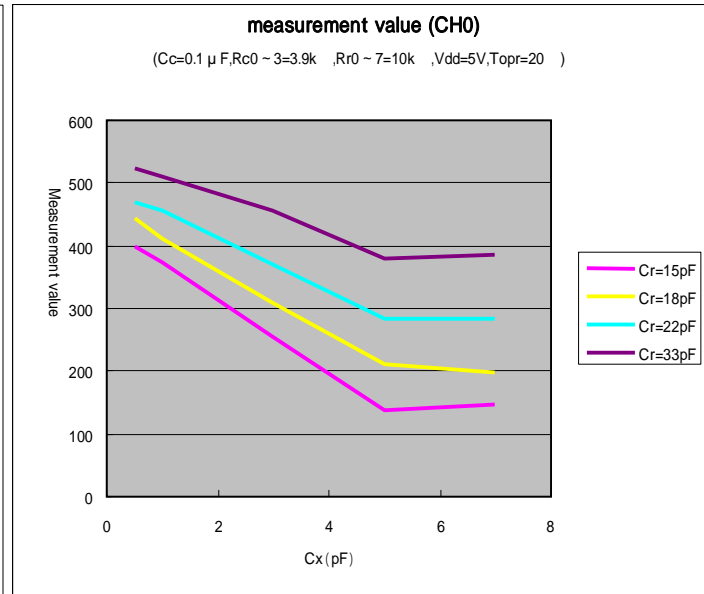
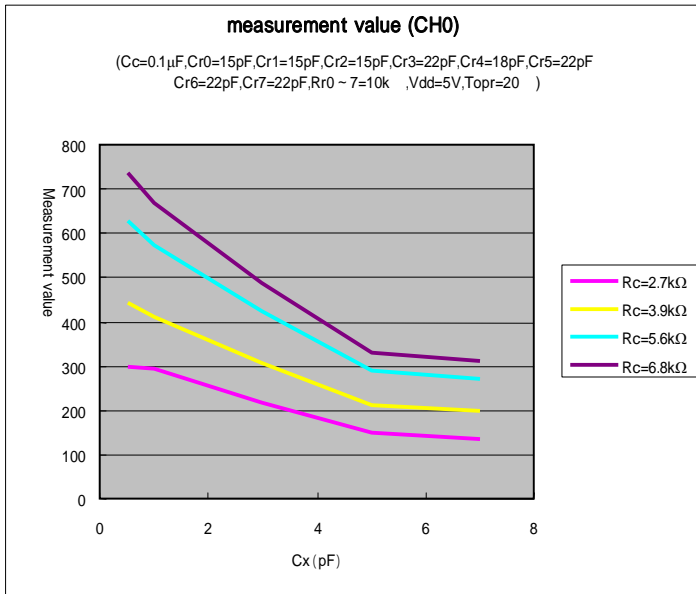
Note 1: Unless otherwise specified, $V_{dd} = 5.0V$, $T_{opr} = 25^{\circ}C$.

Note 2: This is the time period when the condition that CHG pulse width is at its minimum in the serial communication mode of normal measurement mode is set. (CHG pin function is set to output at the end of every measurement [CHG bit = 0 with MODE command]) and the sleep time is set to zero [SLP command value = 0]).

Note 3: The delay time for the mode shift between normal measurement mode and setup mode.

Note 4: Reference data. (When power-on Reset function is used)

8.5 Measurement characteristics (typical example)



9. Appearance and dimensions

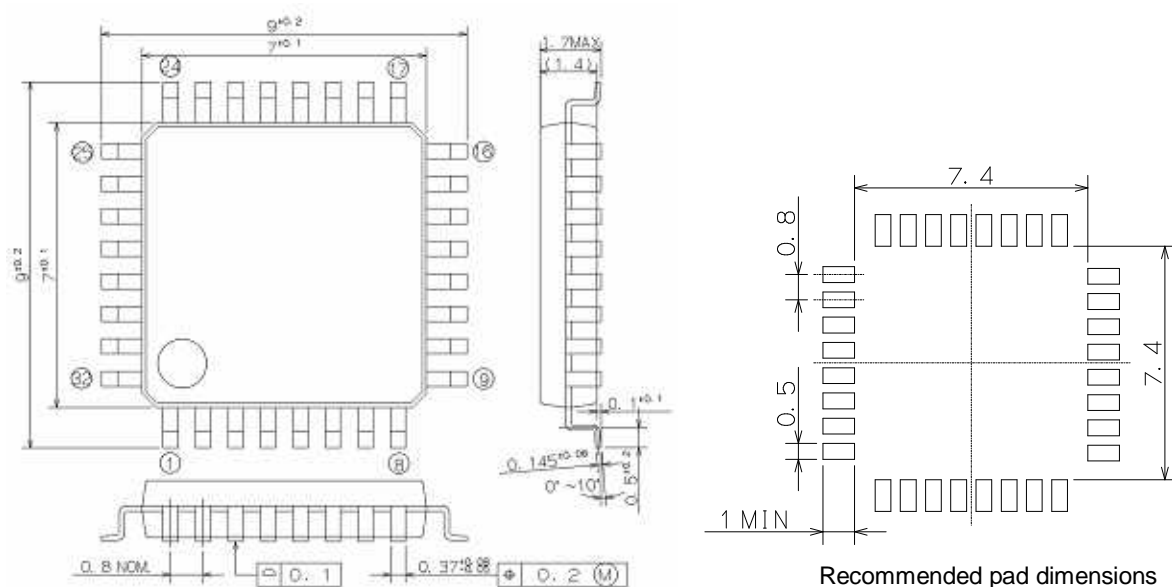


Figure 12. Appearance and dimensions

Warranty Details

1. Warranty period

The warranty period for an OMRON product is one year from purchase or delivery to a customer-specified place.

2. Scope of warranty

If any OMRON product fails under OMRON liability within the above warranty period, OMRON shall supply a replacement or repair the product free of charge at the place of purchase. However, if the reason for the product failure falls into any of the following categories, the warranty will not apply:

- The product has been used or handled under conditions or in an environment not listed in the product's specifications, catalog, or operation manual (hereinafter referred to as the "catalog and the like").
- The failure has been caused by a non-OMRON product.
- The product has been modified or repaired by somebody or corporation other than OMRON.
- The product has been used for other than its intended use.
- The failure could not have been predicted based on the level of science or technology at the time of shipment.
- The failure has been caused by a natural or other disaster, an accident or the like that is not OMRON's liability.

This warranty applies only to the OMRON product itself, and any damage induced by a failed OMRON product is excluded from this warranty.

3. Scope of service

The price of an OMRON product does not include service expenses such as the cost of sending out technicians. If you wish to request non-inclusive services, please consult OMRON sales personnel.

4. Scope of application

The above apply only to business and usage in Japan. Please consult OMRON sales personnel about business and usage in other countries.