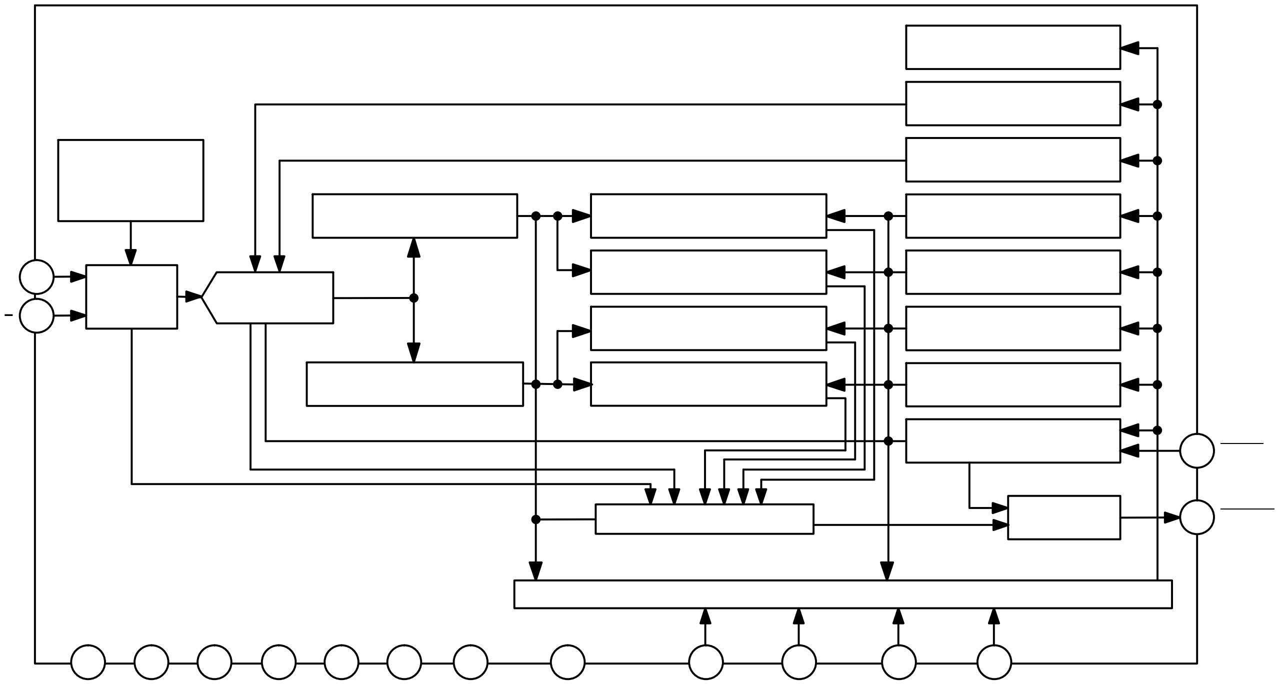
NCT210

Low Cost Microprocessor System Temperature Monitor Microcomputer

The NCT210 is a two-channel digital thermometer and under/overtemperature alarm, intended for use in personal computers

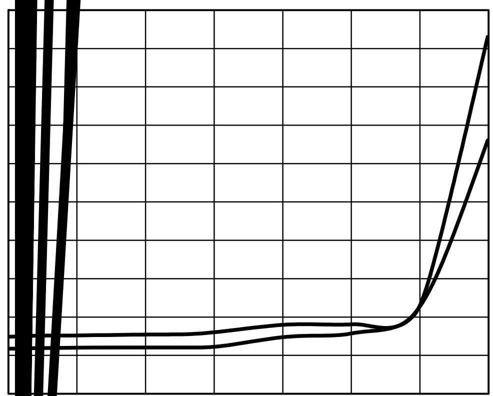
Publication Order Number:

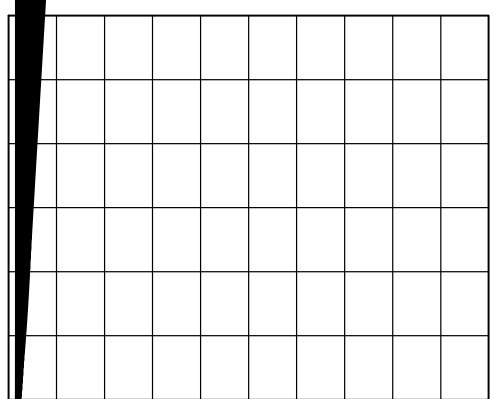


1	NC	No Connect
2	V_{DD}	Positive Supply, 3.0 V to 5.5 V
3	D+	Positive Connection to Remote Temperature Sensor
4	D−	Negative Connection to Remote Temperature Sensor
5	NC	No Connect
6	ADD1	Three-state Logic Input, Higher Bit of Device Address
7	GND	Supply 0 V Connection
8	GND	Supply 0 V Connection
9	NC	No Connect
10	ADD0	Three-state Logic Input, Lower Bit of Device Address
11	$\overline{ALERT}$	

Positive Supply Voltage (V_{DD}) to GND	−0.3 to +6.0	V
D+, ADD0, ADD1	−0.3 to V_{DD} +0.3	V
D− to GND	−0.3 to +0.6	
SCLK, SDATA, $\overline{ALERT}$, $\overline{STBY}$	−0.3 to +6.0	V
Input Current	±50	mA
Input Current, D−	±1	mA
ESD Rating, All Pins (Human Body Model)	2,000	V
Continuous Power Dissipation Up to 70°C Derating Above 70°C	 650 6.7	 mW mW/°C
Operating Temperature Range	−55 to +125	°C
Maximum Junction Temperature ($T_{J\,MAX}$)	150	°C
Storage Temperature Range	−65 to +150	°C
Lead Temperature, Soldering (10 sec)	300	°C
IR Reflow Peak Temperature	220	°C

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.





The NCT210 contains a two-channel A-to-D converter with special input-signal conditioning to enable operation with remote and on-chip diode temperature sensors. When the NCT210 is operating normally, the A-to-D converter operates in free-running mode. The analog input multiplexer alternately selects either the on-chip temperature sensor to measure its local temperature or the remote temperature sensor. These signals are digitized by the ADC and the results stored in the local and remote temperature value registers as 8-bit, twos complement words.

The measurement results are compared with local and remote, high and low temperature limits, stored in four on-chip registers. Out-of-limit comparisons generate flags that are stored in the status register, and one or more out-of-limit results will cause the $\overline{\text{ALERT}}$ output to pull low.

The limit registers can be programmed and the device controlled and configured via the serial System Management Bus (SMBus). The contents of any register can also be read back via the SMBus.

Control and configuration functions consist of:

- Switching the Device between Normal Operation and Standby Mode
- Masking or Enabling the $\overline{\text{ALERT}}$ Output
- Selecting the Conversion Rate

On initial powerup, the remote and local temperature values default to –128°C. Since the device normally powers up converting, a measurement of local and remote temperature is made, and these values are then stored before

One LSB of the ADC corresponds to 1°C so the ADC can theoretically measure from 128°C to +127°C, although the device does not measure temperatures below 65°C; therefore, the actual range is 65°C to 127°C. The temperature data format is shown in Table 5.

The results of the local and remote temperature measurements are stored in the local and remote temperature value registers and are compared with limits programmed into the local and remote high and low limit registers.

°	
−65	1 011 1111
−55	1 100 1001
−25	1 110 0111
0	0 000 0000
1	0 000 0001
10	0 000 1010
25	0 001 1001
50	0 011 0010
75	0 100 1011
100	0 110 0100
125	0 111 1101
127	0 111 1111

The NCT210 contains nine registers that are used to store the results of remote and local temperature measurements, and high and low temperature limits, and to configure and control the device. A description of these registers follows, and further details are given in Table 6 to Table 8. It should be noted that the NCT210's registers are dual port and have different addresses for read and write operations. Attempting to write to a read address, or to read from a write address, produces an invalid result. Register addresses above 0x0F are reserved for future use or used for factory test purposes and should not be written to.

The address pointer register does not have and does not require an address, because it is the register to which the first data byte of every write operation is written automatically.

Not Applicable	Not Applicable	Address Pointer	Undefined
00	Not Applicable	Local Temperature Value	1000 0000 (0x80) (−128°C)
01	Not Applicable	Remote Temperature Value	1000 0000 (0x80) (−128°C)
02	Not Applicable	Status	Undefined
03	09	Configuration	0000 0000 (0x00)
04	0A	Conversion Rate	0000 0010 (0x02)
05	0B	Local Temperature High Limit	0111 1111 (0x7F) (+127°C)
06	0C	Local Temperature Low Limit	1100 1001 (0xC9) (−55°C)
07	0D	Remote Temperature High Limit	0111 1111 (0x7F) (+127°C)
08	0E	Remote Temperature Low Limit	1100 1001 (0xC9) (−55°C)
Not Applicable	0F (Note 1)	One-shot	
10	Not Applicable	Reserved	Reserved for Future Versions
12	12	Reserved	Reserved for Future Versions
13	13	Reserved	Reserved for Future Versions
14	14	Reserved	Reserved for Future Versions
15	16	Reserved	Reserved for Future Versions
17	18	Reserved	Reserved for Future Versions
19	Not Applicable	Reserved	Reserved for Future Versions
20	21	Reserved	Reserved for Future Versions
FE	Not Applicable	Manufacturer Device ID	0100 0001 (0x41)
FF	Not Applicable	Die revision Code	0011 xxxx (0x3x)

1. Writing to Address 0F causes the NCT210 to perform a single measurement. It is not a data register and data written to it is irrelevant.

The $\overline{\text{ALERT}}$ interrupt latch is not reset by reading the status register, but is reset when the $\overline{\text{ALERT}}$ output is serviced by the master reading the device address, provided the error condition has gone away and the status register flag bits have been reset.

Two bits of the configuration register are used. If Bit 6 is 0, which is the power-on default, the device is in operating mode with the ADC converting. If Bit 6 is set to 1, the device is in standby mode and the ADC does not convert. Standby mode can also be selected by taking the $\overline{\text{STBY}}$ pin low. In standby mode, the values stored in the remote and local temperature registers remain at the values they were when the part was placed in standby.

Bit 7 of the configuration register is used to mask the $\overline{\text{ALERT}}$ output. If Bit 7 is 0, which is the power-on default, the $\overline{\text{ALERT}}$ output is enabled. If Bit 7 is set to 1, the $\overline{\text{ALERT}}$ output is disabled.

7	MASK1	0 = $\overline{\text{ALERT}}$ Enabled 1 = $\overline{\text{ALERT}}$ Masked	0
6	$\overline{\text{RUN}}$/STOP	0 = Run 1 = Standby	0
5 to 0		Reserved	0

The lowest three bits of this register are used to program the conversion rate by dividing the ADC clock by 1, 2, 4, 8, 16, 32, 64, or 128 to give conversion times from 125 ms (Code 0x07) to 16 seconds (Code 0x00). This register can be written to and read back over the SMBus. The higher five bits of this register are unused and must be set to 0. Use of slower conversion times greatly reduces the device power consumption, as shown in Table 9.

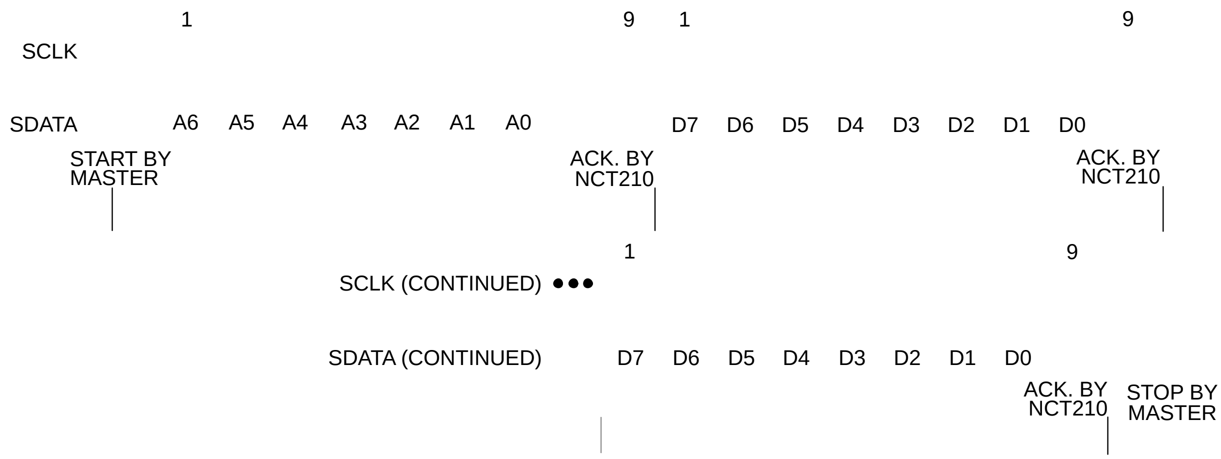
before the 10th clock pulse, then high during the 10th clock pulse to assert a stop condition.

Any number of bytes of data can be transferred over the serial bus in one operation, but it is not possible to mix read and write in one operation, because the type of operation is determined at the beginning and cannot subsequently be changed without starting a new operation.

For the NCT210, write operations contain either one or two bytes, while read operations contain one byte.

To write data to one of the device data registers or read data from it, the address pointer register must be set so that the correct data register is addressed, data can then be written into that register or read from it. The first byte of a write operation always contains a valid address that is stored in the address pointer register. If data is to be written to the device, the write operation contains a second data byte that is written to the register selected by the address pointer register.

This is illustrated in Figure 13. The device address is sent over the bus followed by $R/\overline{W}$ set to 0. This is followed by two data bytes. The first data byte is the address of the internal data register to be written to, which is stored in the address pointer register. The second data byte is the data to be written to the internal data register.



by the data byte read from the data register. This is shown in Figure 15.

2. If the address pointer register is known to be already at the desired address, data can be read from the corresponding data register without first writing to the address pointer register, so Figure 14 can be omitted.

NOTES: Although it is possible to read a data byte from a data register without first writing to the address pointer register, if the address pointer register is already at the correct value, it is not possible to write data to a register without writing to the address pointer register; this is because the first data byte of a write is always written to the address pointer register.

Remember that the NCT210 registers have different addresses for read and write operations. The write address of a register must be written to the address pointer if data is to be written to that register, but it is not possible to read data from that address. The read address of a register must be written to the address pointer before data can be read from that register.

The $\overline{\text{ALERT}}$ output goes low whenever an out-of-limit measurement is detected, or if the remote temperature sensor is open-circuit. It is an open drain and requires a 10 kΩ pullup to V_{DD}. Several $\overline{\text{ALERT}}$ outputs can be wire-ANDed together so the common line goes low if one or more of the $\overline{\text{ALERT}}$ outputs goes low.

The $\overline{\text{ALERT}}$ output can be used as an interrupt signal to a processor, or it can be used as an $\overline{\text{SMBALERT}}$. Slave devices on the SMBus cannot normally signal to the master that they want to talk, but the $\overline{\text{SMBALERT}}$ function allows them to do so.

One or more $\overline{\text{ALERT}}$ outputs are connected to a common $\overline{\text{SMBALERT}}$

obtained by choosing devices according to the following criteria:

1. Base-emitter voltage greater than 0.25 V at 6 μA, at the highest operating temperature.
2. Base-emitter voltage less than 0.95 V at 100 μA, at the lowest operating temperature.
3. Base resistance less than 100 Ω.
4. Small variation in h_{FE} (such as 50 to 150), which indicates tight control of V_{BE} characteristics.

Transistors, such as 2N3904, 2N3906, or equivalents, in SOT 23 package are suitable devices to use.

Accuracy depends on the temperature of the remote-sensing diode and/or the internal temperature sensor being at the same temperature as that being measured, and a number of factors can affect this. Ideally, the sensor should be in good thermal contact with the part of the system being measured, for example the processor. If it is not, the thermal inertia caused by the mass of the sensor causes a lag in the response of the sensor to a temperature change. For the remote sensor, this should not be a problem, because it is either a substrate transistor in the processor or a small package device, such as SOT 23, placed in close proximity to it.

The on-chip sensor is, however, often remote from the processor and only monitors the general ambient temperature around the package. The thermal time constant of the QSOP 16 package is approximately 10 seconds.

In practice, the package will have an electrical, and hence a thermal, connection to the printed circuit board, so the temperature rise due to self-heating is negligible.

Digital boards can be electrically noisy environments, and because the NCT210 is measuring very small voltages from the remote sensor, care must be taken to minimize noise induced at the sensor inputs. The following precautionsA25(on)-1inimize ion to the print2himize ion .1962 TD-.0092 Tc0 Tw(I)s.6

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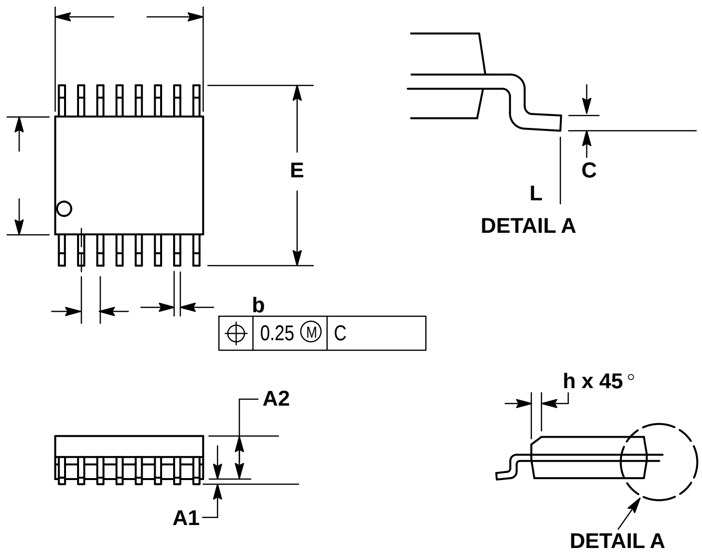
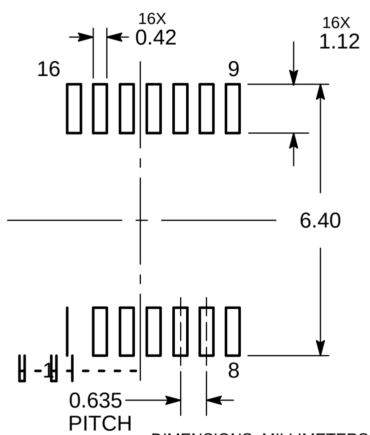
SCALE 2:1



NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION.
4. DIMENSION D DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS. MOLD FLASH, PROTRUSIONS, OR GATE BURRS SHALL NOT EXCEED 0.005 PER SIDE. DIMENSION E1 DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.005 PER SIDE. D AND E1 ARE DETERMINED AT DATUM H.
5. DATUMS A AND B ARE DETERMINED AT DATUM H.

	INCHES	
DIM	MIN	MAX
A	0.053	0.069
A1	0.004	0.010
b	0.008	0.012
c	0.007	0.010
e	0.025 BSC	
h	0.009	0.020
L	0.016	0.050
M	0°	8°

SOLDERING FOOTPRINT



DIMENSIONS: MILLIMETERS

XXXXX = Specific Device Code
YY = Year
WW = Work Week
G = Pb−Free Package