

ADT7482

Dual Channel Temperature Sensor and Overtemperature Alarm

The ADT7482 is a three-channel digital thermometer and under/overtemperature alarm for PCs and thermal management systems. It can measure the temperature in two remote locations, such as in the remote thermal diode in a CPU or GPU, or using a discrete diode connected transistor. This device also measures its own ambient temperature.

One feature of the ADT7482 is series resistance cancellation where up to 1.5 k Ω (typical) of resistance in series with each of the temperature monitoring diodes can be automatically cancelled from the temperature result, allowing noise filtering. The temperature of the remote thermal diodes and ambient temperature can be measured accurate to 1 C. The temperature measurement range, which defaults to 0 C to 127

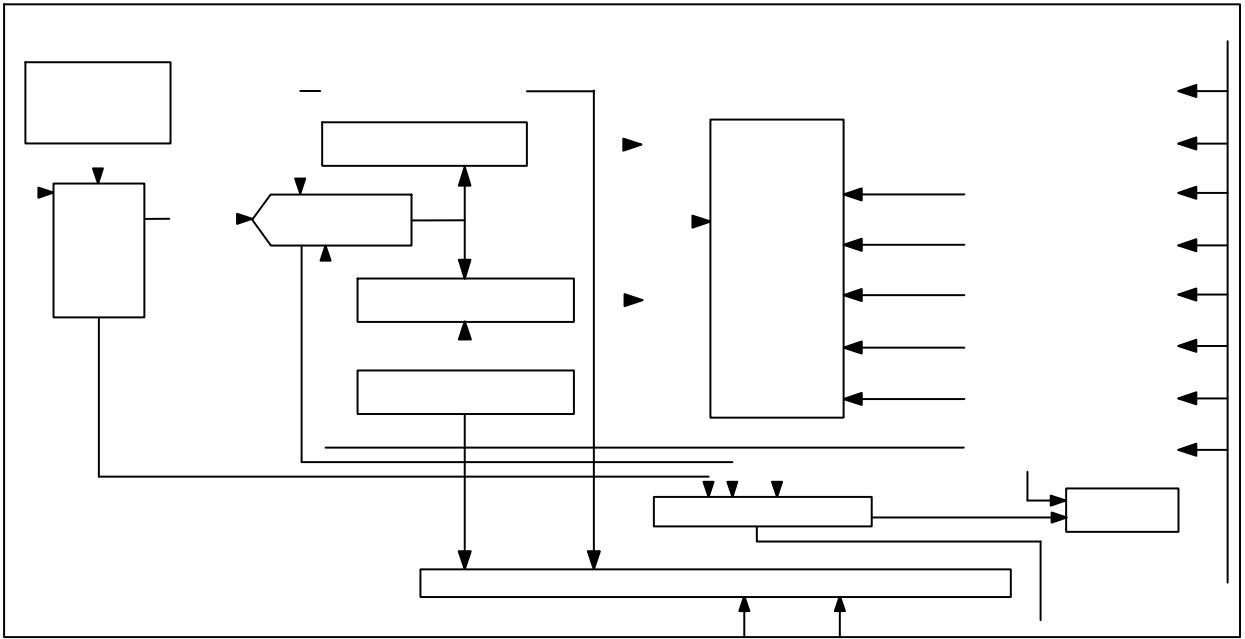


Figure 1. Functional Block Diagram

ADT7482

Table 3. PIN ASSIGNMENT

Pin No.	Mnemonic	Description
---------	----------	-------------

ADT7482

Table 5. ELECTRICAL CHARACTERISTICS ($T_A = -40\text{ C to }+120\text{ C}$, $V_{DD} = 3.0\text{ V to }3.6\text{ V}$, unless otherwise noted.)

Parameter	Test Conditions	Min	Typ	Max	Unit
Power Supply					
Supply Voltage, V_{DD}		3.0	3.30	3.6	V
Average Operating Supply Current, I_{DD}	0.0625 Conversions/Sec Rate (Note 1)	-	240	350	μA

ADT7482

ADT7482

Theory of Operation

The ADT7482 is a local and 2 remote temperature sensor

ADT7482

*CAPACITOR C1 IS OPTIONAL.
IT SHOULD ONLY BE USED IN
NOISY ENVIRONMENTS.

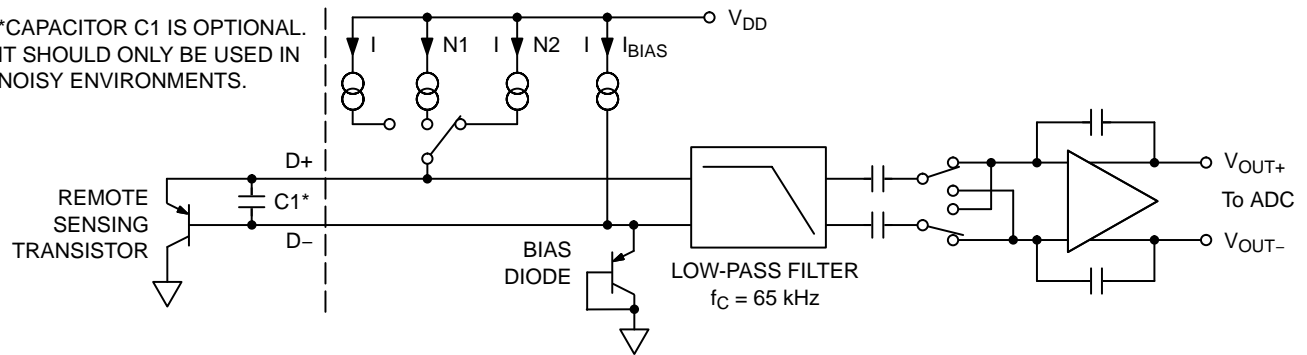


Figure 15. Input Signal Conditioning

Temperature Measurement Results

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.

The local temperature measurement is an 8-bit measurement with 1

The ADT7482 has two temperature data formats. When the temperature measurement range is from 0 C to 127 C (default), the temperature data format for both local and remote temperature results is binary.

**Table 8. TEMPERATURE DATA FORMAT
(LOCAL AND REMOTE TEMPERATURE HIGH BYTE)**

Temperature	Binary	Offset Binary (Note 1)
-55 C	0 000 0000 (Note 2)	0 000 1001
0 C	0 000 0000	0 100 0000
+1 C	0 000 0001	0 100 0001
+10 C	0 000 1010	0 100 1010
+25 C	0 001 1001	0 101 1001
+50 C	0 011 0010	0 111 0010
+75 C	0 100 1011	1 000 1011
+100 C	0 110 0100	1 010 0100
+125 C	0 111 1101	1 011 1101
+127 C	0 111 1111	1 011 1111
+150 C	0 111 1111 (Note 3)	1 101 0110

1. Offset binary scale temperature values are offset by +64.
2. Binary scale temperature measurement returns 0 for all temperatures < 0 C.
3. Binary scale temperature measurement returns 127 for all temperatures > 127 C.

Registers

The registers in the ADT7482 are 8-bits wide. These registers 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.

Address Pointer Register

The address pointer register itself does not have, or require, an address, as the first byte of every write operation is automatically written to this register. The data in this first byte always contains the address of another register on the ADT7482, which is stored in the address pointer register. It

is to this register address that the second byte of a write operation is written to or to which a subsequent read operation is performed.

The power-on default value of the address pointer register is 0x00. Therefore, if a read operation is performed immediately after power-on, without first writing to the address pointer, the value of the local temperature is returned, since its register address is 0x00.

Configuration Registers

There are two configuration registers used to control the operation of the ADT7482. Configuration 1 register is at Address 0x03 for reads and Address 0x09 for writes. See Table 9 for details regarding the operation of this register. Configuration 2 Register is at Address 0x24 for both reads and writes. Setting Bit 7 of this register locks all lockable registers. The affected registers can only be modified if the ADT7482 is powered down and powered up again. See Table 16 for a list of the registers affected by the lock bit.

The temperature values of the register is at

ADT7482

Table 10. CONFIGURATION 2 REGISTER (ADDRESS 0x24)

Bit	Mnemonic	Function
7	Lock Bit	Setting this bit to 1 locks all lockable registers to their current values. This prevents tampering with settings until the device is powered down. Default = 0.
<6:0>	Res	Reserved for future use.

Conversion Rate Register

The conversion rate register is at Address 0x04 for reads and Address 0x0A for writes. The four LSBs of this register are used to program the conversion times from 15.5 ms (Code 0x0A) to 16 seconds (Code 0x00). To program the ADT7482 to perform continuous measurements, set the conversion rate register to 0x0B. For example, a conversion

ADT7482

Status Registers

The status registers are read-only registers at Addresses 0x02 (Status Register 1) and Address 0x23 (Status Register 2). They contain status information for the ADT7482.

Table 12. STATUS REGISTER 1 BIT ASSIGNMENTS

Bit	Mnemonic	Function
-----	----------	----------

Table 14. SAMPLE OFFSET REGISTER CODES

Offset Value	0x11/0x34	0x12/0x35
-128 C	1000 0000	00 00 0000
-4 C	1111 1100	00 00 0000
-1 C	1111 1111	00 000000
-0.25 C	1111 1111	10 00 0000
0 C	0000 0000	00 00 0000
+0.25 C	0000 0000	01 00 0000
+1 C	0000 0001	00 00 0000
+4 C	0000 0100	00 00 0000
+127.75 C	0111 1111	11 00 0000

One-shot Register

The one-shot register initiates a conversion and comparison cycle when the ADT7482 is in standby mode, after which the device returns to standby. Writing to the one-shot register address (0x0F) causes the ADT7482 to perform a conversion and comparison on both the local and the remote temperature channels. This is not a data register as such, and it is the write operation to Address 0x0F that causes the one-shot conversion. The data written to this address is irrelevant and is not stored.

Table 16. LIST OF REGISTERS

Read Address (Hex)	Write Address (Hex)	Mnemonic	Power-On Default	Comment	Lock
N/A	N/A	Address Pointer	Undefined		No
00	N/A	Local Temperature Value	0000 0000 (0x00)		No
01	N/A	Remote 1 Temperature Value High Byte	0000 0000 (0x00)	Bit 3 Conf. Reg. = 0	No
01	N/A	Remote 2 Temperature Value High Byte	0000 0000 (0x00)	Bit 3 Conf. Reg. = 1	No
02	N/A	Status Register 1	Undefined		No
03	09	Configuration Register 1	0000 0000 (0x00)		Yes
04	0A	Conversion Rate	0000 0111 (0x07)		Yes
05	0B	Local Temperature High Limit	0101 0101 (0x55) (85 C)		Yes
06	0C	Local Temperature Low Limit	0000 0000 (0x00) (0 C)		Yes
07	0D	Remote 1 Temperature High Limit High Byte	0101 0101 (0x55) (85 C)	Bit 3 Conf. Reg. = 0	Yes
07	0D	Remote 2 Temperature High Limit High Byte	0101 0101 (0x55) (85 C)	Bit 3 Conf. Reg. = 1	Yes
08	0E	Remote 1 Temperature Low Limit High Byte	0000 0000 (0x00) (0 C)	Bit 3 Conf. Reg. = 0	Yes
08	0E	Remote 2 Temperature Low Limit High Byte	0000 0000 (0x00) (0 C)	Bit 3 Conf. Reg. = 1	Yes
N/A	0F (Note 1)	One Shot			N/A
10	N/A	Remote 1 Temperature Value Low Byte	0000 0000	Bit 3 Conf. Reg. = 0	No

Consecutive ALERT Register

The value written to this register determines how many out-of-limit measurements must occur before an ALERT is generated. The default value is that one out-of-limit measurement generates an ALERT. The maximum value that can be chosen is 4. This register allows some filtering of the output. This is particularly useful at the fastest three conversion rates, where no averaging takes place. This register address is 0x22. For more information, refer to Table 15.

Table 15. CONSECUTIVE ALERT REGISTER BIT

Register Value	Amount of Out-of-Limit Measurements Required
yz a 000x	1
yz a 001x	2
yz a 011x	3
yz a 111x	4

NOTES: y = SMBus SCL timeout bit. Default = 0. See the Serial Bus Interface section for more information.
z = SMBus SDA timeout bit. Default = 0. See the Serial Bus Interface section for more information.
a = Mask Internal ALERTs.
x = Don't care bit.

ADT7482

acknowledge. The master then takes the data line low during the low period before the tenth clock pulse, then high during the tenth 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. In the case of the ADT7482, 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 to read

Reading Data from a Register

When reading data from a register there are two possibilities:

1. If the ADT7482 address pointer register value is unknown or not the desired value, it is first necessary to set it to the correct value before data can be read from the desired data register. This is done by performing a write to the ADT7482 as before, but only the data byte containing the register read address is sent, as data is not to be written to the register. This is shown in Figure 17. A read operation is then performed consisting of the serial bus address, R/\overline{W} bit set to 1, followed by the data byte read from the data register. This is shown in Figure 18.
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 and the bus transaction shown in Figure 17 can be omitted.

When reading data from a register, it is important to note the following points:

It is possible to read a data byte from a data register without first writing to the address pointer register. However, 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 some of the ADT7482 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 may not be 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.

$\overline{\text{ALERT}}$ Output

Pin 8 can be configured as an $\overline{\text{ALERT}}$ output. The $\overline{\text{ALERT}}$ output goes low whenever an out-of-limit measurement is detected, or if the remote temperature sensor is an open circuit. It is an open-drain output and requires a pullup to V_{DD} . Several $\overline{\text{ALERT}}$ outputs can be wire-OR'ed together, so that 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 a $\overline{\text{SMBALERT}}$. Slave devices on the SMBus cannot normally signal to the bus master that they want to talk, but the $\overline{\text{SMBALERT}}$ function allows them to do so.

One or more $\overline{\text{ALERT}}$ outputs can be connected to a common $\overline{\text{SMBALERT}}$ line connected to the master. When the $\overline{\text{SMBALERT}}$ line is pulled low by one of the devices, the following procedure occurs as illustrated in Figure 19.

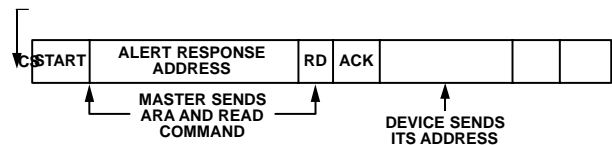


Figure 19. Use of $\overline{\text{SMBALERT}}$

maskable. The programmed hysteresis value applies to $\overline{\text{THERM2}}$ also.

Figure 21 shows how $\overline{\text{THERM}}$ and $\overline{\text{THERM2}}$ might operate together to implement two methods of cooling the system. In this example, the $\overline{\text{THERM2}}$ limits are set lower than the $\overline{\text{THERM}}$ limits. The $\overline{\text{THERM2}}$ output could be used to turn on a fan. If the temperature continues to rise and exceeds the $\overline{\text{THERM}}$ limits, the $\overline{\text{THERM}}$ output could provide additional cooling by throttling the CPU.

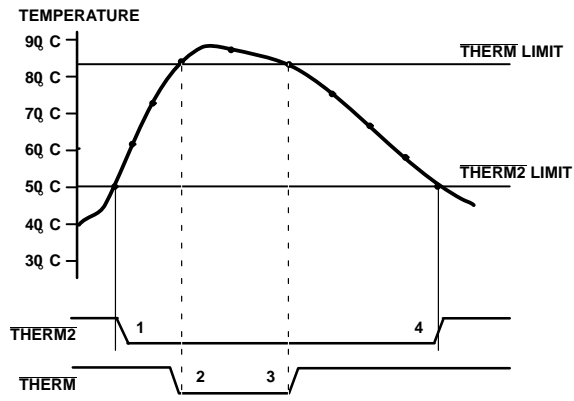


Figure 21. Operation of the $\overline{\text{THERM}}$ and $\overline{\text{THERM2}}$ Interrupts

1. When the $\overline{\text{THERM2}}$ limit is exceeded, the $\overline{\text{THERM2}}$ signal asserts low.
2. If the temperature continues to increase and exceeds the $\overline{\text{THERM}}$ limit, the $\overline{\text{THERM}}$ output asserts low.
3. The $\overline{\text{THERM}}$ output de-asserts (goes high) when the temperature falls to $\overline{\text{THERM}}$ limit minus hysteresis. In Figure 21, there is no hysteresis value shown.
4. As the system cools further, and the temperature falls below the $\overline{\text{THERM2}}$ limit, the $\overline{\text{THERM2}}$ signal resets. Again, no hysteresis value is shown for $\overline{\text{THERM2}}$.

The temperature measurement could be either the local or the remote temperature measurement.

Applications Information

Noise Filtering

For temperature sensors operating in noisy environments,

This offset can be programmed to the offset register. It is important to note that if more than one offset must be considered, the algebraic sum of these offsets must be programmed to the offset register.

If a discrete transistor is being used with the ADT7482, the best accuracy is obtained by choosing devices according to the following criteria:

Base-emitter voltage greater than 0.25 V at 6 μ A, at the highest operating temperature.

Base-emitter voltage less than 0.95 V at 100 μ A, at the lowest operating temperature.

Base resistance less than 100 Ω .

Small variation in h_{FE} (such as 50 to 150) that indicates tight control of V_{BE} characteristics.

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

Thermal Inertia and Self-heating

Accuracy depends on the temperature of the remote sensing diode and/or the local temperature sensor being at the same temperature as that being measured. A number of factors can affect this. Ideally, the sensor should be in good thermal contact with the part of the system being measured. If it is not, the thermal inertia caused by the sensor's mass causes a lag in the response of the sensor to a temperature change. In the case of the remote sensor, this should not be a problem, since 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, however, is often remote from the

ADT7482

Application Circuit

Figure 24 shows a typical application circuit for the ADT7482, using discrete sensor transistors. The pullups on SCLK, SDATA, and $\overline{\text{ALERT}}$ are required only if they are not already provided elsewhere in the system.

The SCLK pin and the SDATA pin of the ADT7482 can be interfaced directly to the SMBus of an I/O controller, such as the Intel 820 chipset.

V

FAN
ENABLE

Figure 24. Typical Application Circuit

ADT7482

PACKAGE DIMENSIONS

MSOP10
CASE 846AC-01
ISSUE O

