Programmable Resolution1-Wire Digital Thermometer

(compatible to DS18B20)

The HT18B20A digital thermometer provides 9-bit to 12-bit Celsius temperature measurements and has an alarm function with nonvolatile user-programmable upper and lower trigger points.
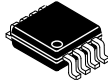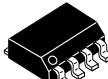
The HT18B20A communicates over a 1-Wire bus that by definition requires only one data line (and ground) for communication with a central micro-processor. In addition, the HT18B20A

can derive power directly from the data line ("parasite power"), eliminating the need for an external power supply. Each HT18B20A has a unique 64-bit serial code, which allows multiple HT18B20As to function on the same 1-Wire bus. Thus, it is simple to use one microprocessor to control many HT18B20As distributed over a large area. Applications that can benefit from this feature include HVAC environmental controls, temperature monitoring systems inside

buildings, equipment, or machinery, and process monitoring and control systems.

DFN–8* D SUFFIX
HT18B20ARDZ

MSOP–8 M SUFFIX
HT18B20ARMZ

SOP–8 R SUFFIX
HT18B20ARZ

TO92 T SUFFIX
HT18B20ATZ

TO-92-3L T SUFFIX
HT18B20ARTZ

NOTE: suffix A is version, suffix R is roll tape, suffix Z environmental protection.

Main features:

- converts temperature to 12-bit digital code;
- user-programmable thermometer accuracy from 9 to 12 bits;
- operating temperature range from minus 55 to plus 125 °C;
- alarm signal on temperature is outside of programmed limits;
- each IC has a unique 64-bit serial code unchangeable by user;
- memory data read/write, data transmitting via 1-Wire interface;
- battery and data line power supply available;
- supply voltage UDD range from 3,0 to 5,5 V;
- acceptable value of ESD protection not less than 2000

Applications:

- Thermostatic Controls
- Industrial Systems
- Consumer Products
- Thermometers
- Thermally Sensitive Systems

Figure 3 – Pinning (SOP8)

Figure 4 – Pinning (TO-92&TO92-3L)

Table 1 – Description of integrated circuit pins in the package and chip contact pads

Package pin number		Contact pad number	Symbol	Description
TO92	SOP8			
-	01	-	NC	Not connected
-	02	-	NC	Not connected
01	05	03	GND	Common pin
02	04	02	DQ	Data input/output
03	03	01	V_{DD}	Power supply pin
-	06-08	-	NC	Not connected
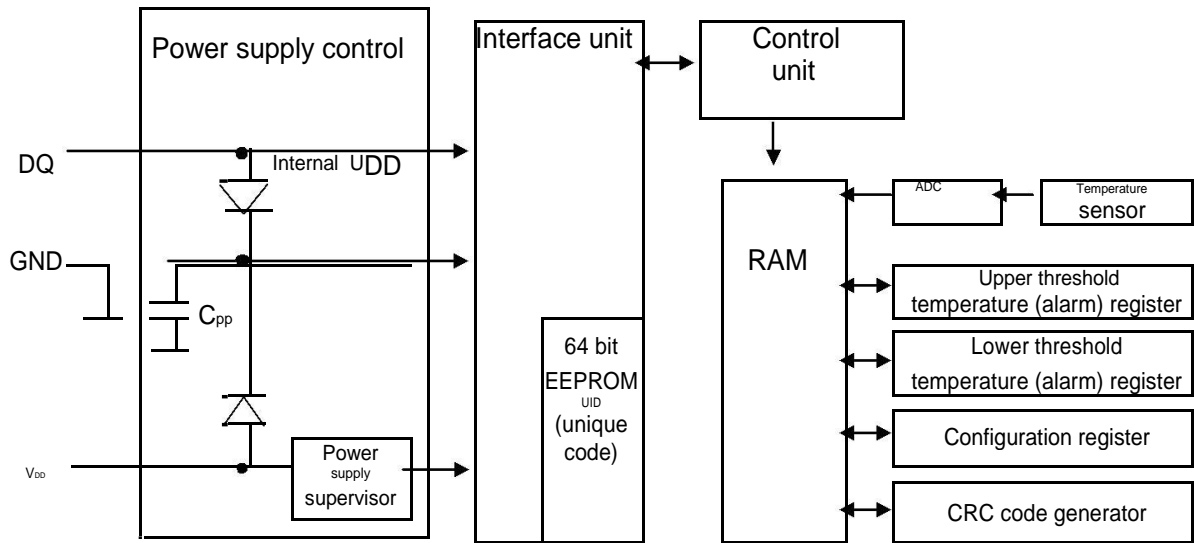
Figure 5 – Integrated circuit block diagram

Table 2 – Maximum ratings

Symbol	Parameter	Norm		Unit
		Min	Max	
U_{DD}	Supply voltage (from power supply element)	-0,5	6,0	B
Ta	Ambient temperature	-60	125	℃

Table 3 – Limit permissible operating modes

Symbol	Parameter	Norm		Unit	Note
		Min	Max		
U_{DD}	Supply voltage	3,0	5,5	V	-
U_{PU}	Supply voltage (on external pull-up resistor)				
	in supply mode on DQ (U_{DD} = 0 V) pin	3,0	5,5	V	1, 2
	in supply mode on V_{DD} pin	3,0	U_{DD}	V	1
U_{IL}	Low level input voltage				
	at U_{DD} = 5 V	-0,3	0,8	V	1, 3
	at U_{DD} = 3 V	-0,3	0,5	V	1, 2, 3
U_{IH}	High level input voltage				
	in supply mode on V_{DD} pin	2,2	U_{DD}+0,3	V	1, 4
	in supply mode on DQ (U_{DD} = 0 V) pin	3,0	U_{DD}+0,3	V	1, 2, 4
t_{WR}	Cycle time of EEPROM record at U_{DD} = 5 V	-	10	ms	2
Ta	Operating ambient temperature	-55	125	℃	-

Notes:
   1 All voltages are referenced to the common pin.
   2 For temperature range from minus 55 to plus 100 °C.
   3 External driver current 4,0 mA.
   4 External driver current 1,0 mA

Table 4 – Integrated circuit electric parameters

Parameter, unit, measurement mode	Symbol	Norm		Ambient temperat ure °C
		Min	Max	
Consumption current, μA at $0\ V \leq U_I \leq 0,4\ V$ или $U_{DD}-0,3\ V \leq U_I \leq U_{DD}$	I_{DD}	-	1,0 1,1	25±1 0 - 55; 70
Dynamic Consumption current, μA at $U_{DD} = 5\ V$	I_{ODD}	-	1500 1550	25±1 0 -55; 125
Low level output current, mA at $U_O = 0,4\ V$	I_{OL}	4,0 4,0	-	

Table 5 – Reference electric parameters

Parameter, unit	Symbol	Measurement mode	Typical value	Ambient temperature, °C
Input current, μA - on DQ pin	I_{DQ}	Line driver off, $U_{DD} = 5\ V$	5	25±10 -55; 125
Consumption current, μA	I_{DD}	$0\ V \leq U_I \leq 0,4\ V$ or $U_{DD}-0,3\ V \leq U_I \leq U_{DD}$	0,75	25±10 -55; 70
Temperature measurement drift, °C	ΔT	After 1000 hours at 125 °C $U_{DD} = 5,5\ V$	±0,2	25±1 0
Temperature measurement error, °C	t_{ERR}	-	±0,5	25±1 0 -10; 85
		-	±2,0	-55; 125

Functional description

The HT18B20A IC uses 1-Wire bus protocol only that implements bus communication using one control signal. The bus is to be connected to power supply source via pullup resistor since all devices are linked to the bus via a 3-state or open-drain port. Using this bus system, the microprocessor (the control device) identifies and addresses to temperature sensors using 64-bit code of integrated circuit. Because each integrated circuit has a unique code, the number of integrated circuits that can be addressed on one bus is virtually unlimited.

Each HT18B20A has unique 64-bit code stored in EEPROM UID. The RAM contains the 2-byte temperature register that stores the temperature value to completion of temperature conversion, two 1-byte registers of threshold temperature (TH and TL) and configuration register. The configuration register allows the user to set the resolution of the temperature –to-digital conversion to 9,10,11 or 12 bits, that effects on the time of conversion.

The TH, TL and configuration registers are nonvolatile (EEPROM), so they will retain data when the device is powered down.

Another feature of the HT18B20A is the ability to operate without an external power supply.

Power is supplied through pullup resistor. The high bus signal charges an internal capacitor (C_{PP}), which then supplies power to the device when the bus is low. This method is referred to as «parasite power». Thus the maximum measured temperature is + 100 °C. An external power supply is required to expand the range of temperature up to + 125 °C.

Instruction set shown in the Table 6.

Table 6 – Instruction set

Instruction	Code	Description
Read ROM (EEPROM UID read)	[33h]	Read data from EEPROM UID (unique code)
Match ROM (EEPROM UID match)	[55h]	Match data from EEPROM UID (unique code)
Skip ROM (EEPROM UID skip)	[CCh]	Skip matching of data from EEPROM UID (unique code)
Search ROM (EEPROM UID search)	[F0h]	Search EEPROM UID (unique code)
Alarm Search (Failure Search)	[ECh]	Alarm Search
Convert T (Temperature Conversion)	[44h]	Initialize temperature conversion
Read Scratchpad (Read Memory)	[BEh]	Read bytes from RAM and CRC code byte
Write Scratchpad (Write Memory)	[4Eh]	Write data 2, 3 and 4 bytes in RAM
Copy Scratchpad (Copy RAM in EEPROM)	[48h]	Copy data from RAM in EEPROM
Recall E2 (Repeat Load)	[B8h]	Data transport from EEPROM in RAM
Read Power Supply (Power Supply Type)	[B4h]	Data outputting about power supply mode of IC

1) Integrated circuits power supply on – time through DQ pin in the «parasite» power mode after «Convert T» and «Copy Scratchpad» instructions not exceed 10 us

Temperature conversion mode

The main functionality of the HT18B20A is temperature converter. The resolution of the temperature converter is user-configurable to 9, 10, 11, or 12 bits, corresponding to increments of (discrecity of temperature measurement) 0,5000; 0,2500; 0,1250 and 0,0625 °C, respectively. The default resolution is 12 bit. After power-up the HT18B20A stays in idle (non-active) state initially. The master must issue a Convert T [0x44] command to initiate a temperature measurement and conversion. After conversion, the resulting data is stored in the 2-byte temperature converter register of the RAM and the HT18B20A returns to its non-active state. If the HT18B20A is powered by an external supply, the master can control the temperature conversion (after instruction [44h]) under the bus state. The HT18B20A will respond by transmitting «0» (on «read» time slots issued by master) while the temperature conversion is in progress and «1» when the conversion is done. If the HT18B20A is powered with parasite power, this notification technique is not available since the high level (power supply) must be applied to bus during the entire temperature conversion. At this case device has to control time of the conversion independently.

The HT18B20A output temperature data calibrated in Celsius degrees. Temperature data is stored as 16-bit number with symbol. The format of the temperature register is shown in Figure 6. S Flag bits indicate whether the temperature is positive or negative: for positive S numbers = 0, and for negative S = 1. If HT18B20A is configured for conversion with 12-bit resolution, then all bits in temperature register will be contain valid data. For 11-bit resolution, bit 0 is not defined. For 10-bit resolution, bits 1 and 0 are undefined, and for 9-bit resolution bits 2, 1 and 0 are undefined.

In table 7 are shown examples of digital output data and appropriate temperature for 12-bit resolution.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
LSB	2^3	2^2	2^1	2^0	2^{-1}	2^{-2}	2^{-3}	2^{-4}

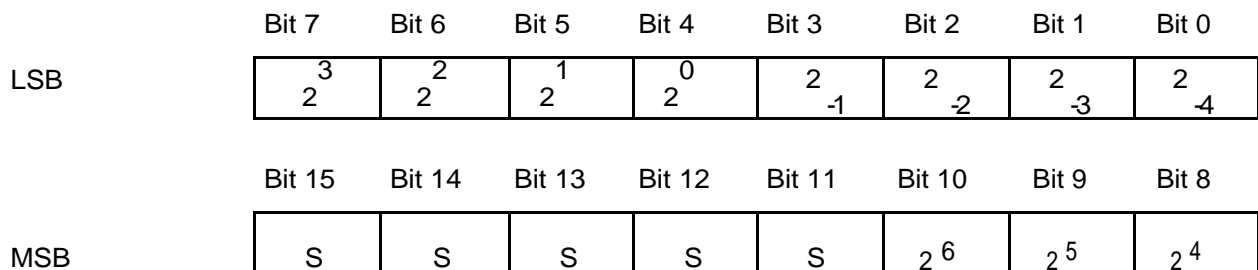|	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
MSB	S	S	S	S	S	2^6	2^5	2^4

Figure 6 – Temperature register format

Table 7 – Examples of data match of digital output to temperature

Temperature	Digital output (binary)	Digital output (hexadecimal)
+125°C	0000 0111 1101 0000	07D0h
+85°C	0000 0101 0101 0000	0550h
+75°C	0000 0100 1011 0000	04B0h
+25,0625°C	0000 0001 1001 0001	0191h
+10,125°C	0000 0000 1010 0010	00A2h
+0,5°C	0000 0000 0000 1000	0008h
0°C	0000 0000 0000 0000	0000h
-0,5°C	1111 1111 1111 1000	FFF8h
-10,125°C	1111 1111 0101 1110	FF5Eh
-55°C	1111 1100 1001 0000	FC90h

Memory

The HT18B20A memory is organized as shown in Figure 7. The memory consists of a main memory (SRAM) and nonvolatile memory (EEPROM). First two registers are registers of temperature converter, further threshold temperature registers and configuration register. If the HT18B20A alarm function is not implemented, the TH and TL registers can be used as general-purpose memory cells. Byte 0 and byte 1 of the RAM contain the LSB and the MSB of the temperature register, respectively. These bytes are read-only. Bytes 2 and 3 provide access to TH and TL registers. Byte 4 contains the configuration register data. Bytes 5, 6, and 7 are reserved for internal use by the device and cannot be overwritten. Byte 8 of the RAM is read-only and contains the cyclic redundancy check (CRC) code for bytes 0-7 of the RAM.

The user can set HT18B20A conversion resolution capability of the conversion, using bits 5 and 6 (R0 and R1) of the configuration register (byte 4), as shown in table 8. The value of these bits on default (after power-up) - R0 = 1 and R1 = 1 (12-bit resolution capability). There is a direct relation between resolution capability of the conversion and time of the conversion. Bit 7 and bits from 0 to 4 in the configuration register is reserved for internal use by the device and cannot be overwritten by user, bit 7 reply «0».

Table 8

R1	R0	Resolution	Max Conversion Time	
0	0	9 bit	93,75 ms	$(t_{CONV}/8)$
0	1	10 bit	187,5 ms	$(t_{CONV}/4)$
1	0	11 bit	375 ms	$(t_{CONV}/2)$
1	1	12 bit	750 ms	(t_{CONV})

RAM

Byte 0	LSB – low byte of temperature data (50h)
Byte 1	MSB – high byte of temperature data (05h)
Byte 2	T_H – high temperature register data or user «Byte 1»
Byte 3	T_L – low temperature register data or user «Byte 2»
Byte 4	Configuration register data
Byte 5	Additional data (FFh)
Byte 6	Additional data (0Ch)
Byte 7	Additional data (10h)
Byte 8	CRC data

EEPROM

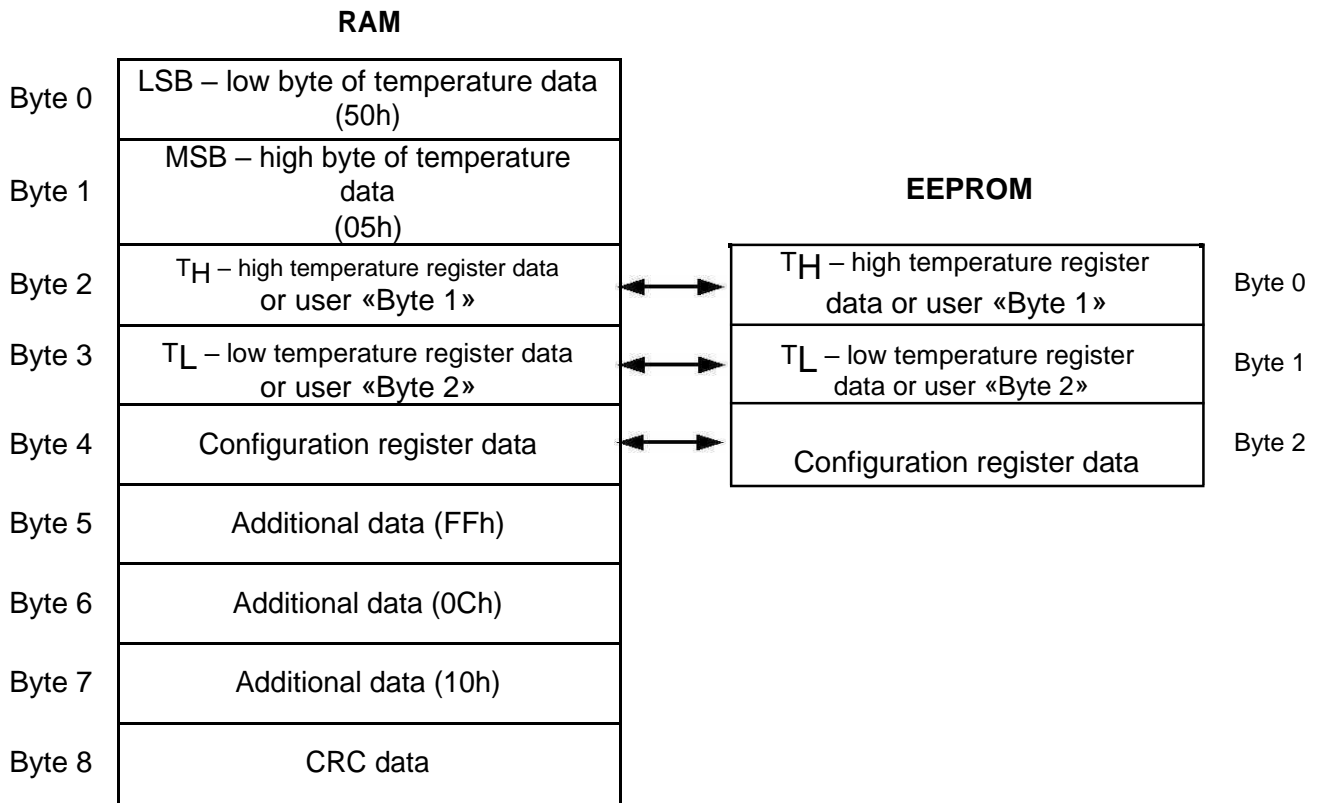|	
T_H – high temperature register data or user «Byte 1»	Byte 0
T_L – low temperature register data or user «Byte 2»	Byte 1
Configuration register data	Byte 2

Figure 7 – Memory map

1-Wire bus protocol

The HT18B20A uses a strict 1-Wire bus communication protocol to insure data integrity. Several signal types are defined by this protocol: reset pulse, presence pulse, write «0», write «1», read «0», and read «1». The master applies all of these signals to bus, with the exception of the presence pulse.
Dynamic parameters of the 1-Wire bus are shown in Table 9.

Initialization

All communication via 1-Wire bus begins with an initialization sequence. The initialization sequence consists of a reset pulse transmitted by the bus master and a presence pulse(es) transmitted by slave devices. The presence pulses indicate to the master that slave devices are on the bus and ready to operate.
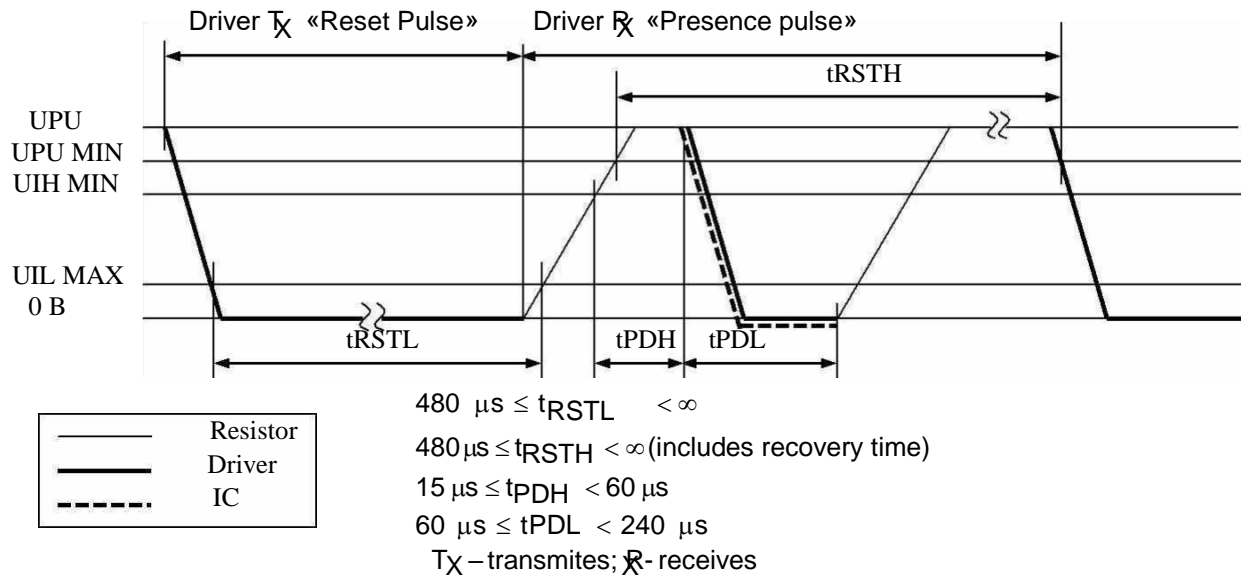The initialization timing diagrams is shown in Figure 8.

READ/WRITE time slots

The bus master writes data to the HT18B20A during write time slots and reads data from the HT18B20A during read time slots. Time slot is the time interval of the 1-Wire interface communication protocol. One bit of data is transmitted per time slot.

Write «0», Write «1», Read timing diagrams are shown on Figures 9-11.

Table 9 – Dynamic parameters of 1-Wire bus communication protocol

Parameter, unit	Symbol	Parameter norm		Note
		Min	Max	

Temperature conversion time, ms
    9-bit resolution
    10-bit resolution
    11-bit resolution
    12-bit resolution
	tCONV	-	93,75
			187,5
			375
			750
				-

Time interval of the 1-Wirw interface communication protocol, μs	tSLOT	60	120	-
Write «1» low level duration, μs	tLOW1	1	15	-
Write «0» low level duration, μs	tLOW0	60	120	-
Read data valid, μs	tRDV	-	15	-
Recovery time, μs	tREC	1	-	-
Reset high level duration, μs	tRSTH	480	-	1
Reset low level duration, μs	tRSTL	480	-	2
Presence pulse high level duration, μs	tPDH	15	60	-
Presence pulse low level duration, μs	tPDL	60	240	-

Notes
    1 Additional reset or communication sequence cannot start during reset high level.
    2 During operation in the power supply mode at pin DQ (U_{DD} =0 V) if t_{RSTL} > 960 μs reset can occur				

Driver T$_X$ «Reset Pulse»   Driver R$_X$ «Presence pulse»

tRSTH

UPU
UPU MIN
UIH MIN

UIL MAX
0 B

tRSTL   tPDH   tPDL

$480 \; \mu s \le t_{RSTL} \; < \infty$

$480 \mu s \le t_{RSTH} \; < \infty$ (includes recovery time)

$15 \; \mu s \le t_{PDH} \; < 60 \; \mu s$

$60 \; \mu s \le tPDL \; < 240 \; \mu s$

T$_X$ – transmites; R$_X$ - receives

	Resistor
	Driver
	IC

In order not to mask interruptions issued by another devices on single   -line bus,

t_{RSTL} duration has to be less than 960 μs always.

Figure 8   – Initialization timing diagram

tSLOT   tREC

UPU
UPU MIN
UIH MIN

Polling window IC

UIL MAX
0 B

15 μs

60 μs

tLOW0

	Resistor
	Driver

$60 \; \mu s \le t_{LOWO} \; < t_{SLOT} \; < 120 \; \mu s$

$1 \; \mu s \; \le t_{REC} \; < \infty$
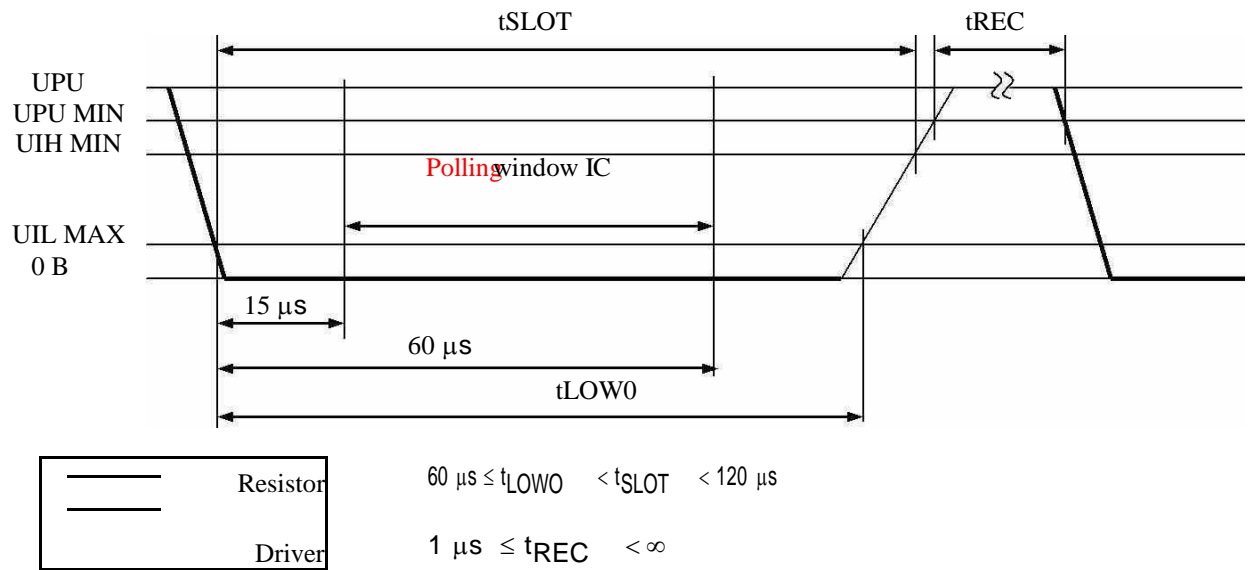
Figure 9   – Write «0» timing diagram
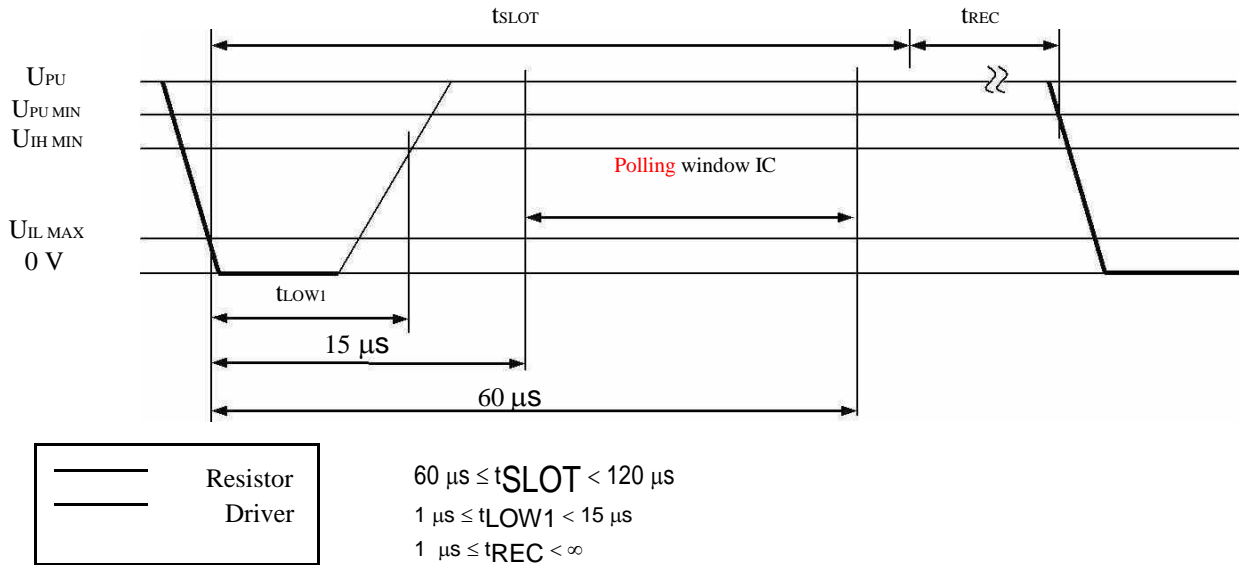
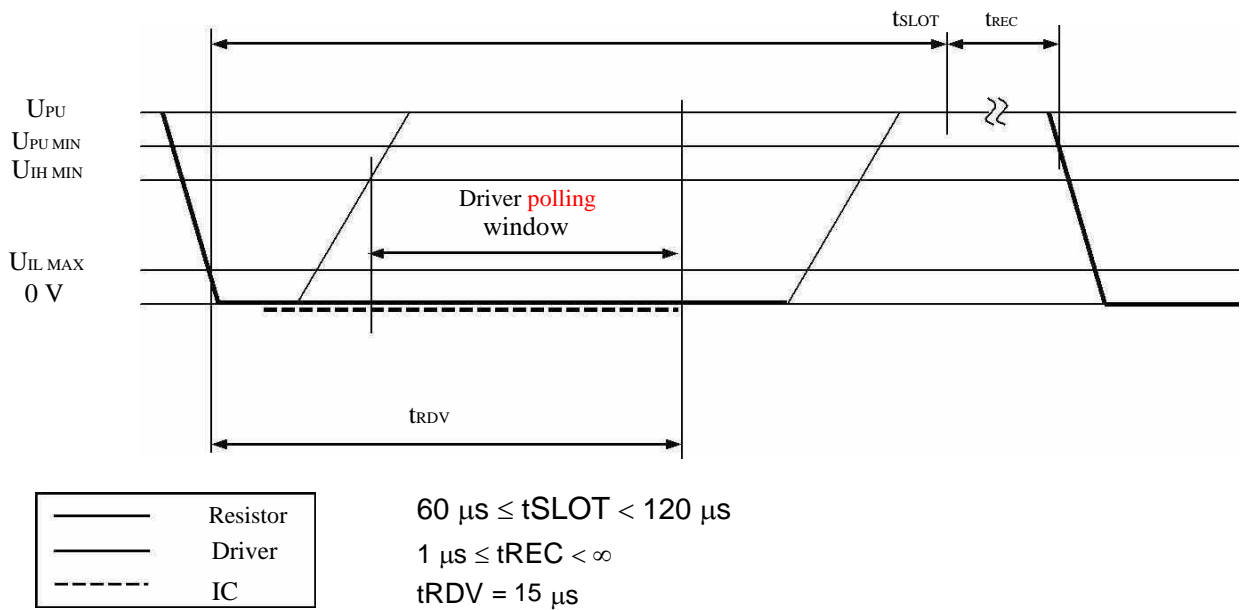Figure 10 – Write «1» timing diagram

Figure 11 – Data read timing diagram

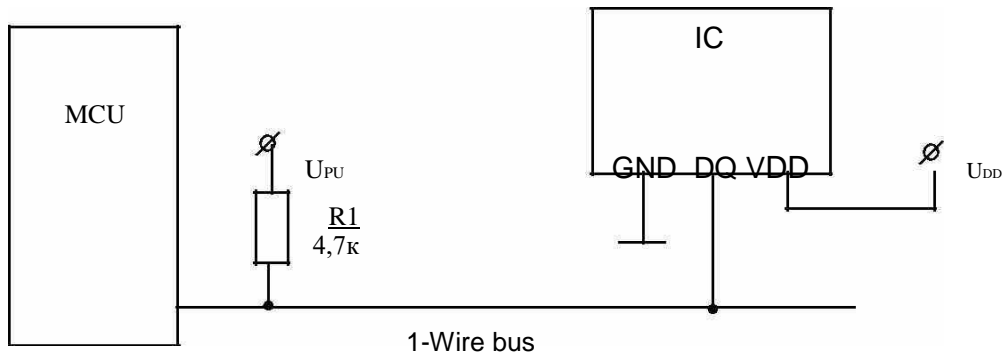Recommended connection diagrams are shown on Figures 12, 13.

Figure 12 – IC connection in the mode of external supply (on V_{DD} pin) U_{PU}
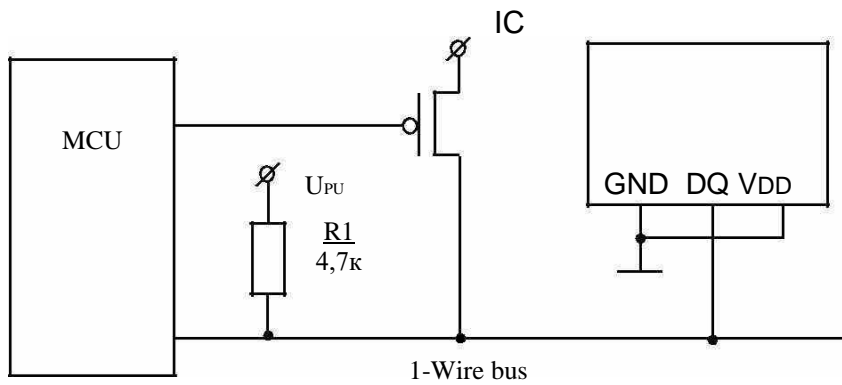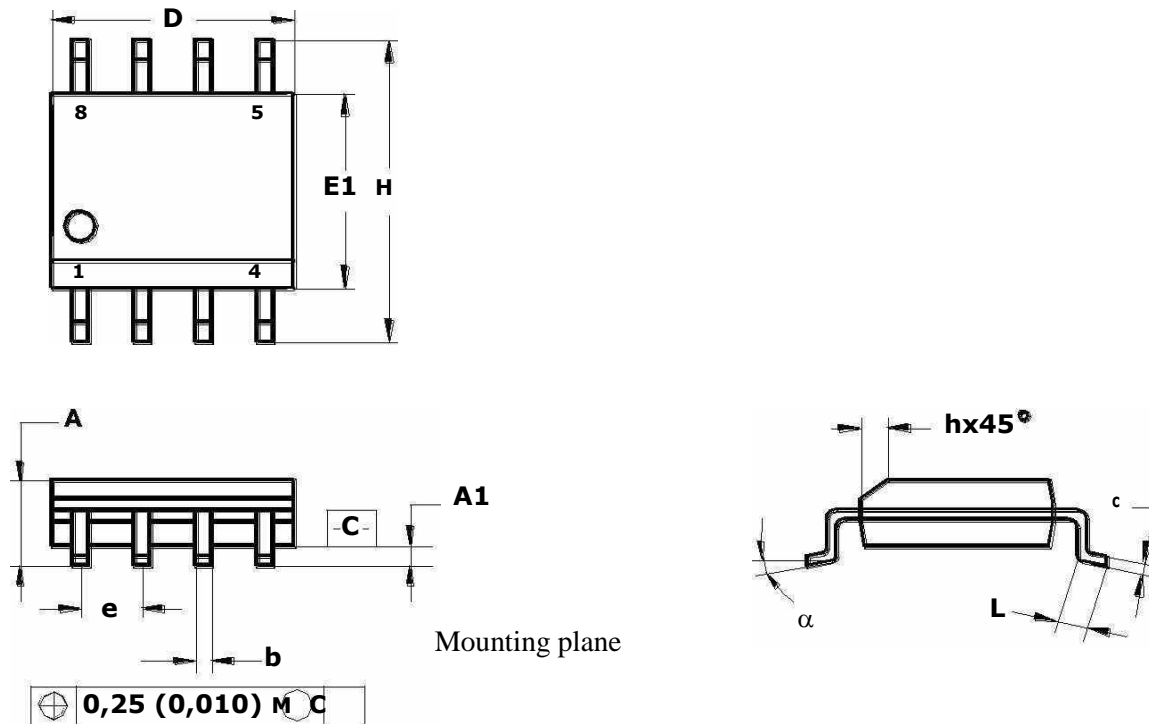
Figure 13 – IC connection in the mode of «parasite» supply (on DQ pin)

Package versions of HT18B20A available for shipment are shown in table 10.
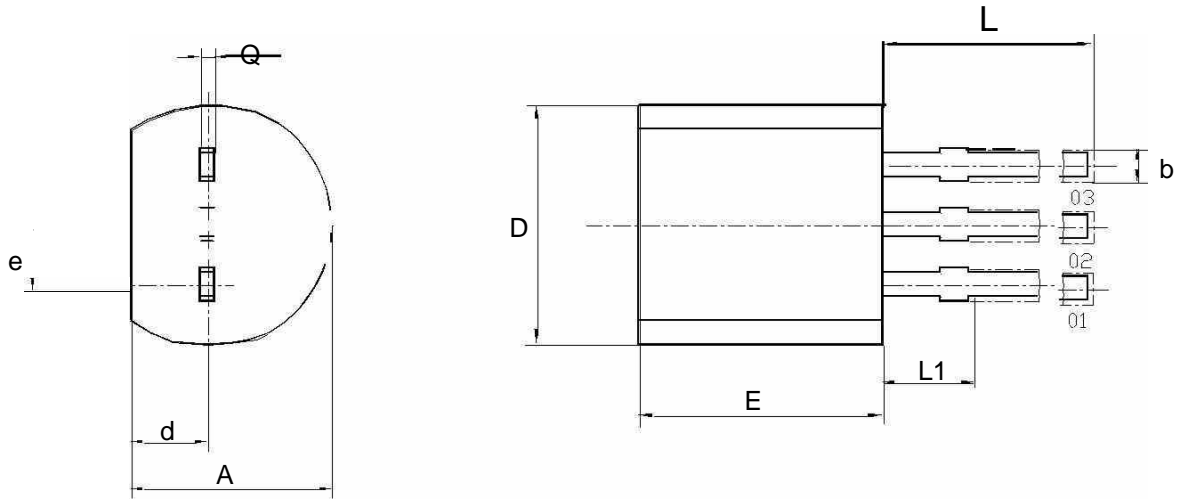
SOP8 150mil

Mounting plane

Note – Dimensions D, E1 do not include the value of fin, which should not exceed 0,25 (0,010) per side.

	D	E1	H	b	e	α	A	A1	c	L	h
Millimeters											
min	4.80	3.80	5.80	0.33		0°	1.35	0.10	0.19	0.41	0.25
max	5.00	4.00	6.20	0.51	1.27	8°	1.75	0.25	0.25	1.27	0.50
Inches											
min	0.1890	0.1497	0.2284	0.013		0°	0.0532	0.0040		0.016	0.0099
max	0.1968	0.1574	0.2440	0.020	0.100	8°	0.0688	0.0090		0.050	0.0196

TO92

Dimensions	mm	
	min	max
E	4,6	5,1
b	-	0,5
D	4,6	5
d	1,25	1,65
A	3,5	3,8
e	1,2573	1,2827
L	12,5	14,5
L1	-	2
Q	-	0,5

TO-92-3L
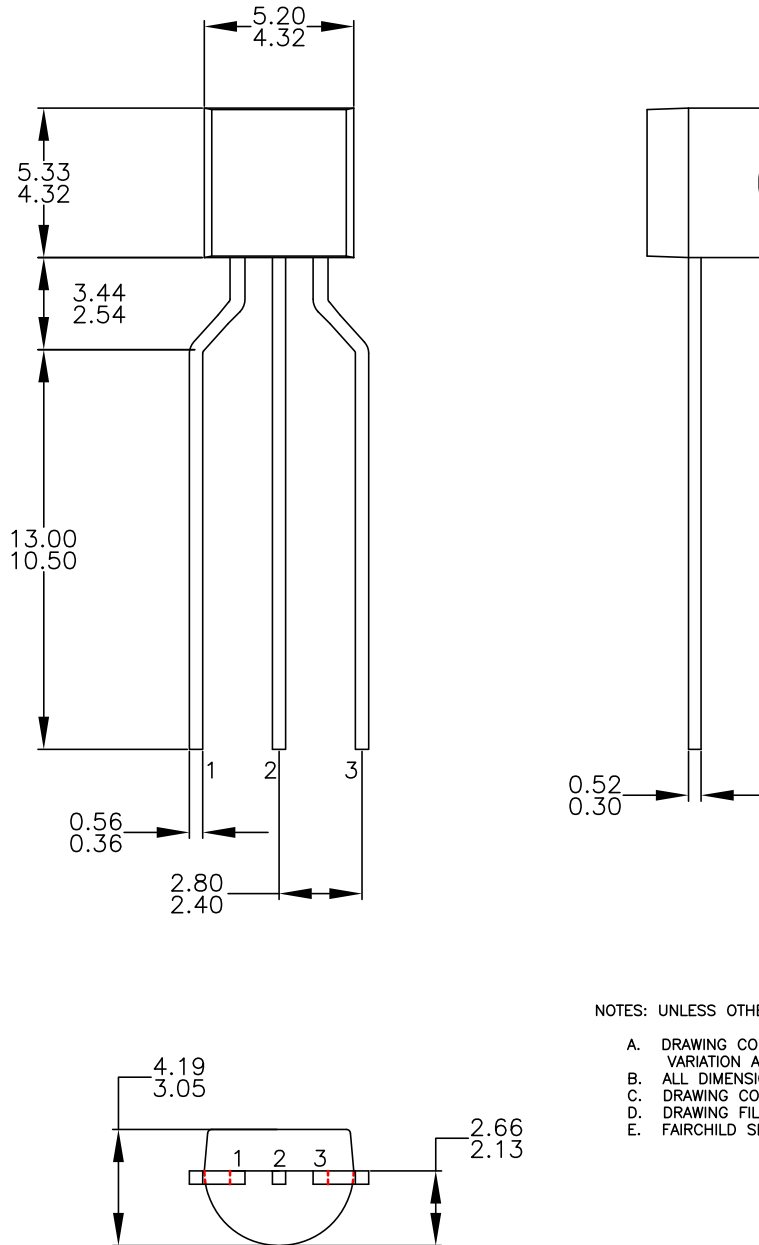
NOTES: UNLESS OTHERWISE SPECIFIED

    A. DRAWING CONFORMS TO JEDEC MS−013,
        VARIATION AC.
    B. ALL DIMENSIONS ARE IN MILLIMETERS.
    C. DRAWING CONFORMS TO ASME Y14.5M−2009.
    D. DRAWING FILENAME: MKT−ZA03FREV3.
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