

MOBILE ACCESS™—CLOCK SYNTHESIZER, TEMPERATURE SENSOR, 9TCS1085 & PWM FAN CONTROLLER FOR PORTABLE DEVICES

Description

The 9TCS1085 is a highly programmable IC that integrates clock synthesizers with a PWM Fan controller and temperature sensor for hardware thermal protection.

The device has an ultra-low-power 32.768 kHz frequency generator to support Real Time Clocks (RTC). This device can generate the 32.768 kHz frequency up to four years of life powered by a CR2032 coin cell battery. The 9TCS1085 can output computer system clock frequencies of 24, 25, 27 and 48 MHz which reduces the component count on the circuit board.

The fan controller is pulsed width modulated (PWM) used for the temperature proportional speed control. The device is highly configurable through I2C for ease and flexibility of use. The fan controller has three different modes of operation and will work with multiple pole, brushless DC fans. An integrated Start-up Timer ensures reliable motor start-up and turn-on or follows a detected fault condition.

The 9TCS1085 includes temperature monitor function that measures an external diode. The temperature sensor is optimized to be accurate within $\pm 1^{\circ}\text{C}$ between the temperature range of 60°C to 100°C . This device is highly programmable through the use of I²C to set high and low limits for the temperature sensor. The hardware limits drive dedicated ALERT and THERM pins for system shutdown.

The 9TCS1085 is available in a 32-pin QFN package and is available for commercial temperature range.

Applications

- Notebook Computers
- Netbook Computers
- Smartbook Computers
- Consumer Portable Devices
- Embedded Systems
- Networking Equipment (i.e. Routers, Switches)
- Network Area Storage

Thermal Sensor

- One channel temperature sensor
- Both H/W & S/W programmable over/under temperature alarms
- No Calibration required in application
- Diode failure detection
- Support SMBUS Alert
- Accuracy: $\pm 1^{\circ}\text{C}$ ($+60^{\circ}\text{C}$ to $+100^{\circ}\text{C}$); $\pm 2^{\circ}\text{C}$ (0°C to $+100^{\circ}\text{C}$)
- Offset register for system calibration
- Series resistor cancellation feature

Fan Controller

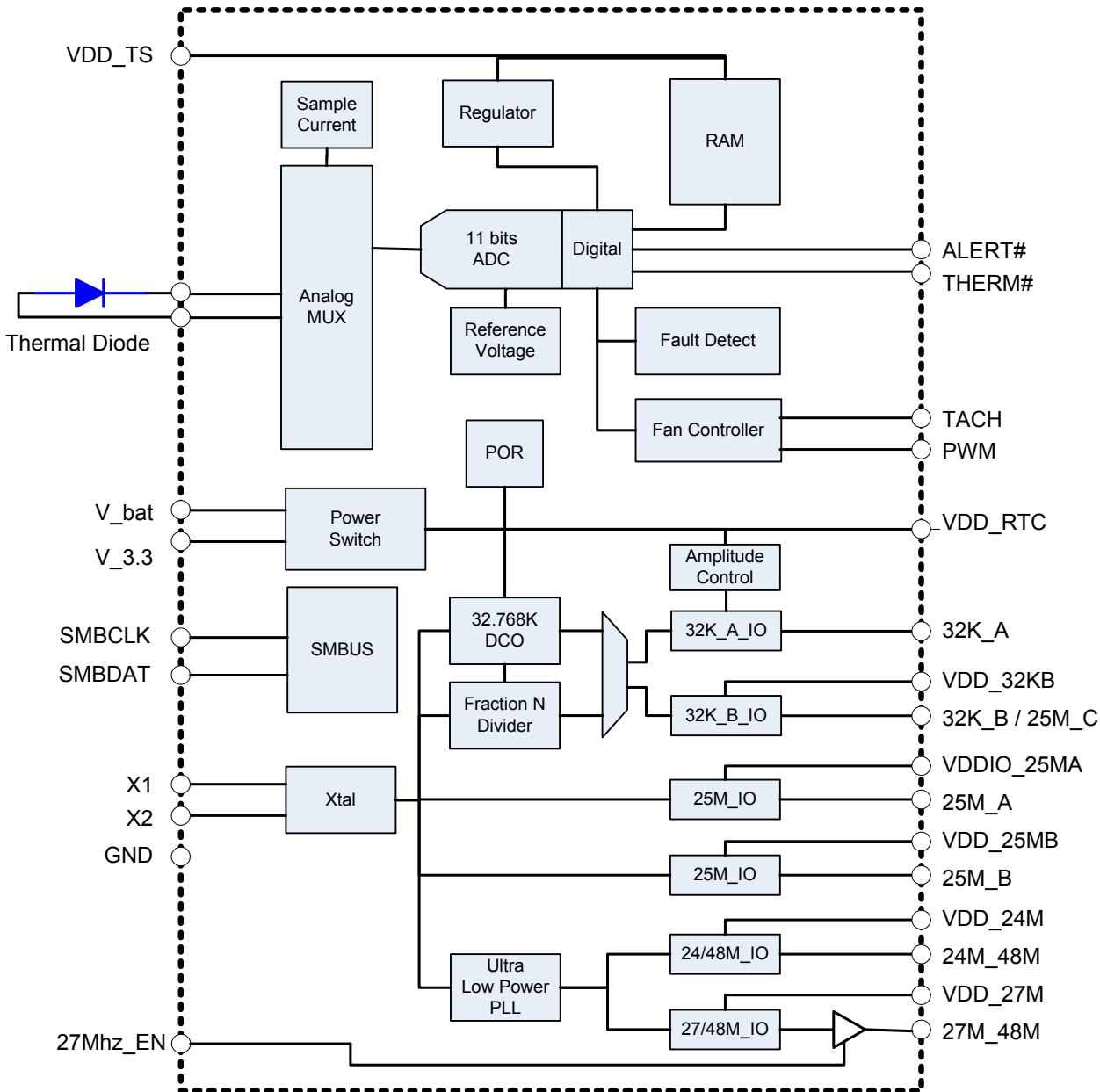
- High frequency or low frequency PWM outputs for use with 4-wire fans
- TACH inputs to measure fan speed
- OS independent automatic fan speed control based on thermal information
- Dynamic TMIN control mode to optimize system acoustics
- Default startup at 100% PWM for all fans for robust operation

System Clock PLL Synthesizers

- Scalable low voltage VDD I/O (1.5V to 1.05V) to reduce power consumption (applies to 25MHz output)
- Integrated series termination resistors
- Selectable – Single-ended 24MHz/27MHz/48MHz clock output @ VDD3.3V
- 3 – Single ended 25MHz clock outputs (buffer out)
- 32.768 kHz outputs with $< 1.8\mu\text{A}$ power consumption for system RTC circuit

Features

Block Diagram



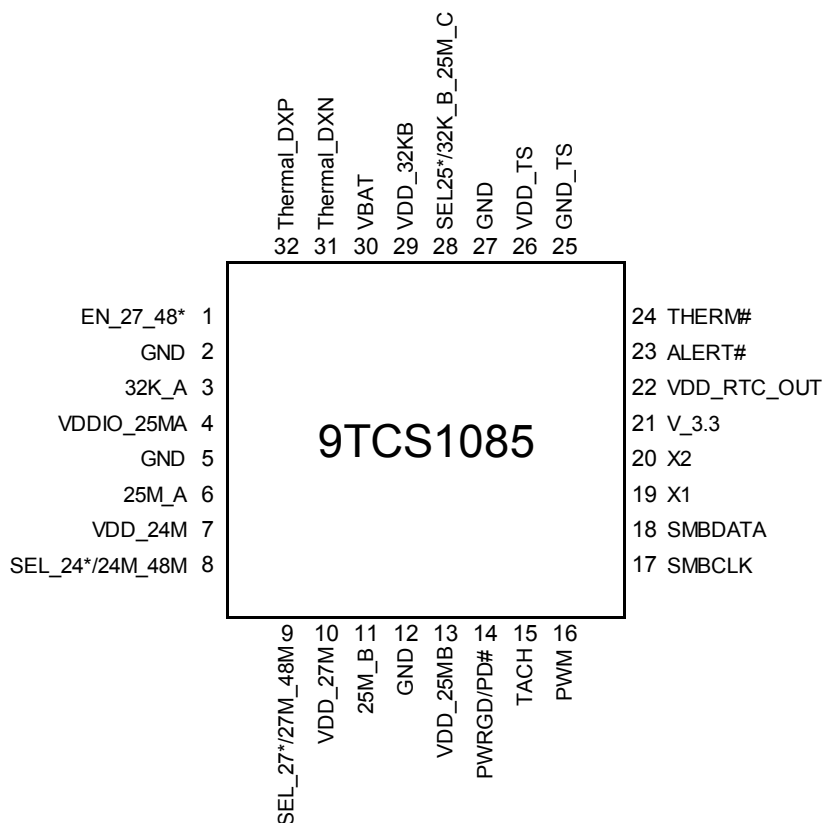
Preferred drive strengths for single-ended outputs.

Transmission lines to load do not share series resistors.

Desktop ($Z_0=50\Omega$) and mobile ($Z_0=55\Omega$) have the same drive strength.

| D.C.Drive Strength | Number of Loads to Drive | Match Point for N & P Voltage / Current (mA) | Number of Loads Actually Driven. | | |
|--------------------|--------------------------|--|----------------------------------|----------------------------|----------------------------|
| | | | 1 Load $R_s =$ | 2 Loads $R_s =$ | 3 Loads $R_s =$ |
| | 1 | 0.56 / 33 (17 Ω) | 33 Ω [39 Ω] | - | - |
| | 2 | 0.92 / 66 (14 Ω) | 39 Ω [43 Ω] | 22 Ω [27 Ω] | - |
| | 3 | 1.15 / 99 (11.6 Ω) | 43 Ω [43 Ω] | 27 Ω [33 Ω] | 15 Ω [22 Ω] |

Pin Assignment



* Internal Pull-Up Resistor
24M/27M/48Mhz outputs require external series resistors on Board.

Power Group

| Pin Number | | Description |
|------------|-----|------------------------------|
| VDD | GND | |
| 4 | 2 | VDDIO_25MA IO power |
| 7 | 5 | VDD_24M power |
| 10 | 12 | VDD_27M power |
| 13 | 2 | VDD_25B Power |
| 21 | 2 | V_3.3 core power |
| 22 | 27 | VDD_RTC_Out |
| 26 | 25 | VDD_TS power |
| 29 | 27 | VDD_32KB Power |
| 30 | 27 | V_bat for DCO and 32KA power |

* pin33: thermal pad

Pin Descriptions

| PIN | PIN NAME | TYPE | DESCRIPTION |
|-----|--------------------|------|--|
| 1 | EN_27_48* | PWR | Pin10 27_48 output enable/disable. Real time |
| 2 | GND | OUT | Ground pin |
| 3 | 32K_A | OUT | RTC clock 32.768KHz output A |
| 4 | VDDIO_25MA | PWR | Power for 25MHz_A output |
| 5 | GND | PWR | Ground pin |
| 6 | 25M_A | OUT | 25MHz_A Output |
| 7 | VDD_24M | PWR | Power for 24/48 MHz output |
| 8 | SEL_24*/24M_48M | I/O | 24Mhz Enable Latched Input, programmable Free Running 24/48M clock output. SEL_24 Selects the functionality of the 24_48M output as follows: 1 = 24M output (Default) 0 = 48M output |
| 9 | SEL_27*/27M_48M | I/O | 27Mhz Enable Latched Input, programmable Free Running 27/48M clock output. SEL_27 Selects the functionality of the 27_48M output as follows: 1 = 27M output (default) 0 = 48M output |
| 10 | VDD_27M | PWR | Power for 27/48 MHz output |
| 11 | 25M_B | OUT | 25MHz_B Output |
| 12 | GND | PWR | Ground pin |
| 13 | VDD_25MB | PWR | Power for LDO and main circuit |
| 14 | PWRGD/PD# | IN | This 3.3V LVTTTL input notifies device to sample latched inputs and start up on first high assertion, or |
| 15 | TACH | IN | Fan controller TACH signal input |
| 16 | PWM | OUT | Fan controller PWM signal output |
| 17 | SMBCLK | IN | SMBUS clock |
| 18 | SMBDAT | I/O | SMBUS data |
| 19 | X1 | IN | Crystal input, Nominally 25MHz. |
| 20 | X2 | OUT | Crystal output, Nominally 25MHz |
| 21 | V_3.3 | PWR | Power for 32K PLL core, connect to system 3.3V_StandBy |
| 22 | VDD_RTC_OUT | OUT | Power for chipset RTC circuit |
| 23 | ALERT# | OUT | open drain interrupt output for SMBUS Alert pin |
| 24 | THERM# | OUT | open drain interrupt output for external hardware connection |
| 25 | GND_TS | PWR | Ground pin for thermal sensor function |
| 26 | VDD_TS | PWR | Power for thermal sensor function |
| 27 | GND | PWR | Ground pin |
| 28 | SEL_25*/32KB_25M_C | I/O | 25Mhz_C output select pin, programmable Free Running 32.768Khz or 25Mhz clock output. SEL_25* Selects the functionality of the 32K_25M output as follows: 1 = 25Mhz output (Default) 0 = 32.768Khz output |
| 29 | VDD_32KB | PWR | Power for 32.768Khz_B output |
| 30 | VBAT | PWR | Power for 32kHz_A output. Connect to coin cell battery |
| 31 | Thermal_DXN1 | IN | external thermal diode N |
| 32 | Thermal_DXP1 | IN | external thermal diode P |
| 33 | Thermal Pad | PWR | GND |

Frequency and Output Selection Tables

Clock Output Selection Table

| Pin number | Setting | Output | Remark |
|------------|---------|-------------|-----------------------------|
| 8 | L | 48MHz | |
| | H | 24MHz | default, internal pull high |
| 9 | L | 48MHz | |
| | H | 27MHz | default, internal pull high |
| 28 | L | 32.768KHz_B | |
| | H | 25MHz_C | default, internal pull high |

Output Selection Table A

| Power Supply | | VDDIO_Control | | | Outputs | | | | |
|--------------|------------------|---------------|-----------------------|---------|---------|-------|-------|-------|---------|
| V_Bat | V_3.3 | VDD_32KB | VDDIO_25A | VDD_25B | 32K_A | 32K_B | 25M_A | 25M_B | VDD_RTC |
| 2.3~3.0 | 0 | 0 | 0 | 0 | ON | OFF | OFF | OFF | Vbat |
| 2.3~3.0 | 3.3 ¹ | 0 | 0 | 0 | ON | OFF | OFF | OFF | V3.3 |
| 2.3~3.0 | 3.3 ¹ | 3.3 | 0 | 0 | ON | ON | OFF | OFF | V3.3 |
| 2.3~3.0 | 3.3 ¹ | 3.3 | 1.05~1.5 ² | 0 | ON | ON | ON | OFF | V3.3 |
| 2.3~3.0 | 3.3 ¹ | 3.3 | 1.05~1.5 ² | 3.3 | ON | ON | ON | ON | V3.3 |

Note 1: When V3.3 is applied, XTAL will always be ON. 32K source will switch to an analog PLL. Fan control will be ON.

Note 2: If amplitude greater than 1.5V is required on 25MHz_A output, please contact IDT support.

Output Selection Table B

| Power Supply | | | | Outputs | | | |
|--------------|----------------------|---------|--------|---------|--------|-------------|----------------|
| V_3.3 | VDD_24M ¹ | VDD_27M | VDD_TS | 24_48M | 27_48M | Fan Control | Thermal Sensor |
| 3.3 | 0 | 0 | 0 | OFF | OFF | ON | OFF |
| 3.3 | 3.3 | 0 | 0 | ON | OFF | ON | OFF |
| 3.3 | 3.3 | 3.3 | 0 | ON | ON | ON | OFF |
| 3.3 | 3.3 | 3.3 | 3.3 | ON | ON | ON | ON |

Note 1: When either VDD_24M, VDD_27M or VDD_TS is ON, V_3.3 should be ON.

Absolute Maximum Ratings

Stresses above the ratings listed below can cause permanent damage to the 9TCS1085. These ratings, which are standard values for IDT commercially rated parts, are stress ratings only. Functional operation of the device at these or any other conditions above those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods can affect product reliability. Electrical parameters are guaranteed only over the recommended operating temperature range.

| PARAMETER | SYMBOL | CONDITIONS | MIN | MAX | UNITS | Notes |
|------------------------|-------------------|--------------------|-----------|-----|-------|-------|
| Maximum Supply Voltage | VDDxxx | Core/Logic Supply | | 3.6 | V | 1,2 |
| Maximum Supply Voltage | VDDIOxxx | Core/Logic Supply | | 3.6 | V | 1,2 |
| Maximum Input Voltage | V _{IH} | 3.3V LVCMOS Inputs | | 3.6 | V | 1,2,3 |
| Minimum Input Voltage | V _{IL} | Any Input | GND - 0.5 | | V | 1,2 |
| Storage Temperature | T _s | - | -65 | 150 | °C | 1,2 |
| Case Temperature | T _{case} | - | | 115 | °C | 1,2 |

¹ Unless otherwise noted, guaranteed by design and characterization, not 100% tested in production.

² Operation under these conditions is neither implied, nor guaranteed.

³ Maximum input voltage is not to exceed maximum VDD

Electrical Characteristics—SMBus Interface

| PARAMETER | SYMBOL | CONDITIONS | MIN | MAX | UNITS | Notes |
|---|---------------------|---|-----|------|-------|-------|
| SMBus Voltage | V _{DD} | | 2.7 | 3.6 | V | 1 |
| Low-level Output Voltage | V _{OL} SMB | @ I _{PULLUP} | | 0.4 | V | 1 |
| Current sinking at V _{OL} SMB = 0.4 V | I _{PULLUP} | SMB Data Pin | 4 | | mA | 1 |
| SCLK/SDATA Clock/Data Rise Time | T _{RI2C} | (Max VIL - 0.15) to (Min VIH + 0.15) | | 1000 | ns | 1 |
| SCLK/SDATA Clock/Data Fall Time | T _{FI2C} | (Min VIH + 0.15) to (Max VIL - 0.15) | | 300 | ns | 1 |
| Maximum SMBus Operating Frequency | F _{SMBUS} | Block Mode | | 400 | kHz | 1 |

¹ Unless otherwise noted, guaranteed by design and characterization, not 100% tested in production.

AC Electrical Characteristics—Input/Common Parameters

| PARAMETER | SYMBOL | CONDITIONS | MIN | MAX | UNITS | Notes |
|-------------------|-------------------|---|-----|-----|-------|-------|
| Clk Stabilization | T _{STAB} | From VDD Power-Up or de-assertion of PD# to 1st clock | | 1.8 | ms | 1 |
| Tdrive_PD# | T _{DRPD} | Differential output enable after PD# de-assertion | | 300 | us | 1 |

¹ Unless otherwise noted, guaranteed by design and characterization, not 100% tested in production.

Electrical Characteristics—Input/Supply/Common Parameters

| PARAMETER | SYMBOL | CONDITIONS | MIN | MAX | UNITS | Notes |
|---|-----------------------|--|-----------------------|-----------------------|-------|-------|
| Ambient Operating Temp | T _{ambient} | - | 0 | 70 | °C | |
| Supply Voltage | V _{3.3} | Supply Voltage | 3.135 | 3.465 | V | |
| Supply Voltage | VDD _{xx} | Other Supply Voltages | 3.135 | 3.465 | V | |
| Supply Voltage | VDDIO_25MA | Supply Voltage | 0.9975 | 1.575 | V | |
| Supply Voltage | V _{bat} | Supply Voltage | 2.3 | 3.465 | V | |
| Input High Voltage | V _{IHSE} | Single-ended inputs | 2 | V _{DD} + 0.3 | V | 1,4 |
| Input Low Voltage | V _{ILSE} | Single-ended inputs | V _{SS} - 0.3 | 0.8 | V | 1,4 |
| Low Threshold Input-High Voltage | V _{IH_FS} | 3.3 V +/-5% | 0.7 | V _{DD} + 0.3 | V | 1 |
| Low Threshold Input-Low Voltage | V _{IL_FS} | 3.3 V +/-5% | V _{SS} - 0.3 | 0.35 | V | 1 |
| Input Leakage Current | I _{IN} | V _{IN} = V _{DD} , V _{IN} = GND | -5 | 5 | uA | 1,3 |
| Input Leakage Current | I _{INRES} | Inputs with pull or pull down resistors V _{IN} = V _{DD} , V _{IN} = GND | -200 | 200 | uA | 1 |
| Output High Voltage | V _{OHSE} | Single-ended outputs, I _{OH} = -1mA | 2.4 | | V | 1,2 |
| Output Low Voltage | V _{OLSE} | Single-ended outputs, I _{OL} = 1 mA | | 0.4 | V | 1,2 |
| 3.3V Operating Supply Current | I _{DD3.3OP} | Full active mode, C _L = Full load, 3.3V Rail | | 50 | mA | 1 |
| | I _{DD3.3PD#} | Complete Power-Down, 3.3V Rail | | 10 | mA | 1 |
| | I _{DD3.3WOL} | WOL Mode with 25MA running, 3.3V Rail | | 25 | mA | 1 |
| | I _{DD3.3RTC} | RTC Mode with 32KA running, 3.3V Rail | | 0.1 | uA | 1 |
| VDDIO Operating Supply Current | I _{DDIO_OP} | Full active mode, C _L = Full load, VDDIO Rails | | 5 | mA | 1 |
| | I _{DDIO_PD#} | Complete Power-Down, VDDIO Rails | | 1 | mA | 1 |
| | I _{DDIO_WOL} | WOL Mode with 25MA running, VDDIO Rails | | 10 | mA | 1 |
| | I _{DDIO_RTC} | RTC Mode with only 32KA running, VDDIO Rails | | 0.5 | uA | 1 |
| V _{bat} Operating Supply Current | I _{DD_V_bat} | RTC Mode with 32KA running, V _{bat} Rail | | 1.8 | uA | 1 |
| Input Frequency | F _i | V _{DD} = 3.3 V | 25MHz Typical | | MHz | 1 |
| Pin Inductance | L _{pin} | | | 7 | nH | 1 |
| Input Capacitance | C _{IN} | Logic Inputs | 1.5 | 5 | pF | 1 |
| | C _{OUT} | Output pin capacitance | | 6 | pF | 1 |
| | C _{INX} | X1 & X2 pins | | 6 | pF | 1 |

*TA = 0 - 70°C; Supply Voltage V_{3.3} = VDD_{TS} = 3.3 V +/-5%, VDD_{24M} = VDD_{27M} = VDD_{25MB} = 3.3V +/- 5%, VDD_{25MA} = 1.05V +/- 5%, VDD_{32KB} = 3.3V +/- 5%, CL = 5pF with Rs = 27Ω (unless otherwise specified)

¹ Unless otherwise noted, guaranteed by design and characterization, not 100% tested in production.

² Signal is required to be monotonic in this region.

³ Input leakage current does not include inputs with pull-up or pull-down resistors

⁴ 3.3V referenced inputs are: SCLK, SDATA, SEL₂₅, SEL₂₄, SEL₂₇, PWRGD.

AC Electrical Characteristics—Power Management

Output Clock Power Consumption Table

| Power Supply | | Power Consumption @ 2' transmission line | | | |
|---------------|-----------------|--|---------|------------|-----------|
| V_bat / V_3.3 | Outputs | I_V_bat | I_V_3.3 | I_VDD_32KB | I_VDD_25M |
| 2.3~3.3 | 32K_A | 1.8uA | 0 | 0 | 0 |
| 2.3~3.3 | 32K_A | 0 | 2mA | 0 | 0 |
| 2.3~3.3 | 32K_A+B | 0 | 2mA | 1uA | 0 |
| 2.3~3.3 | 32K, 25M_A | 0 | 2mA | 1uA | 1mA |
| 2.3~3.3 | 32K_A+B, 25MA+B | 0 | 2mA | 1uA | 2mA |

Note: When V_3.3 is applied, XTAL will always be ON. 32K source will switch to an analog PLL.

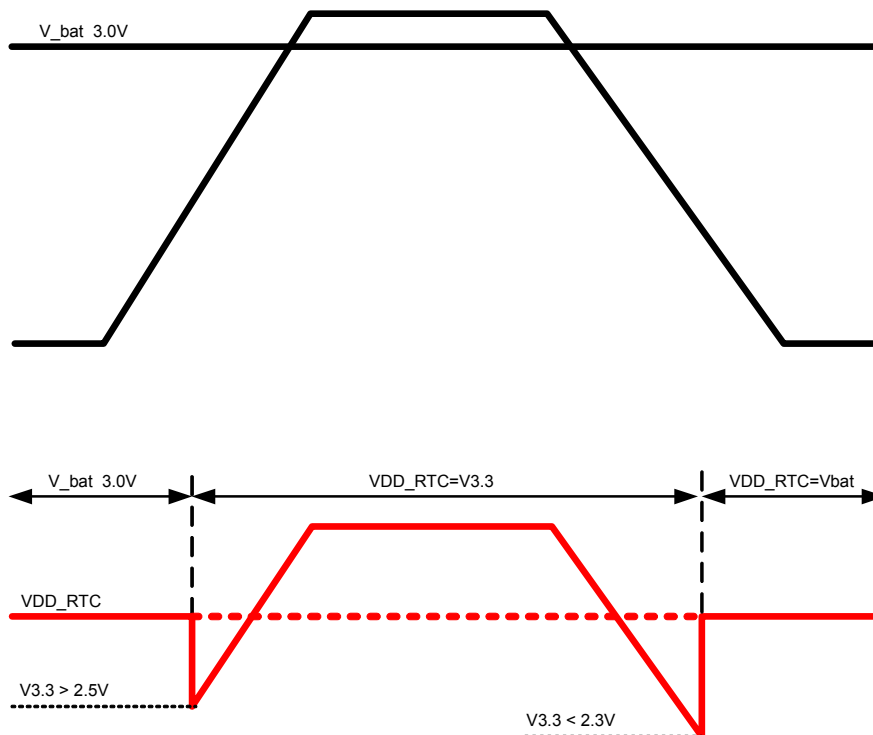
| Power Supply | | Power consumption @ 2' transmission line | | | |
|--------------|----------------------|--|-----------|-----------|----------|
| V_3.3 | VDD_24/27/TS | I_V3.3 | I_VDD_24M | I_VDD_27M | I_VDD_TS |
| 3.3 | 0 | 2mA | 0 | 0 | 0 |
| 3.3 | 24Mhz | 2mA | 3mA | 0 | 0 |
| 3.3 | 24/27Mhz | 2mA | 3mA | 1mA | 0 |
| 3.3 | 24/27Mhz+Thermal+Fan | 2mA | 3mA | 1mA | 0.8mA |

Note: When either VDD_24M, VDD_27M or VDD_TS is ON, V3.3 should be ON

Power Switch (VBAT/V33 -> VDD_RTC)

Integrated power switch detects the VDD_RTC SW to coin cell battery (VBAT) or main power supply (V33).

When there is no V33 (V33=0), the SW will connect the VDD_RTC to VBAT; when V33 goes higher than 2.5V, the VDD_RTC will be switched to V33 with no delay. After V33 goes lower than 2.3V, the VDD_RTC will be switched to VBAT, no delay.



When VDD_RTC = VBAT, the power SW circuit consumes < 100nA.

When VDD_RTC = V33, the power consumption on VBAT needs to be "0".

Electrical Characteristics—USB48MHz

| PARAMETER | SYMBOL | CONDITIONS | MIN | MAX | UNITS | NOTES |
|------------------------|----------------------|--|---------|---------|-------|-------|
| Long Accuracy | ppm | see T _{period} min-max values | -100 | 100 | ppm | 1,2 |
| Clock period | T _{period} | 48.00MHz output nominal | 20.8313 | 20.8354 | ns | 1,2 |
| Output High Voltage | V _{OH} | I _{OH} = -1 mA | 2.4 | | V | 1 |
| Output Low Voltage | V _{OL} | I _{OL} = 1 mA | | 0.4 | V | 1 |
| Output High Current | I _{OH} | V _{OH} @ MIN = 1.0 V | -33 | | mA | 1 |
| | | V _{OH} @ MAX = 3.135 V | | -33 | mA | 1 |
| Output Low Current | I _{OL} | V _{OL} @ MIN = 1.95 V | 30 | | mA | 1 |
| | | V _{OL} @ MAX = 0.4 V | | 38 | mA | 1 |
| Rising Edge Slew Rate | t _{SLR} | Measured from 0.8 to 2.0 V | 0.5 | 2.5 | V/ns | 1 |
| Falling Edge Slew Rate | t _{SLR} | Measured from 2.0 to 0.8 V | 0.5 | 2.5 | V/ns | 1 |
| Duty Cycle | d _{t1} | V _T = 1.5 V | 45 | 55 | % | 1 |
| Jitter, Cycle to cycle | t _{jcy-cyc} | V _T = 1.5 V | | 350 | ps | 1 |

*TA = 0 - 70°C; Supply Voltage V_{3.3} = VDD_{TS} = 3.3 V +/- 5%, VDD_{24M} = VDD_{27M} = VDD_{25MB} = 3.3V +/- 5%, VDD_{25MA} = 1.05V +/- 5%, VDD_{32KB} = 3.3V +/- 5%, CL = 5pF with R_s = 27Ω (unless otherwise specified)

¹Guaranteed by design and characterization, not 100% tested in production.

² All Long Term Accuracy and Clock Period specifications are guaranteed assuming that REFOUT is at 25.000000MHz

Electrical Characteristics—24MHz

| PARAMETER | SYMBOL | CONDITIONS | MIN | MAX | UNITS | NOTES |
|------------------------|----------------------|--|---------|---------|-------|-------|
| Long Accuracy | ppm | see T _{period} min-max values | -100 | 100 | ppm | 1,2 |
| Clock period | T _{period} | 24.00MHz output nominal | 41.6625 | 41.6708 | ns | 1,2 |
| Output High Voltage | V _{OH} | I _{OH} = -1 mA | 2.4 | | V | 1 |
| Output Low Voltage | V _{OL} | I _{OL} = 1 mA | | 0.4 | V | 1 |
| Output High Current | I _{OH} | V _{OH} @ MIN = 1.0 V | -33 | | mA | 1 |
| | | V _{OH} @ MAX = 3.135 V | | -33 | mA | 1 |
| Output Low Current | I _{OL} | V _{OL} @ MIN = 1.95 V | 30 | | mA | 1 |
| | | V _{OL} @ MAX = 0.4 V | | 38 | mA | 1 |
| Rising Edge Slew Rate | t _{SLR} | Measured from 0.8 to 2.0 V | 0.5 | 4 | V/ns | 1 |
| Falling Edge Slew Rate | t _{SLR} | Measured from 2.0 to 0.8 V | 0.5 | 4 | V/ns | 1 |
| Duty Cycle | d _{t1} | V _T = 1.5 V | 45 | 55 | % | 1 |
| Jitter, Cycle to cycle | t _{jcy-cyc} | V _T = 1.5 V | | 350 | ps | 1 |

*TA = 0 - 70°C; Supply Voltage V_{3.3} = VDD_{TS} = 3.3 V +/- 5%, VDD_{24M} = VDD_{27M} = VDD_{25MB} = 3.3V +/- 5%, VDD_{25MA} = 1.05V +/- 5%, VDD_{32KB} = 3.3V +/- 5%, CL = 5pF with R_s = 27Ω (unless otherwise specified)

¹Guaranteed by design and characterization, not 100% tested in production.

² All Long Term Accuracy and Clock Period specifications are guaranteed assuming that REFOUT is at 25.000000MHz

Electrical Characteristics–25MHz

| PARAMETER | SYMBOL | CONDITIONS | MIN | MAX | UNITS | NOTES |
|------------------------|----------------------|--------------------------------|----------|----------|-------|-------|
| Long Accuracy | ppm | see Tperiod min-max values | -100 | 100 | ppm | 1,2 |
| Clock period | T _{period} | 25.00MHz output nominal | 39.99600 | 40.00400 | ns | 1,2 |
| Output High Voltage | V _{OH} | I _{OH} = -1 mA | 2.4 | | V | 1 |
| Output Low Voltage | V _{OL} | I _{OL} = 1 mA | | 0.4 | V | 1 |
| Output High Current | I _{OH} | V _{OH} @MIN = 1.0 V | -29 | | mA | 1 |
| | | V _{OH} @MAX = 3.135 V | | -23 | mA | 1 |
| Output Low Current | I _{OL} | V _{OL} @ MIN = 1.95 V | 29 | | mA | 1 |
| | | V _{OL} @ MAX = 0.4 V | | 27 | mA | 1 |
| Rising Edge Slew Rate | t _{SLR} | Measured from 0.8 to 2.0 V | 0.5 | 4 | V/ns | 1 |
| Falling Edge Slew Rate | t _{SLR} | Measured from 2.0 to 0.8 V | 0.5 | 4 | V/ns | 1 |
| Duty Cycle | d _{t1} | V _T = 1.5 V | 40 | 60 | % | 1 |
| Jitter, Cycle to cycle | t _{jcy-cyc} | V _T = 1.5 V | | 500 | ps | 1 |

*TA = 0 - 70°C; Supply Voltage V_{3.3} = VDD_{TS} = 3.3 V +/-5%, VDD_{24M} = VDD_{27M} = VDD_{25MB} = 3.3V +/- 5%, VDD_{25MA} = 1.05V +/- 5%, VDD_{32KB} = 3.3V +/- 5%, CL = 5pF with Rs = 0Ω (unless otherwise specified)

¹Guaranteed by design and characterization, not 100% tested in production.

² All Long Term Accuracy and Clock Period specifications are guaranteed assuming that REFOUT is at 25.000000MHz

Electrical Characteristics–27MHz

| | | | | | | |
|------------------------|----------------------|--|---------|---------|------|-----|
| Long Accuracy | ppm | see Tperiod min-max values | -50 | 50 | ppm | 1,2 |
| Clock period | T _{period} | 27.000MHz output nominal | 37.0365 | 37.0376 | ns | 1,2 |
| Output High Voltage | V _{OH} | I _{OH} = -1 mA | 2.4 | | V | 1 |
| Output Low Voltage | V _{OL} | I _{OL} = 1 mA | | 0.4 | V | 1 |
| Output High Current | I _{OH} | V _{OH} @MIN = 1.0 V | -29 | | mA | 1 |
| | | V _{OH} @MAX = 3.135 V | | -23 | mA | 1 |
| Output Low Current | I _{OL} | V _{OL} @ MIN = 1.95 V | 29 | | mA | 1 |
| | | V _{OL} @ MAX = 0.4 V | | 27 | mA | 1 |
| Rising Edge Slew Rate | t _{SLR} | Measured from 0.8 to 2.0 V | 1 | 4 | V/ns | 1 |
| Falling Edge Slew Rate | t _{FLR} | Measured from 2.0 to 0.8 V | 1 | 4 | V/ns | 1 |
| Duty Cycle | d _{t1} | V _T = 1.5 V | 45 | 55 | % | 1 |
| Jitter, Cycle to cycle | t _{jcy-cyc} | Cycle to Cycle, V _T = 1.5 V | | 200 | ps | 1 |

*TA = 0 - 70°C; Supply Voltage V_{3.3} = VDD_{TS} = 3.3 V +/-5%, VDD_{24M} = VDD_{27M} = VDD_{25MB} = 3.3V +/- 5%, VDD_{25MA} = 1.05V +/- 5%, VDD_{32KB} = 3.3V +/- 5%, CL = 5pF with Rs = 27Ω (unless otherwise specified)

¹Guaranteed by design and characterization, not 100% tested in production.

² All Long Term Accuracy and Clock Period specifications are guaranteed assuming that REFOUT is at 25.000000MHz

Electrical Characteristics—32KHz_A (Low Voltage Output)

| PARAMETER | SYMBOL | CONDITIONS | MIN | MAX | UNITS | Notes |
|-------------------------|-----------------------|----------------------------|----------------|-------|---------|-------|
| Long Accuracy | ppm | see Tperiod min-max values | 32.768 Typical | | kHz | 1,2 |
| Output High Voltage | V _{OH} | 32K_A Output | 0.8 | 1.2 | V | 1 |
| Output Low Voltage | V _{OL} | 32K_A Output | | 0.3 | V | 1 |
| Initial Frequency Error | 32K _{INI} | 0C to 70C | | +/-10 | ppm | 1 |
| | | | | 0.86 | sec/day | 1 |
| RTC Frequency Error | 32K _{RTC_7D} | 7-day measurement | | 8 | sec | 1 |
| Rising Edge Slew Rate | t _{SLR} | Measured from 20% to 80% | 0.03 typ | | V/ns | 1 |
| Falling Edge Slew Rate | t _{FLR} | Measured from 80% to 20% | 0.03 typ | | V/ns | 1 |
| Duty Cycle | d _{t1} | VT = V _{bat} /2 | 40 | 60 | % | 1 |

*TA = 0 - 70°C; Supply Voltage V_{3.3} = VDD_{TS} = 3.3 V +/-5%, VDD_{24M} = VDD_{27M} = VDD_{25MB} = 3.3V +/- 5%, VDD_{25MA} = 1.05V +/- 5%, VDD_{32KB} = 3.3V +/- 5%, CL = 2pF with Rs = 0Ω (unless otherwise specified)

¹Guaranteed by design and characterization, not 100% tested in production.

² All Long Term Accuracy and Clock Period specifications are guaranteed assuming that REFOUT is at 25.000000MHz

Electrical Characteristics—32KHz_B

| PARAMETER | SYMBOL | CONDITIONS | MIN | MAX | UNITS | Notes |
|-------------------------|--------------------|----------------------------|----------------|-------|---------|-------|
| Long Accuracy | ppm | see Tperiod min-max values | 32.768 Typical | | kHz | 1,2 |
| Output High Voltage | V _{OH} | 32K_B Output | 0.9975 | 3.465 | V | 1 |
| Output Low Voltage | V _{OL} | 32K_B Output | | 0.3 | V | 1 |
| Initial Frequency Error | 32K _{INI} | 0C to 70C | | +/-10 | ppm | 1 |
| | | | | 0.86 | sec/day | 1 |
| Rising Edge Slew Rate | t _{SLR} | Measured from 20% to 80% | 0.3 | 2 | V/ns | 1 |
| Falling Edge Slew Rate | t _{FLR} | Measured from 80% to 20% | 0.3 | 2 | V/ns | 1 |
| Duty Cycle | d _{t1} | VT = V _{bat} /2 | 40 | 60 | % | 1 |

*TA = 0 - 70°C; Supply Voltage V_{3.3} = VDD_{TS} = 3.3 V +/-5%, VDD_{24M} = VDD_{27M} = VDD_{25MB} = 3.3V +/- 5%, VDD_{25MA} = 1.05V +/- 5%, VDD_{32KB} = 3.3V +/- 5%, CL = 2pF with Rs = 0Ω (unless otherwise specified)

¹Guaranteed by design and characterization, not 100% tested in production.

² All Long Term Accuracy and Clock Period specifications are guaranteed assuming that REFOUT is at 25.000000MHz

Recommended 25MHz Crystal Specification

| PARAMETER | SYMBOL | CONDITIONS | MIN | MAX | UNITS | NOTES |
|----------------------------------|--------------------|--------------------|-------------|-------|-------|-------|
| Frequency Accuracy | F _{accr} | @25C | | +/-10 | ppm | 1 |
| Frequency Error over temperature | F _{errt} | -10C ~ 70C | | +/-10 | ppm | 1 |
| Frequency Aging | F _{aging} | 1 year | | +/-1 | ppm | 1 |
| Driver Level | DL | | | 100 | uW | 1 |
| Crystal Load Capacitance | CL | Parallel Resonance | 8pF Typical | | pF | 1 |

*TA = 0 - 70°C; Supply Voltage V_{3.3} = VDD_{TS} = 3.3 V +/-5%, VDD_{24M} = VDD_{27M} = VDD_{25MB} = 3.3V +/- 5%, VDD_{25MA} = 1.05V +/- 5%, VDD_{32KB} = 3.3V +/- 5% (unless otherwise specified)

¹Guaranteed by design and characterization, not 100% tested in production.

Electrical Characteristics—Thermal Sensor Controller

| PARAMETER | SYMBOL | CONDITIONS | MIN | MAX | UNITS | Notes |
|------------------------|--------|-------------|-----|------|-------|-------|
| Local Sensor Accuracy | | 0C<TA<60C | | 2 | C | 1 |
| | | 60C<TA<100C | | 1 | C | 1 |
| Resolution | | | | 1 | C | 1 |
| Remote Sensor Accuracy | Raccu | 0C<TA<60C | | 2 | C | 1 |
| | | 60C<TA<100C | | 1 | C | 1 |
| Resolution | Rs | | | 1 | C | 1 |
| Conversion Rate | CR | | 16 | 1/64 | Sec | 1 |

*TA = 0 - 70°C; Supply Voltage V_{3.3} = VDD_{TS} = 3.3 V +/- 5%, VDD_{24M} = VDD_{27M} = VDD_{25MB} = 3.3V +/- 5%, VDD_{25MA} = 1.05V +/- 5%, VDD_{32KB} = 3.3V +/- 5% (unless otherwise specified)

¹Guaranteed by design and characterization, not 100% tested in production.

Electrical Characteristics—Fan Controller

| PARAMETER | SYMBOL | CONDITIONS | MIN | MAX | UNITS | Notes |
|------------------|--------|------------|-----|-----|-------|-------|
| PWM frequency | PWM | | 25 | 27 | kHz | 1 |
| PWM Duty Cycle | DUTY | | | 100 | % | 1 |
| Tachometer Range | TACH | | 1 | 4 | POLE | 1 |

*TA = 0 - 70°C; Supply Voltage V_{3.3} = VDD_{TS} = 3.3 V +/- 5%, VDD_{24M} = VDD_{27M} = VDD_{25MB} = 3.3V +/- 5%, VDD_{25MA} = 1.05V +/- 5%, VDD_{32KB} = 3.3V +/- 5% (unless otherwise specified)

¹Guaranteed by design and characterization, not 100% tested in production.

General SMBus Serial Interface Information for 9TCS1085

How to Write

- Controller (host) sends a start bit
- Controller (host) sends the write address
- IDT clock will **acknowledge**
- Controller (host) sends the beginning byte location = N
- IDT clock will **acknowledge**
- Controller (host) sends the byte count = X
- IDT clock will **acknowledge**
- Controller (host) starts sending Byte N through Byte N+X-1
- IDT clock will **acknowledge** each byte **one at a time**
- Controller (host) sends a Stop bit

| Index Block Write Operation | | | |
|-----------------------------|-----------|-----|----------------------|
| Controller (Host) | | | IDT (Slave/Receiver) |
| T | starT bit | | |
| Slave Address | | | |
| WR | WWrite | | |
| | | | ACK |
| Beginning Byte = N | | | |
| | | | ACK |
| Data Byte Count = X | | | |
| | | | ACK |
| Beginning Byte N | | | X Byte |
| | | ACK | |
| O | | | |
| O | | O | |
| O | | O | |
| | | O | |
| Byte N + X - 1 | | | |
| | | | ACK |
| P | stoP bit | | |

| Read Address | Write Address |
|-------------------|-------------------|
| D3 _(H) | D2 _(H) |

How to Read

- Controller (host) will send a start bit
- Controller (host) sends the write address
- IDT clock will **acknowledge**
- Controller (host) sends the beginning byte location = N
- IDT clock will **acknowledge**
- Controller (host) will send a separate start bit
- Controller (host) sends the read address
- IDT clock will **acknowledge**
- IDT clock will send the data byte count = X
- IDT clock sends Byte N+X-1
- IDT clock sends **Byte 0 through Byte X (if X_(H) was written to Byte 8)**
- Controller (host) will need to acknowledge each byte
- Controller (host) will send a not acknowledge bit
- Controller (host) will send a stop bit

| Index Block Read Operation | | | |
|----------------------------|-----------------|----------------|----------------------|
| Controller (Host) | | X Byte | IDT (Slave/Receiver) |
| T | starT bit | | |
| Slave Address | | | |
| WR | WRite | | |
| | | | ACK |
| Beginning Byte = N | | | |
| | | | ACK |
| RT | Repeat starT | | |
| Slave Address | | | |
| RD | ReaD | | |
| | | | ACK |
| | | | |
| | | | Data Byte Count=X |
| ACK | | | |
| ACK | | | Beginning Byte N |
| | | | |
| O | | O | |
| O | | O | |
| O | | O | |
| | | | |
| | | Byte N + X - 1 | |
| N | Not acknowledge | | |
| P | stoP bit | | |

| Byte0 | Name | Control Function | Type | 0 | 1 | PWD |
|-------|-----------|--|------|---|------|-----|
| Bit7 | ALERT_TH1 | CH1 Diode ALERT High Temperature Limit | RW | - | SIGN | 0 |
| Bit6 | | | | | 64C | 1 |
| Bit5 | | | | | 32C | 1 |
| Bit4 | | | | | 16C | 1 |
| Bit3 | | | | | 8C | 1 |
| Bit2 | | | | | 4C | 1 |
| Bit1 | | | | | 2C | 1 |
| Bit0 | | | | | 1C | 1 |

Note: Register readback uses 2's Complement

| Byte1 | Name | Control Function | Type | 0 | 1 | PWD |
|-------|----------|------------------|------|---|---|-----|
| Bit7 | Reserved | Reserved | RW | - | - | 0 |
| Bit6 | | | | | - | 1 |
| Bit5 | | | | | - | 1 |
| Bit4 | | | | | - | 1 |
| Bit3 | | | | | - | 1 |
| Bit2 | | | | | - | 1 |
| Bit1 | | | | | - | 1 |
| Bit0 | | | | | - | 1 |

Note: Register readback uses 2's Complement

Byte 2 Reserved Register

| Byte3 | Name | Control Function | Type | 0 | 1 | PWD |
|-------|-----------|---------------------------------------|------|---|------|-----|
| Bit7 | ALERT_TL1 | CH1 Diode ALERT Low Temperature Limit | RW | - | SIGN | 1 |
| Bit6 | | | | | 64C | 0 |
| Bit5 | | | | | 32C | 0 |
| Bit4 | | | | | 16C | 0 |
| Bit3 | | | | | 8C | 0 |
| Bit2 | | | | | 4C | 0 |
| Bit1 | | | | | 2C | 0 |
| Bit0 | | | | | 1C | 1 |

Note: Register readback uses 2's Complement

Byte 4~5 Reserved Register

| Byte6 | Name | Control Function | Type | 0 | 1 | PWD |
|-------|-------------------|-----------------------------------|------|---------|---------|-----|
| Bit7 | CH1_EN | Enable Temp-Sensor Channel1 | RW | Disable | Enable | 0 |
| Bit6 | Reserved | Reserved | RW | - | - | 0 |
| Bit5 | Reserved | Reserved | RW | - | - | 1 |
| Bit4 | Reserved | Reserved | RW | - | - | 0 |
| Bit3 | Consecutive ALERT | Consecutive ALERT Report | RW | 00 = 1 | 01 = 2 | 0 |
| Bit2 | | | RW | 10 = 3 | 11 = 4 | 0 |
| Bit1 | Average_Fact | Average the converted temperature | RW | 00 = 1 | 01 = 4 | 0 |
| Bit0 | | | RW | 10 = 8 | 11 = 16 | 0 |

| Byte7 | Name | Control Function | Type | 0 | 1 | PWD |
|-------|----------|------------------------------------|------|---|----------|-----|
| Bit7 | THERMAL1 | CH1 Diode THERMALTemperature Limit | RW | - | Reserved | 0 |
| Bit6 | | | | | 64C | 1 |
| Bit5 | | | | | 32C | 1 |
| Bit4 | | | | | 16C | 1 |
| Bit3 | | | | | 8C | 1 |
| Bit2 | | | | | 4C | 1 |
| Bit1 | | | | | 2C | 1 |
| Bit0 | | | | | 1C | 1 |

Byte 8~9 Reserved Register

| Byte10 | Name | Control Function | Type | 0 | 1 | PWD |
|--------|------|------------------------------|------|---|-------|-----|
| Bit7 | D_A1 | CH1 Gain (Slope) Coefficient | RW | - | 1.28C | 1 |
| Bit6 | | | RW | | 0.64C | 0 |
| Bit5 | | | RW | | 0.32C | 0 |
| Bit4 | | | RW | | 0.16C | 0 |
| Bit3 | D_B1 | CH1 Offset Coefficient | RW | | 4C | 1 |
| Bit2 | | | RW | | 2C | 0 |
| Bit1 | | | RW | | 1C | 0 |
| Bit0 | | | RW | | 0.5C | 0 |

Byte 11 Reserved Register

| Byte12 | Name | Control Function | Type | 0 | 1 | PWD |
|--------|-------------|--------------------------|------|----------|------|-----|
| Bit7 | Reserved | Reserved | RW | - | - | 0 |
| Bit6 | Reserved | Reserved | RW | - | - | 0 |
| Bit5 | MASK1 | MASK Channel1 ALERT | RW | Non-Mask | Mask | 0 |
| Bit4 | THERMAL_HYS | THERMAL Limit Hysteresis | RW | - | 16C | 0 |
| Bit3 | | | RW | | 8C | 0 |
| Bit2 | | | RW | | 4C | 1 |
| Bit1 | | | RW | | 2C | 0 |
| Bit0 | | | RW | | 1C | 0 |

| Byte13 | Name | Control Function | Type | 0 | 1 | PWD |
|--------|-----------|------------------------------|------|----------|------|-----|
| Bit7 | Reserved | Reserved | R | - | - | 0 |
| Bit6 | Reserved | Reserved | R | - | - | 0 |
| Bit5 | Reserved | Reserved | R | - | - | 0 |
| Bit4 | Reserved | Reserved | R | - | - | 0 |
| Bit3 | CH1 High | Channel 1 ALERT High Alarm | R | Non-Flag | Flag | 0 |
| Bit2 | CH1 Low | Channel 1 ALERT Low Alarm | R | Non-Flag | Flag | 0 |
| Bit1 | CH1 Fault | Channel 1 Diode Fault (Open) | R | Non-Flag | Flag | 0 |
| Bit0 | Reserved | Reserved | R | - | - | 0 |

| Byte 14 | Name | Control Function | Type | 0 | 1 | PWD |
|---------|-------------|-----------------------------------|------|----------|------|-----|
| Bit7 | BUSY | ADC is converting | R | Non-Flag | Flag | 0 |
| Bit6 | HIGH | One of the Channels ALERT High | R | Non-Flag | Flag | 0 |
| Bit5 | LOW | One of the Channels ALERT Low | R | Non-Flag | Flag | 0 |
| Bit4 | FAULT | One of the EXT-Channel Open/Short | R | Non-Flag | Flag | 0 |
| Bit3 | Reserved | Reserved | R | - | - | 0 |
| Bit2 | CH1_THERMAL | Channel1 THERMAL Alarm | R | Non-Flag | Flag | 0 |
| Bit1 | Reserved | Reserved | R | - | - | 0 |
| Bit0 | Reserved | Reserved | R | - | - | 0 |

| Byte 15 | Name | Control Function | Type | 0 | 1 | PWD |
|---------|--------------|---------------------------------|------|-------------------------------------|------------------------|-----|
| Bit7 | Fault_Clear | Clear all the Alarm Flag | RW | No Clear | Clear | 0 |
| Bit6 | One-Shot | One-Shot Temperature Conversion | RW | Disable Oneshot | Do OneShot | 0 |
| Bit5 | DYN_AVE_EN | Enable Dynamic average | RW | Disable Dynamic Average | Enable Dynamic Average | 0 |
| Bit4 | Conv. Rate 3 | | RW | See Detail From Convert Ratio Table | | 0 |
| Bit3 | Conv. Rate 2 | | RW | | | 0 |
| Bit2 | Conv. Rate 1 | | RW | | | 1 |
| Bit1 | Conv. Rate 0 | | RW | | | 0 |
| Bit0 | Reserved | Reserved | RW | - | - | 0 |

| Byte 16 | Name | Control Function | Type | 0 | 1 | PWD |
|---------|-------------|--------------------|------|---|------|-----|
| Bit7 | TEMP <10:3> | MSB of Temperature | R | - | SIGN | 0 |
| Bit6 | | | R | | 64 | 0 |
| Bit5 | | | R | | 32 | 0 |
| Bit4 | | | R | | 16 | 0 |
| Bit3 | | | R | | 8 | 0 |
| Bit2 | | | R | | 4 | 0 |
| Bit1 | | | R | | 2 | 0 |
| Bit0 | | | R | | 1 | 0 |

| Byte 17 | Name | Control Function | Type | 0 | 1 | PWD |
|---------|-----------|--------------------|------|---|-------|-----|
| Bit7 | Reserved | Reserved | R | - | - | 0 |
| Bit6 | Reserved | Reserved | R | - | - | 0 |
| Bit5 | Reserved | Reserved | R | - | - | 0 |
| Bit4 | Reserved | Reserved | R | - | - | 0 |
| Bit3 | Reserved | Reserved | R | - | - | 0 |
| Bit2 | TEMP<2:0> | LSB of Temperature | R | - | 0.5 | 0 |
| Bit1 | | | R | | 0.25 | 0 |
| Bit0 | | | R | | 0.125 | 0 |

Byte 18~21 Reserved Register

| Byte 22 | Name | Control Function | Type | 0 | 1 | PWD |
|---------|-------------------|-------------------------|------|---|-----|-----|
| Bit7 | TACH_MEASURE<7:0> | LSB of TACH Measurement | R | - | 128 | 0 |
| Bit6 | | | R | | 64 | 0 |
| Bit5 | | | R | | 32 | 0 |
| Bit4 | | | R | | 16 | 0 |
| Bit3 | | | R | | 8 | 0 |
| Bit2 | | | R | | 4 | 0 |
| Bit1 | | | R | | 2 | 0 |
| Bit0 | | | R | | 1 | 0 |

| Byte23 | Name | Control Function | Type | 0 | 1 | PWD |
|--------|--------------------|-------------------------|------|---|------|-----|
| Bit7 | Reserved | Reserved | R | - | - | 0 |
| Bit6 | Reserved | Reserved | R | - | - | 0 |
| Bit5 | Reserved | Reserved | R | - | - | 0 |
| Bit4 | TACH_MEASURE<12:8> | MSB of TACH Measurement | R | - | 4096 | 0 |
| Bit3 | | | R | | 2048 | 0 |
| Bit2 | | | R | | 1024 | 0 |
| Bit1 | | | R | | 512 | 0 |
| Bit0 | | | R | | 256 | 0 |

| Byte24 | Name | Control Function | Type | 0 | 1 | PWD |
|--------|-------------|---------------------------------|------|------------------------|---------------------------|-----|
| Bit7 | Mode Select | Select the FAN Operating Mode | RW | 00 - Direct Drive Mode | 01 - Thermal Trigger Mode | 1 |
| Bit6 | | | RW | 10 - Dynamic PWM Mode | 11 - Reserved | 0 |
| Bit5 | Freq_Sel | Select the PWM frequency | RW | 00 - 25KHz | 01 - 22KHz | 0 |
| Bit4 | | | RW | 10 - 27KHz | 11 - Reserved | 0 |
| Bit3 | Edge | FAN Type Selection | RW | 00 - 1Pole FAN | 01 - 2 Poles FAN | 0 |
| Bit2 | | | RW | 10 - 3 Poles FAN | 11 - 4 Poles FAN | 1 |
| Bit1 | Error Range | TACH Detect Tolerant Error Rang | RW | 00 - 0 | 01 - 32 | 0 |
| Bit0 | | | RW | 10 - 64 | 11 - 128 | 1 |

| Byte25 | Name | Control Function | Type | 0 | 1 | PWD |
|--------|--------------|----------------------------|------|--|------------|-----|
| Bit7 | Spin-Up Time | The Time For Spin-Up | RW | 00 - 250ms | 01 - 500ms | 0 |
| Bit6 | | | RW | 10 - 1s | 11 - 2s | 1 |
| Bit5 | Spin-Up Duty | PWM Duty-Cycle For Spin-Up | RW | 000 - 30%, 001 - 35%, 010 - 40%, 011 - 45%, 100 - 50%, 101 - 55%, 110 - 60%, 111 - 65% | | 1 |
| Bit4 | | | RW | | | 1 |
| Bit3 | | | RW | | | 0 |
| Bit2 | Spin-Up cnt | Time Out Times For Spin-Up | RW | 00 - 3 | 01 - 4 | 0 |
| Bit1 | | | RW | 10 - 5 | 11 - 6 | 1 |
| Bit0 | Reserved | Reserved | RW | - | - | 0 |

| Byte26 | Name | Control Function | Type | 0 | 1 | PWD |
|--------|------------------|-------------------------------|------|---|-------|-----|
| Bit7 | Duty_Cycle<10:3> | MSB of PWM Duty-Cycle Setting | RW | - | 1 | 0 |
| Bit6 | | | RW | | 1/2 | 0 |
| Bit5 | | | RW | | 1/4 | 0 |
| Bit4 | | | RW | | 1/8 | 0 |
| Bit3 | | | RW | | 1/16 | 0 |
| Bit2 | | | RW | | 1/32 | 0 |
| Bit1 | | | RW | | 1/64 | 0 |
| Bit0 | | | RW | | 1/128 | 0 |

| Byte27 | Name | Control Function | Type | 0 | 1 | PWD |
|--------|-----------------|--|------|--|----------|-----|
| Bit7 | Duty_Cycle<2:0> | LSB of PWM Duty-Cycle Setting | RW | - | 1/256 | 0 |
| Bit6 | | | RW | | 1/512 | 0 |
| Bit5 | | | RW | | 1/1024 | 0 |
| Bit4 | Update Time | TACH Detect Update Time | RW | 000 - 100ms, 001 - 200ms, 010 - 300ms, 011 - 400m, 100 - 500ms, 101 - 600ms, 110 - 700ms, 111 - 800ms | | 0 |
| Bit3 | | | RW | | | 1 |
| Bit2 | | | RW | | | 1 |
| Bit1 | T_Hys | Temperature Hysteresis For FAN's Trigger Point | RW | 00 - 2C | 01 - 5C | 0 |
| Bit0 | | | RW | 10 - 10C | 11 - 15C | 1 |

| Byte28 | Name | Control Function | Type | 0 | 1 | PWD |
|--------|--------|--|------|---|----------|-----|
| Bit7 | TL_FAN | First Temperature Trigger Point of FAN | RW | - | Reserved | 0 |
| Bit6 | | | RW | | 64C | 1 |
| Bit5 | | | RW | | 32C | 1 |
| Bit4 | | | RW | | 16C | 1 |
| Bit3 | | | RW | | 8C | 1 |
| Bit2 | | | RW | | 4C | 1 |
| Bit1 | | | RW | | 2C | 1 |
| Bit0 | | | RW | | 1C | 1 |

| Byte29 | Name | Control Function | Type | 0 | 1 | PWD |
|--------|--------|---|------|---|----------|-----|
| Bit7 | TH_FAN | Second Temperature Trigger Point of FAN | RW | - | Reserved | 0 |
| Bit6 | | | RW | | 64C | 1 |
| Bit5 | | | RW | | 32C | 1 |
| Bit4 | | | RW | | 16C | 1 |
| Bit3 | | | RW | | 8C | 1 |
| Bit2 | | | RW | | 4C | 1 |
| Bit1 | | | RW | | 2C | 1 |
| Bit0 | | | RW | | 1C | 1 |

| Byte30 | Name | Control Function | Type | 0 | 1 | PWD |
|--------|----------|----------------------------------|------|---|------|-----|
| Bit7 | TACH_MAX | The Maximum Limit of TACH Number | RW | - | 4096 | 1 |
| Bit6 | | | RW | | 2048 | 1 |
| Bit5 | | | RW | | 1024 | 1 |
| Bit4 | | | RW | | 512 | 1 |
| Bit3 | | | RW | | 256 | 1 |
| Bit2 | | | RW | | 128 | 1 |
| Bit1 | | | RW | | 64 | 1 |
| Bit0 | | | RW | | 32 | 1 |

| Byte31 | Name | Control Function | Type | 0 | 1 | PWD |
|--------|----------|----------------------------------|------|---|-----|-----|
| Bit7 | TACH_MIN | The Minimum Limit of TACH Number | RW | - | 512 | 0 |
| Bit6 | | | RW | | 256 | 0 |
| Bit5 | | | RW | | 128 | 0 |
| Bit4 | | | RW | | 64 | 0 |
| Bit3 | | | RW | | 32 | 0 |
| Bit2 | | | RW | | 16 | 0 |
| Bit1 | | | RW | | 8 | 0 |
| Bit0 | | | RW | | 4 | 0 |

| Byte32 | Name | Control Function | Type | 0 | 1 | PWD |
|--------|---------------|---|------|---|------|-----|
| Bit7 | TACH_S1<12:5> | MSB TACH threshold of Static Mode(T>TL_FAN) | RW | - | 4096 | 0 |
| Bit6 | | | RW | | 2048 | 0 |
| Bit5 | | | RW | | 1024 | 0 |
| Bit4 | | | RW | | 512 | 0 |
| Bit3 | | | RW | | 256 | 0 |
| Bit2 | | | RW | | 128 | 0 |
| Bit1 | | | RW | | 64 | 0 |
| Bit0 | | | RW | | 32 | 0 |

| Byte33 | Name | Control Function | Type | 0 | 1 | PWD |
|--------|--------------|---|------|----------------------------|----|-----|
| Bit7 | TACH_S1<4:0> | LSB TACH threshold of Static Mode(T>TL_FAN) | RW | - | 16 | 0 |
| Bit6 | | | RW | | 8 | 0 |
| Bit5 | | | RW | | 4 | 0 |
| Bit4 | | | RW | | 2 | 0 |
| Bit3 | | | RW | | 1 | 0 |
| Bit2 | Reserved | Reserved | RW | - | - | 0 |
| Bit1 | FAN_SEL | Temperature Selection For FAN | RW | 00 - enable, 01~11 disable | | 1 |
| Bit0 | | | RW | | | 0 |

| Byte34 | Name | Control Function | Type | 0 | 1 | PWD |
|--------|---------------|---|------|---|------|-----|
| Bit7 | TACH_S2<12:5> | MSB TACH threshold of Static Mode(T>TH_FAN) | RW | - | 4096 | 0 |
| Bit6 | | | RW | | 2048 | 0 |
| Bit5 | | | RW | | 1024 | 0 |
| Bit4 | | | RW | | 512 | 0 |
| Bit3 | | | RW | | 256 | 0 |
| Bit2 | | | RW | | 128 | 0 |
| Bit1 | | | RW | | 64 | 0 |
| Bit0 | | | RW | | 32 | 0 |

| Byte35 | Name | Control Function | Type | 0 | 1 | PWD |
|--------|--------------|---|------|--|---|-----|
| Bit7 | TACH_S2<4:0> | LSB TACH threshold of Static Mode(T>TH_FAN) | RW | - | 16 | 0 |
| Bit6 | | | RW | | 8 | 0 |
| Bit5 | | | RW | | 4 | 0 |
| Bit4 | | | RW | | 2 | 0 |
| Bit3 | | | RW | | 1 | 0 |
| Bit2 | FAN MASK | Mask Fan Fault | RW | 0=normal | 1=masked | 0 |
| Bit1 | SEL_ALERT | Select the ALERT Source | RW | 00 - ALERT=Temp-Sensor Alert | 01 - ALERT=FAN Fault | 0 |
| Bit0 | | | RW | 10 - ALERT=Temp-Senso Alert or FAN Fault | 10 - ALERT=Temp-Senso Alert and FAN Fault | 0 |

| Byte36 | Name | Control Function | Type | 0 | 1 | PWD |
|--------|----------|--|------|---|-----|-----|
| Bit7 | PWM Step | The PWM DutyCycle Incremental/Decremental Step | RW | - | 128 | 0 |
| Bit6 | | | RW | | 64 | 0 |
| Bit5 | | | RW | | 32 | 0 |
| Bit4 | | | RW | | 16 | 0 |
| Bit3 | | | RW | | 8 | 1 |
| Bit2 | | | RW | | 4 | 0 |
| Bit1 | | | RW | | 2 | 0 |
| Bit0 | | | RW | | 1 | 0 |

| Byte37 | Name | Control Function | Type | 0 | 1 | PWD |
|--------|------------|--|------|----------|------|-----|
| Bit7 | Reserved | Reserved | R | - | - | 0 |
| Bit6 | Reserved | Reserved | R | - | - | 0 |
| Bit5 | Reserved | Reserved | R | - | - | 0 |
| Bit4 | Reserved | Reserved | R | - | - | 0 |
| Bit3 | Reserved | Reserved | R | - | - | 0 |
| Bit2 | Reserved | Reserved | R | - | - | 0 |
| Bit1 | FAN_Fault1 | FAN TACH measurement is < Minimum limit (Too Fast) | R | Non-Flag | Flag | 0 |
| Bit0 | FAN_Fault2 | FAN TACH measurement is > Maximum limit (Too Slow) | R | Non-Flag | Flag | 0 |

| Byte38 | Name | Control Function | Type | 0 | 1 | PWD |
|--------|--------------|------------------------|------|---|---|-----|
| Bit7 | TACH_AIM_OUT | Targeted TACH Readback | R | - | - | 0 |
| Bit6 | | | R | - | - | 0 |
| Bit5 | | | R | - | - | 0 |
| Bit4 | | | R | - | - | 0 |
| Bit3 | | | R | - | - | 0 |
| Bit2 | | | R | - | - | 0 |
| Bit1 | | | R | - | - | 0 |
| Bit0 | | | R | - | - | 0 |

Byte 39~ 40 Reserved Register

| Byte41 | Name | Control Function | Type | 0 | 1 | PWD |
|--------|--------------|---------------------------------------|------|----------|-----------|-----|
| Bit7 | STOP_27M_48M | Stop 27M_48M output | RW | Stopped | Run | 1 |
| Bit6 | STOP_24M_48M | Stop 24M_48M output | RW | Stopped | Run | 1 |
| Bit5 | EN_STOP25M_C | Enable pin for 25M_C after at PWRGD=0 | RW | Free-Run | Stoppable | 1 |
| Bit4 | EN_STOP25M_B | Enable pin for 25M_B after at PWRGD=0 | RW | Free-Run | Stoppable | 1 |
| Bit3 | EN_STOP25M_A | Enable pin for 25M_A after at PWRGD=0 | RW | Free-Run | Stoppable | 0 |
| Bit2 | STOP_25M_C | Stop 25M_C output | RW | Stopped | Run | 1 |
| Bit1 | STOP_25M_B | Stop 25M_B output | RW | Stopped | Run | 1 |
| Bit0 | STOP_25M_A | Stop 25M_A output | RW | Stopped | Run | 1 |

| Byte42 | Name | Control Function | Type | 0 | 1 | PWD |
|--------|---------------------------------|------------------|------|---|---|-----|
| Bit7 | BYTE COUNT Register Bit[7:0] | MSB | RW | - | - | 0 |
| Bit6 | | - | RW | - | - | 0 |
| Bit5 | | - | RW | - | - | 0 |
| Bit4 | | - | RW | - | - | 1 |
| Bit3 | | - | RW | - | - | 1 |
| Bit2 | | - | RW | - | - | 1 |
| Bit1 | | - | RW | - | - | 1 |
| Bit0 | | LSB | RW | - | - | 1 |

Byte 43 ~ Byte 46 Reserved Registers

| Byte47 | Name | Control Function | Type | 0 | 1 | PWD |
|--------|-----------|----------------------|------|---|---|-----|
| Bit7 | REV_ID | Revision ID | RW | - | - | 0 |
| Bit6 | | | RW | - | - | 0 |
| Bit5 | | | RW | - | - | 0 |
| Bit4 | | | RW | - | - | 0 |
| Bit3 | VENDOR_ID | Vendor ID (IDT=0001) | RW | - | - | 0 |
| Bit2 | | | RW | - | - | 0 |
| Bit1 | | | RW | - | - | 0 |
| Bit0 | | | RW | - | - | 1 |

Byte 48 ~ Byte 63 Reserved Registers

| Byte64 | Name | Control Function | Type | 0 | 1 | PWD |
|--------|----------------|------------------|------|--------|-----------|-----|
| Bit7 | LCKBYPASSB | PLL Lock Bypassb | RW | Bypass | Not Bypas | 1 |
| Bit6 | REF COUNT<6:0> | PLL M Counter | RW | - | - | 0 |
| Bit5 | | | RW | - | - | 0 |
| Bit4 | | | RW | - | - | 1 |
| Bit3 | | | RW | - | - | 1 |
| Bit2 | | | RW | - | - | 0 |
| Bit1 | | | RW | - | - | 0 |
| Bit0 | | | RW | - | - | 1 |

| Byte65 | Name | Control Function | Type | 0 | 1 | PWD |
|--------|----------------|------------------|------|---|---|-----|
| Bit7 | VCO COUNT<9:2> | PLL N COUNTER | RW | - | - | 0 |
| Bit6 | | | RW | - | - | 0 |
| Bit5 | | | RW | - | - | 0 |
| Bit4 | | | RW | - | - | 1 |
| Bit3 | | | RW | - | - | 1 |
| Bit2 | | | RW | - | - | 0 |
| Bit1 | | | RW | - | - | 1 |
| Bit0 | | | RW | - | - | 1 |

Byte 66 Reserved Register

| Byte67 | Name | Control Function | Type | 0 | 1 | PWD |
|--------|-----------------|-------------------------|------|--------------|--------------|-----|
| Bit7 | SL<1:0>(25MHzB) | 25M_B Slew Rate Control | RW | 00 = 0.5V/ns | 01 = 1.0V/ns | 0 |
| Bit6 | | | RW | 10 = 1.0V/ns | 11 = 1.5V/ns | 1 |
| Bit5 | SL<1:0>(25MHzA) | 25M_A Slew Rate Control | RW | 00 = 1.0V/ns | 01 = 1.5V/ns | 0 |
| Bit4 | | | RW | 10 = 1.5V/ns | 11 = 2.0V/ns | 1 |
| Bit3 | SL<1:0>(27MHz) | 27M Slew Rate Control | RW | 00 = 1.0V/ns | 01 = 1.5V/ns | 0 |
| Bit2 | | | RW | 10 = 1.5V/ns | 11 = 2.0V/ns | 1 |
| Bit1 | SL<1:0>(24MHz) | 24M Slew Rate Control | RW | 00 = 1.0V/ns | 01 = 1.5V/ns | 0 |
| Bit0 | | | RW | 10 = 1.5V/ns | 11 = 2.0V/ns | 1 |

All reserved bits and reserved bytes in this SMBus table should not be overwritten at any instance. Writing to these reserved bits and bytes may cause unexpected behavior. IDT does not warrant any application issue going forward if continuing to overwrite these reserve bits and bytes.

Frequency Generator 32.768 kHz

Recommended 25MHz Quartz Crystal Specifications

SMD 25MHz AT cut crystal and maximum driver level at 100μW, for example TXC.

VBAT Battery Recommendations and Connection Considerations

Recommended to use coin cell battery CR2032, CR2025 or equivalent.

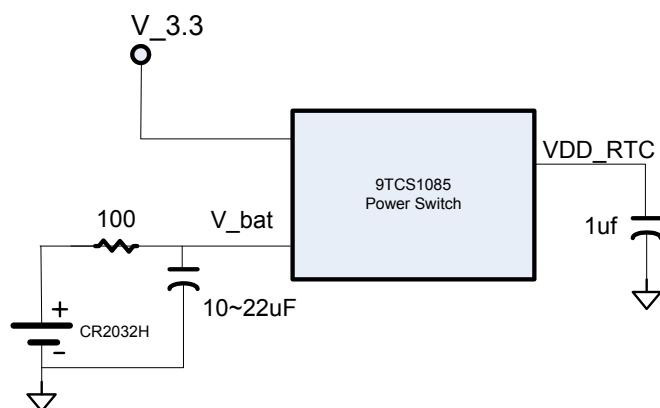
The normal coin cell battery storage capacity is 170 mAh to 220mAh and the average total RTC circuit current required 5μA, the battery life will be at least:

$$170,000 \mu\text{Ah} / 5 \mu\text{A} = 34,000 \text{ hours} = 3.88 \text{ years}$$

The RTC circuit (PCH) usually consumes 3μA power, thus the 32.768kHz clock generator circuit needs be less than 2μA. The 9TCS1085 32.768kHz generator averaged operation current is less than 2μA.

The coin cell battery with 9TCS1085 VBAT power pin connection required a 100 ohm and 22μF ceramic capacitor current limitation and noise filtering. The RC needs to be added to the battery to limit the current spikes effects.

The VDD_RTC connect to the Intel ICH chip and the 9TCS1085 provide seamless power switching between main V_3.3 and V_bat.



32.768K Clocks Operation

The 9TCS1085 32.768K clock output operates in two modes:

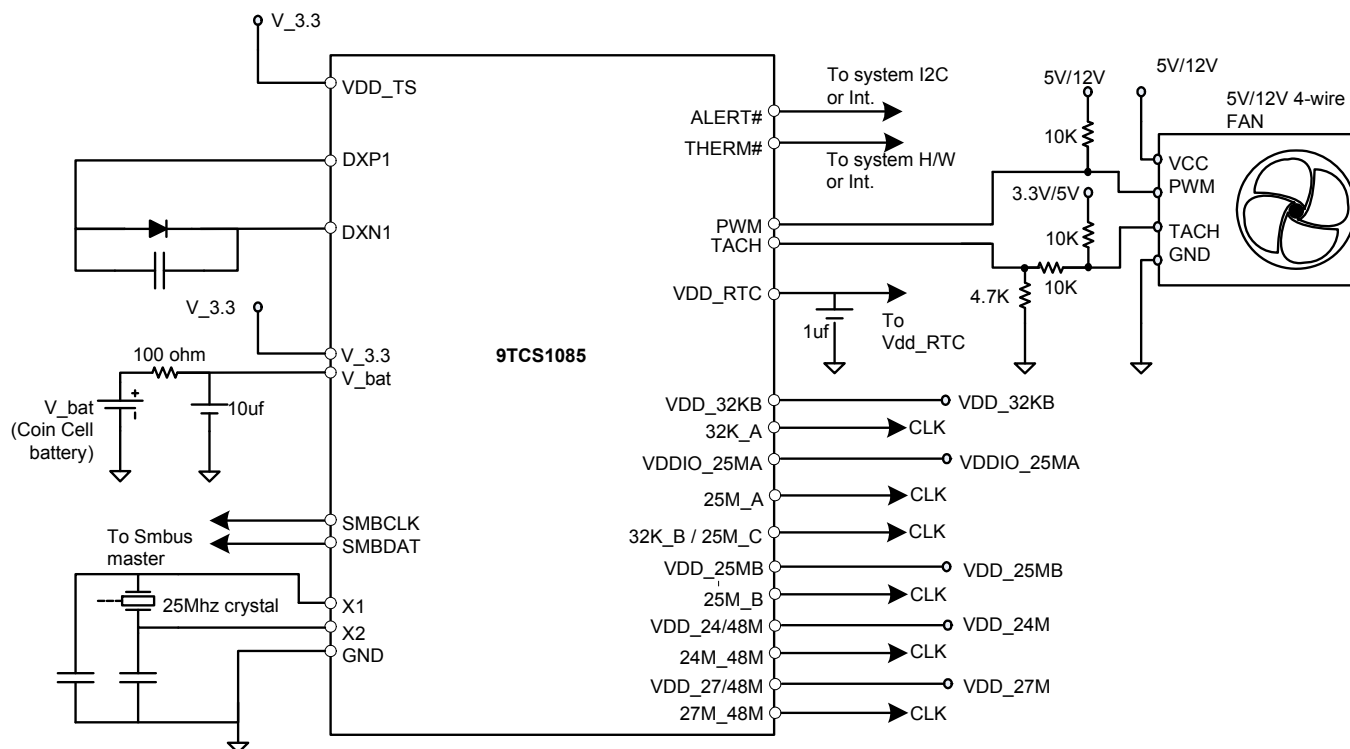
1. When the system is not power ON, V_3.3 is not ready and 9TCS1085 is powered with the coin cell battery. The 32kHz comes from the DCO with the digital calibration to keep the accuracy.
2. After V_3.3 is ready, the 9TCS1085 creates a seamless switch power from V_bat to V_3.3 and the calibration will go to full speed: this will happen every 2~3ms to keep the accuracy and the 32K source will be switched to 25MHz oscillator with Fraction-N divider to get the 0ppm.

32.768K DCO uses a 25Mhz crystal oscillator for calibration reference, thus the 25MHz oscillator must be fine tuned in order to get the best 32.768kHz accuracy.

RTC Routing Guidelines

| Single | face impedanc | Length | Notes |
|--------|---------------|----------|-------|
| X1 | 50 ohm | 6 inches | |
| X2 | 50 ohm | 6 inches | |

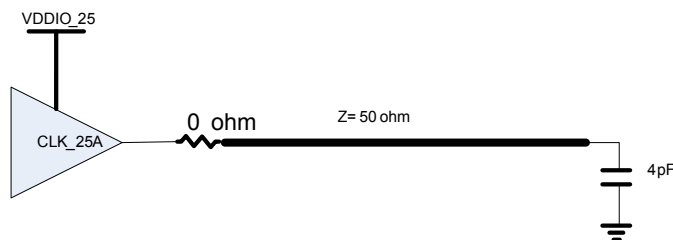
Reference Schematic For VBAT and VDD_RTC



Frequency Synthesizer – 24/48/27/25 MHz

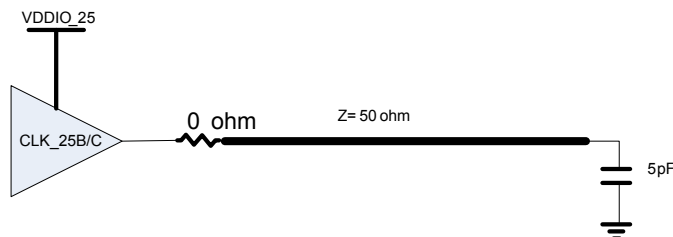
The 9TCS1085 includes a low power PLL to generate 24/27/48 MHz clock outputs. The PLL uses an external 25MHz crystal for reference clock input, thus all 25MHz clock outputs are through a fanout buffer directly for optimal performance. Fine tuning on the external crystal cap load is required to get an accurate 25MHz reference clock.

25MHz_A Connection Recommendations



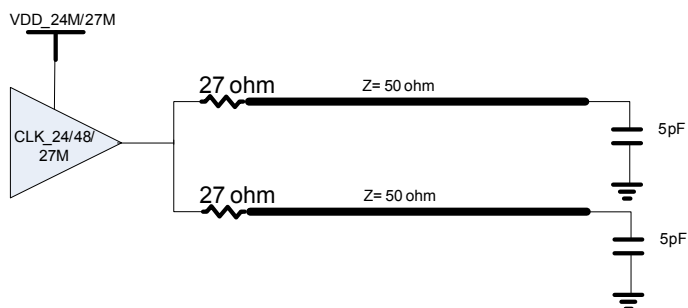
- VDDIO_25A range is from 1.05V to 3.3V.
- Optimize range is 1.05V to 1.5V.
- Pull up strength is 50 ohm@VDDIO_25A=1.5V
- Pull down strength is 50 ohm.
- No on-board 33 ohm series resistor is required.

25MHz_B/C Connection Recommendations



- VDD_25B/C range is from 1.05V to 3.3V.
- Optimized for 3.3V VDDIO.
- Pull up strength is 50 ohm@VDD_25B/C=3.3V
- Pull down strength is 50 ohm.
- No on-board 33 ohm series resistor is required.

24/27/48MHz Connection Recommendations



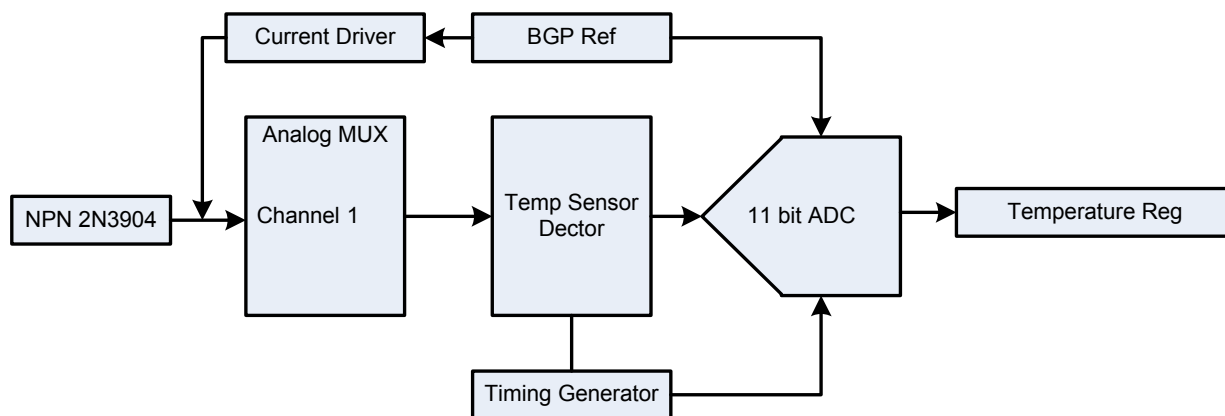
- Default 2X push-pull IO drive strength for 24/48/27MHz.
- On board 27 ohm series resistor for each path.
- Rising/falling slew rate: 1v/ns~4v/ns
- 2 bits (3 steps) I2C for the Slew Rate.

Thermal Sensor

The thermal sensor in the 9TCS1085 is a low power and highly accurate temperature sensor. It is optimized to operate between 60°C to 100°C with an external thermal diode connection input. There are diode faults and temperature alerts for the thermal sensor; Moreover, the thermal sensor has the capability to go into standby mode for power savings.

The temperature sensor's analog to digital converter (ADC) has 11 bits of resolution. One LSB is equal to 0.125°C. The accuracy of the temperature sensor is $\pm 1^\circ\text{C}$ between 60°C to 100°C.

The 9TCS1085 temperature sensor has the ability to cancel the series resistance on the remote diode inputs. Parasitic resistances to the DXP and DXN inputs seen in series with the remote diode are caused by PCB trace resistance along with the overall length, bulk parasitic resistance in the remote temperature transistor junctions, and series resistance in the CPU. This resistance appears as a temperature offset in the thermal sensor measurement and is approximately $+0.7^\circ\text{C}$ per Ohm. The 9TCS1085 has the ability to cancel up to 100Ω of series resistance.



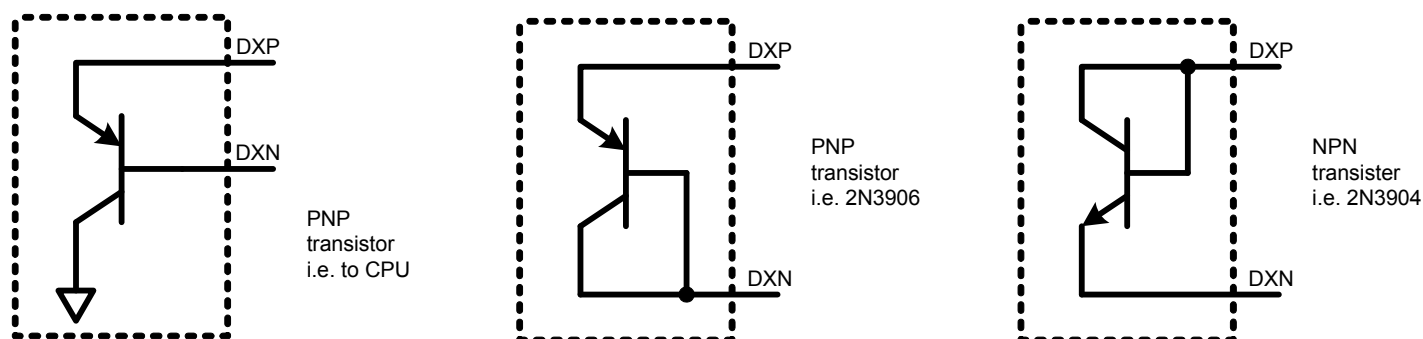
The thermal sensor in 9TCS1085 outputs the measured temperature from a beta compensated temperature reading from an external diode. The temperature sensor architecture uses an on-chip ADC as shown to convert the analog temperature into an 11-bit digital code. Using averaging techniques along with the ADC architecture allows accurate temperature measurements. The ability to have programmable conversion rates and adjustable averaging schemes allow the user the flexibility to balance accuracy versus conversion speed per the system requirements.

The temperature measurement relies on the characteristics of a semiconductor junction operating at a fixed current level. Forcing a fixed current through the temperature diodes and detecting the changes in VBE, the forward voltage of the diode, the temperature proportionality can be determined.

External Thermal Diode Selection

The 9TCS1085 supports the following temperature diodes:

- Typical remote substrate transistor (i.e. CPU substrate PNP intrinsic diode)
- Discrete PNP transistor diode (i.e. 2N3906)
- Discrete NPN transistor diode (i.e. 2N3904)



When the thermal sensor is used in a noisy environment, a capacitor can be connected across DXP and DXN to provide some noise filtering capabilities. However, large capacitances affect the accuracy of the temperature measurement. A maximum capacitance of 300pF can be used to help mitigate the noise.

Thermal Diode Fault Conditions

9TCS1085 has the ability to detect an open or a short condition for each temperature sensor diode. An external diode fault is defined as one of the following:

- An open between DXP and DXN
- A short from VDD to DXP
- A short from VDD to DXN

The diode fault monitoring is enabled at the start of every temperature measurement. When an external diode fault is detected, the ALERT# pin asserts and the temperature data reads 00h in the MSB and LSB of the corresponding temperature registers:

- DX1 MSB - byte[17], bit[2:0]
- DX1 LSB - byte[16], bit[7:0]

During the fault condition, byte[13], bit[1] or bit[0], will be set depending on the channel that has the fault. Bit[1] corresponds to DX1, and furthermore, an open/short fault flag will be set in register byte[14], bit[4].

Temperature Threshold Alerts

Through register writes, the high and low temperature limits can be set such that it will trigger an alert. This alert can be monitored through the registers or can be sent to the ALERT# pin. Each channel has its own programmable register to set the thresholds as follows:

(1) High Temperature Alert (default 127°C)

| Byte[2:0], Bit[7:0] | Temperature |
|---------------------|-------------|
| Bit[7] | Sign Bit |
| Bit[6] | 64°C |
| Bit[5] | 32°C |
| Bit[4] | 16°C |
| Bit[3] | 8°C |
| Bit[2] | 4°C |
| Bit[1] | 2°C |
| Bit[0] | 1°C |

Where byte[0] is the high temperature alert for DX1.

(2) Low Temperature Alert (default 127°C)

| Byte[5:3], Bit[7:0] | Temperature |
|---------------------|-------------|
| Bit[7] | Sign Bit |
| Bit[6] | 64°C |
| Bit[5] | 32°C |
| Bit[4] | 16°C |
| Bit[3] | 8°C |
| Bit[2] | 4°C |
| Bit[1] | 2°C |
| Bit[0] | 1°C |

Where byte[3] is the low alert for DX1, byte[4] is for DX2.

Temperature Threshold Alert Status

When a temperature threshold alert is activated, a status indicator bit is also set. Register byte[14], bit[6:5] will be set depending on the high or low alert. Bit[6] is the high and bit[5] is the low alert flag. To clear the alert, register byte[15], bit[7] needs to be written with a "1". Writing this bit will also clear the critical thermal warnings.

Temperature Threshold ALERT# Pin

The temperature threshold alerts are sent to the ALERT# pin. To mask this alert being sent to the ALERT# pin, set register byte[12], bit[7] to logic 1.

Consecutive Alerts

The number of temperature threshold alerts before the assertion of the ALERT# pin can be set by the user through register byte[6], bit[3:2] as follows:

| Byte[6], Bit[3:2] | Number of Alert Events |
|-------------------|------------------------|
| [00] (default) | 1 |
| [01] | 2 |
| [10] | 3 |
| [11] | 4 |

Temperature Threshold Alert Alarm Register

All three temperature channels have a readable registers, byte[13], bit[7:2] that is set when a temperature threshold alert has occurred. Bit[3:2] is for temperature high and low thresholds.

Critical Thermal Warnings

The 9TCS1085 will have register programmable critical thermal threshold warnings for all three temperature sensor channels. Similar to the temperature threshold alerts, the critical high temperatures can be set such that a warning can be dispatched to the THERM# pin and the readable registers. The thermal warnings also have programmable hysteresis. Each channel has its own programmable register to set the thresholds as follows:

(1) Critical Thermal Warning (default 127°C)

| Byte[9:7], Bit[6:0] | Temperature |
|---------------------|-------------|
| Bit[6] | 64°C |
| Bit[5] | 32°C |
| Bit[4] | 16°C |
| Bit[3] | 8°C |
| Bit[2] | 4°C |
| Bit[1] | 2°C |
| Bit[0] | 1°C |

Where byte[7] is the critical thermal warning for DX1.

(2) Critical Thermal Warning Temperature Hysteresis (default 4°C)

| Byte[12], Bit[4:0] | Temperature |
|--------------------|-------------|
| Bit[4] | 16°C |
| Bit[3] | 8°C |
| Bit[2] (default) | 4°C |
| Bit[1] | 2°C |
| Bit[0] | 1°C |

Critical Thermal Warning Status

When a critical warning is activated, a status indicator bit is also set. Register byte[14], bit[2] will be set when the critical event happens.

Critical Thermal Warning THERM# Pin

The critical thermal warnings are sent to the THERM# pin and requires a system register write to byte[15], bit[7] to reset. This fault clear I2C write will also clear the temperature threshold alerts

Active/Standby Mode

The thermal sensor has two modes in the temperature conversion process:

(1) Active mode – In this mode the ADC will have a selectable conversion rate for the temperature sensing.

(2) Standby mode – The system will command via I2C the 9TCS1085 to sample the temperature sensors. Once the temperature reading from the ADC is updated, the temperature sensor will be on stand-by awaiting the next system request.

Register byte[15], bit[6] controls whether the thermal sensor is in active or standby mode.

The conversion rate programmable register detail is as follows:

| Byte[17], Bit[4:1] | Conversion Rate |
|--------------------|-----------------|
| [0000] | 16/sec * |
| [0001] | 8/sec ** |
| [0010] (default) | 4/sec |
| [0011] | 2/sec |
| [0100] | 1/sec |
| [0101] | 1/2 sec |
| [0110] | 1/4 sec |
| [0111] | 1/8 sec |
| [1000] | 1/16 sec |
| [1001] | 1/32 sec |
| [1010] | 1/64 sec |

* Valid when only one temperature sensor channel is used.

** Valid when the number of temperature sensor channel is less than three.

The thermal sensor architecture has dynamic averaging to smooth out the temperature conversion readings. To select the number of temperature reading averages requires the dynamic averaging function to be enabled, register byte[15], bit[5]. The number of averages is then selected as follows:

| Byte[6], Bit[1:0] | Average the ADC Temperature |
|-------------------|-----------------------------|
| [00] | 1 |
| [01] | 4 |
| [10] | 8 |
| [11] | 16 |

Fan Controller

Fan Controller Description

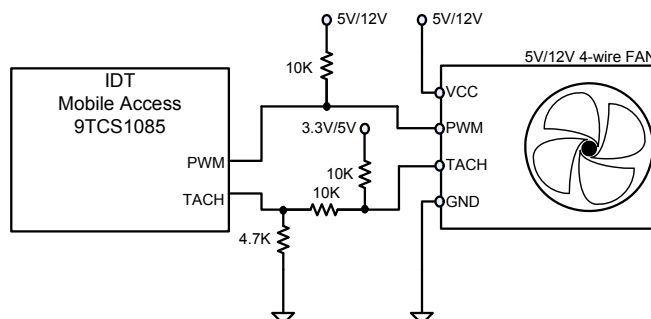
The fan driver for the 9TCS1085 controls a 4-wire, 12V or 5V, multiple pole DC fan. The fan controller has three modes of operation: (1) Direct drive, (2) Thermal trigger, and (3) Dynamic PWM. All modes have register programmability for the user to set the desired fan speed and necessary parameters. The controller is also capable of detecting stalled fans and upon detection will set the appropriate alerts. The 9TCS1085 also has user configuration registers to adjust both the ramp-rate and the spin-up routine to accommodate different fan start up requirements.

The fan controller uses the input from the external diode connections. The 9TCS1085 fan controller can be set to run a user specified fan speed. In this mode the tachometer signal from the fan will be ignored. In thermal trigger mode, the user specifies the temperature thresholds, the temperature threshold hysteresis, and the corresponding fan speed (fan tachometer target) for the different temperature zones defined by the thresholds. The controller will then run the fan at the specified fixed fan speed settings depending on the temperature from the sensors. In dynamic PWM mode, the fan controller will adjust the PWM duty cycle to maintain the system defined fan speed. In this mode, the system reads a temperature sensor and the corresponding fan speed, tachometer reading. The system will then determine and update the 9TCS1085 directly by writing the accessible registers byte 32 and byte 33. 9TCS1085 will then adjust the PWM to achieve the desired system fan speed.

The PWM has ten bits of duty cycle resolution with a 25kHz frequency. The PWM frequency is selectable between 22, 25, and 27kHz.

The 9TCS1085 includes hardware programmable temperature limits and dedicated system shutdown output for thermal protection.

Fan Controller System Diagram (Schematic Example)



Fan Selection Detail

The 9TCS1085 fan controller will control 5V - 12V Brushless DC fans. The fans need to be 4-wire fans and can have one to four poles. The number of fan poles is specified in Register byte[24], bit[3:2]. A 2-pole fan is the default.

| Byte[24], Bit[3:2] | Fan Poles |
|--------------------|-----------|
| [00] | 1 |
| [01] (default) | 2 |
| [10] | 3 |
| [11] | 4 |

Modes of Operation

The 9TCS1085 fan controller has three user selectable methods to control the fan speed. The default fan speed control mode is Thermal Trigger mode. The modes are selected by writing the I2C register byte[24], bit[7:6] as follows:

| Fan Controller Modes | Byte[24], Bit[7:6] |
|-----------------------|--------------------|
| Direct Drive | [00] |
| Thermal Trigger | [01] |
| Dynamic PWM (default) | [10] |

The PWM frequency can be set by writing register byte[24], bit[5:4] as follows:

| PWM Frequency | Duty Cycle Resolution [# bits] | Byte[24], Bit[5:4] |
|-----------------|--------------------------------|--------------------|
| 25kHz (default) | 10 | 00 |
| 22kHz | 11 | 01 |
| 27kHz | 9 | 10 |

Direct Drive Mode

In Direct Drive Mode, the fan speed is directly controlled by setting a fixed PWM duty cycle. After a proper fan speed spin-up, the tachometer signal will be ignored and the 9TCS1085 will output the fixed programmed PWM duty cycle to the fan.

To operate in direct drive mode, Register byte[24], bit[7:6] = [00].

The duty cycle is selectable through registers by writing byte[26], bit[7:0] and byte[27], bit[7:5] as follows:

| Byte[26], Bit[7:0] | Logic "1", Selects Duty Cycle |
|--------------------|-------------------------------|
| Bit[7] | 1 |
| Bit[6] | 1/2 |
| Bit[5] | 1/4 |
| Bit[4] | 1/8 |
| Bit[3] | 1/16 |
| Bit[2] | 1/32 |
| Bit[1] | 1/64 |
| Bit[0] | 1/128 |

| Byte[27], Bit[7:5] | Logic "1", Selects Duty Cycle |
|--------------------|-------------------------------|
| Bit[7] | 1/256 |
| Bit[6] | 1/512 |
| Bit[5] | 1/1024 |

It is important to also set the required fan spin-up specifics for proper use. The 9TCS1085 after completion of the fan spin-up routine will then put out the correct programmed PWM duty cycle.

Thermal Trigger Mode

In this mode the 9TCS1085 fan speed controller is programmed to run at different fan speeds. The 9TCS1085 will monitor the fan tachometer and depending on the temperature from a thermal sensor diode and the pre-programmed temperature settings, the 9TCS1085 will adjust the fan speed to the targeted tachometer settings.

Register byte[24], bit[7:6] = [01] will put 9TCS1085 into thermal trigger mode.

Temperature Sensor

The temperature can be set to read from the external thermal sensors; it is selected by byte33b[1:0]=00.

FAN_CH_SEL - byte[33], bit[1:0]

| Byte[33], bit[1:0] | Temperature Sensor Enable/Disable |
|--------------------|-----------------------------------|
| [00] | 00=ON, 01~11=disable |

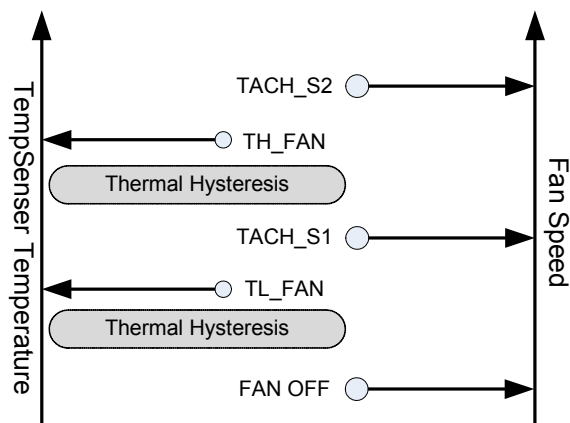
Tachometer Update

The tachometer reading can be updated at a rate of 700msec up to 100msecs. Tachometer Update Time, byte[27], bit[4:2]

| Byte[27], bit[4:2] | Tachometer Update Time |
|--------------------|------------------------|
| [000] | 100 msec |
| [001] | 200 msec |
| [010] | 300 msec |
| [011] (default) | 400 msec |
| [100] | 500 msec |
| [101] | 600 msec |
| [110] | 700 msec |
| [111] | 800 msec |

Example of Thermal Trigger Mode Setup

The figure below shows how the programmable thresholds relate to the fan speed settings.



From the figure above, it can be seen that the fan speed will adjust between the tachometer settings TACH_S1 and TACH_S2 given the temperature from the thermal sensor. The temperature thresholds are set by TH_FAN and TL_FAN along with the temperature hysteresis, T_HYS. In this mode, the fan will have active fault condition monitoring along with fan spin-up control. The rate at which the fan will speed up or slow down, going from one TACH setting to the other, can be programmed by the user. Lastly, the fan speed tolerance can also be selectable via registers.

To set up the fan speed controller in Thermal Trigger Mode, the following registers will need to be programmed.

(1) Temperature Thresholds:

a. TL_FAN - byte[28], bit[6:0] (default 127°C)

| Byte[28], Bit[7:0] | Logic "1", Selects Temp Threshold |
|--------------------|-----------------------------------|
| Bit[7] | — |
| Bit[6] | 64°C |
| Bit[5] | 32°C |
| Bit[4] | 16°C |
| Bit[3] | 8°C |
| Bit[2] | 4°C |
| Bit[1] | 2°C |
| Bit[0] | 1°C |

b. TH_FAN - byte[29], bit[6:0] (default 127°C)

| Byte[29], Bit[7:0] | Logic "1", Selects Temp Threshold |
|--------------------|-----------------------------------|
| Bit[7] | — |
| Bit[6] | 64°C |
| Bit[5] | 32°C |
| Bit[4] | 16°C |
| Bit[3] | 8°C |
| Bit[2] | 4°C |
| Bit[1] | 2°C |
| Bit[0] | 1°C |

To set TL_FAN and TH_FAN a logic "1" is written into the proper register. For example, to get 70°C, a "1" would be written for Bit[6], Bit[2], and Bit[1].

(2) Temperature Hysteresis, T_HYS, byte[27], bit[1:0]:

| Byte[27], bit[1:0] | Temperature Threshold Hysteresis |
|--------------------|----------------------------------|
| [00] | 2°C |
| [01] | 5°C |
| [10] | 10°C |
| [11] (default) | 15°C |

(3) Tachometer Targets:

a. TACH_S1 - byte[32], bit[7:0] and byte[33], bit[7:3]

| Byte[32], bit[7:0] | Logic "1" selects Tachometer Reading |
|--------------------|--------------------------------------|
| Bit[7] | 4096 |
| Bit[6] | 2048 |
| Bit[5] | 1024 |
| Bit[4] | 512 |
| Bit[3] | 256 |
| Bit[2] | 128 |
| Bit[1] | 64 |
| Bit[0] | 32 |

| Byte[33], bit[7:3] | Logic "1" selects Tachometer Reading |
|--------------------|--------------------------------------|
| Bit[7] | 16 |
| Bit[6] | 8 |
| Bit[5] | 4 |
| Bit[4] | 2 |
| Bit[3] | 1 |

b. TACH_S2 - byte[34], bit[7:0] and byte[35], bit[7:3]

| Byte[34], bit[7:0] | Logic "1" selects Tachometer Reading |
|--------------------|--------------------------------------|
| Bit[7] | 4096 |
| Bit[6] | 2048 |
| Bit[5] | 1024 |
| Bit[4] | 512 |
| Bit[3] | 256 |
| Bit[2] | 128 |
| Bit[1] | 64 |
| Bit[0] | 32 |

| Byte[35], bit[7:3] | Logic "1" selects Tachometer Reading |
|--------------------|--------------------------------------|
| Bit[7] | 16 |
| Bit[6] | 8 |
| Bit[5] | 4 |
| Bit[4] | 2 |
| Bit[3] | 1 |

The TACH_S1/S2 is set using the following RPM formula:

$$RPM = 2 \times F_{sample} \times \frac{60}{TACH_Reading} \quad (\text{Formula 1})$$

where: RPM - fan revolution per minute

F_{sample} - 25kHz sample internal clock sample rate

TACH_Reading - user programmable registers Byte[32] through Byte[35]

(4) To Set the minimum and maximum fan speed, use the RPM formula, "Formula 1".

a. TACH_MIN - byte[31], bit[7:0]

| Byte[31], bit[7:0] | Logic "1" selects Tachometer Reading |
|--------------------|--------------------------------------|
| Bit[7] | 512 |
| Bit[6] | 256 |
| Bit[5] | 128 |
| Bit[4] | 64 |
| Bit[3] | 32 |
| Bit[2] | 16 |
| Bit[1] | 8 |
| Bit[0] | 4 |

b. TACH_MAX - byte[30], bit[7:0]

| Byte[30], bit[7:0] | Logic "1" selects Tachometer Reading |
|--------------------|--------------------------------------|
| Bit[7] | 4096 |
| Bit[6] | 2048 |
| Bit[5] | 1024 |
| Bit[4] | 512 |
| Bit[3] | 256 |
| Bit[2] | 128 |
| Bit[1] | 64 |
| Bit[0] | 32 |

(5) To adjust the rate at which the fan speed will transition from one TACH setting to the other, the RPM equation, "Formula 1" is again applied to determine the incremental or decremental fan speed step size.

Tachometer PWM Step Control - byte[36], bit[7:0]

| Byte[36], bit[7:0] | Logic "1" selects Tachometer Reading |
|--------------------|--------------------------------------|
| Bit[7] | 128 |
| Bit[6] | 64 |
| Bit[5] | 32 |
| Bit[4] | 16 |
| Bit[3] | 8 |
| Bit[2] | 4 |
| Bit[1] | 2 |
| Bit[0] | 1 |

Spin-up

In this mode the fan controller will also have spin-up control capabilities. At any time the fan attempts to go from a zero RPM to a higher fan speed, the fan will always go through the proper spin-up routine. The time allotted for fan spin-up as well as the spin-up PWM duty cycle can be adjusted via registers by writing byte[25], bit[7:3] as follows:

Spin-up Time - byte[25], bit[7:6]

| Byte[25], bit[7:6] | Spin-up Time |
|---------------------------|--------------|
| Bit[7:6] = [00] | 250msec |
| Bit[7:6] = [01] (default) | 500msec |
| Bit[7:6] = [10] | 1sec |
| Bit[7:6] = [11] | 2sec |

Spin-up PWM duty cycle - byte[25], bit[5:3]

| Byte[25], bit[5:3] | Spin-up PWM duty cycle |
|----------------------------|------------------------|
| Bit[5:3] = [000] | 30% |
| Bit[5:3] = [001] | 35% |
| Bit[5:3] = [010] | 40% |
| Bit[5:3] = [011] | 45% |
| Bit[5:3] = [100] | 50% |
| Bit[5:3] = [101] | 55% |
| Bit[5:3] = [110] (default) | 60% |
| Bit[5:3] = [111] | 65% |

Dynamic PWM Mode

The 9TCS1085 in this mode will be directed by the system via registers as to the target RPM by which the fan speed should be running. The system will read a temperature sensor along with the fan tachometer information and make the determination as to what the nominal fan speed should be. This information is fed back to the 9TCS1085 via register writes. 9TCS1085 will comply and attempt to run the fan at the requested speed.

To put the 9TCS1085 in Dynamic PWM mode register byte[24], bit[7:6] = [10]

The system will poll byte[22], bit[7:0], and byte[23], bit[4:0] for the TACH reading which will correlate to the current fan speed by the RPM equation, "Formula 1".

| Byte[22], bit[7:0] | Logic "1" selects Tachometer Reading |
|--------------------|--------------------------------------|
| Bit[7] | 128 |
| Bit[6] | 64 |
| Bit[5] | 32 |
| Bit[4] | 16 |
| Bit[3] | 8 |
| Bit[2] | 4 |
| Bit[1] | 2 |
| Bit[0] | 1 |

| Byte[23], bit[4:0] | Logic "1" selects Tachometer Reading |
|--------------------|--------------------------------------|
| Bit[7] | 4096 |
| Bit[6] | 2048 |
| Bit[5] | 1024 |
| Bit[4] | 512 |
| Bit[3] | 256 |

The system can read the temperature sensor diodes from the 9TCS1085 or from any sensor available to the system to determine the necessary adjustments to the fan speed.

System Direct Tachometer Control

The system will directly write to register byte[32], bit[7:0] and byte[33], bit[7:3] a desired TACH setting.

| Byte[32], bit[7:0] | Logic "1" selects Tachometer Reading |
|--------------------|--------------------------------------|
| Bit[7] | 4096 |
| Bit[6] | 2048 |
| Bit[5] | 1024 |
| Bit[4] | 512 |
| Bit[3] | 256 |
| Bit[2] | 128 |
| Bit[1] | 64 |
| Bit[0] | 32 |

| Byte[33], bit[7:3] | Logic "1" selects Tachometer Reading |
|--------------------|--------------------------------------|
| Bit[7] | 16 |
| Bit[6] | 8 |
| Bit[5] | 4 |
| Bit[4] | 2 |
| Bit[3] | 1 |

The tachometer setting is related to the fan speed by the RPM equation, "Formula 1".

Setting Minimum and Maximum Tachometer RPM

The minimum and maximum tachometer settings can be set for the fan faults.

a. TACH_MIN - byte[31], bit[7:0]

| Byte[31], bit[7:0] | Logic "1" selects Tachometer Reading |
|--------------------|--------------------------------------|
| Bit[7] | 512 |
| Bit[6] | 256 |
| Bit[5] | 128 |
| Bit[4] | 64 |
| Bit[3] | 32 |
| Bit[2] | 16 |
| Bit[1] | 8 |
| Bit[0] | 4 |

b. TACH_MAX - byte[30], bit[7:0]

| Byte[30], bit[7:0] | Logic "1" selects Tachometer Reading |
|--------------------|--------------------------------------|
| Bit[7] | 4096 |
| Bit[6] | 2048 |
| Bit[5] | 1024 |
| Bit[4] | 512 |
| Bit[3] | 256 |
| Bit[2] | 128 |
| Bit[1] | 64 |
| Bit[0] | 32 |

Fan Fault Conditions

The fan fault conditions will be activated and reported if the minimum or maximum fan speed is detected. During a FAULT1, maximum fan speed, 9TCS1085 will stop the fan and then wait for the FAULT1 flag to be cleared. For a FAULT2 condition, stalled fan, 9TCS1085 will go through the spin-up procedure to try to start the fan. The number of attempts to try to restart the fan is programmable. The fan fault conditions are reported via register on byte[37], bit[1:0].

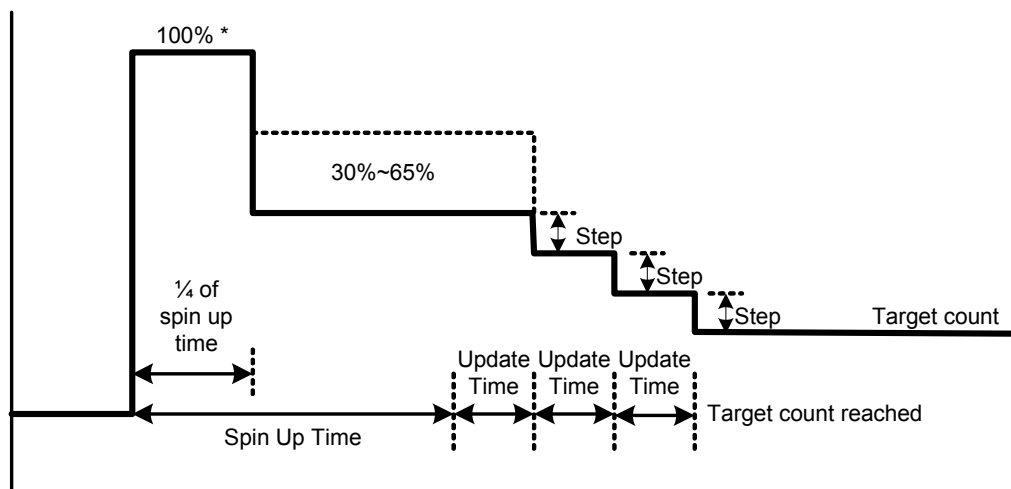
Fan Fault Conditions

| Byte[37], bit[1:0] | Logic "1" = FAULT CONDITION |
|--------------------|-----------------------------|
| Bit[1] | Fault1 - Fan speed too fast |
| Bit[0] | Fault2 - Fan speed too slow |

The number of times for spin-up retries:

| Byte[25], bit[2:1] | Number of Spin-up Attempts |
|--------------------|----------------------------|
| [00] | 3 |
| [01] (default) | 4 |
| [10] | 5 |
| [11] | 6 |

Spin-up Details



1. The spin-up time can be specified in register byte[25], bit[7:6].

Spin-up Time - byte[25], bit[7:6]

| Byte[25], bit[7:6] | Spin-up Time |
|---------------------------|--------------|
| Bit[7:6] = [00] | 250msec |
| Bit[7:6] = [01] (default) | 500msec |
| Bit[7:6] = [10] | 1sec |
| Bit[7:6] = [11] | 2sec |

2. During spin-up, the PWM duty cycle can be set to 100% for one quarter of the total spin-up time by register byte[25], bit[0].

3. The next three quarters of the spin-up time, the PWM duty cycle is set by register[25], bit[5:3].

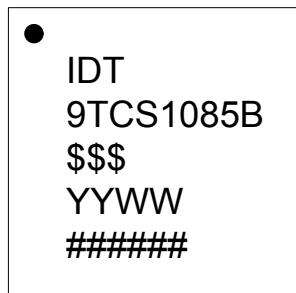
Spin-up PWM duty cycle - byte[25], bit[5:3]

| Byte[25], bit[5:3] | Spin-up PWM duty cycle |
|----------------------------|------------------------|
| Bit[5:3] = [000] | 30% |
| Bit[5:3] = [001] | 35% |
| Bit[5:3] = [010] | 40% |
| Bit[5:3] = [011] | 45% |
| Bit[5:3] = [100] | 50% |
| Bit[5:3] = [101] | 55% |
| Bit[5:3] = [110] (default) | 60% |
| Bit[5:3] = [111] | 65% |

Fan Controller Temperature Diode Sensor

The fan controller can use either one of the three channels for temperature sensing. To specify which temperature sensor is used for the fan controller, register byte[33], bit[1:0].

Marking Diagram (NLG32)



Notes:

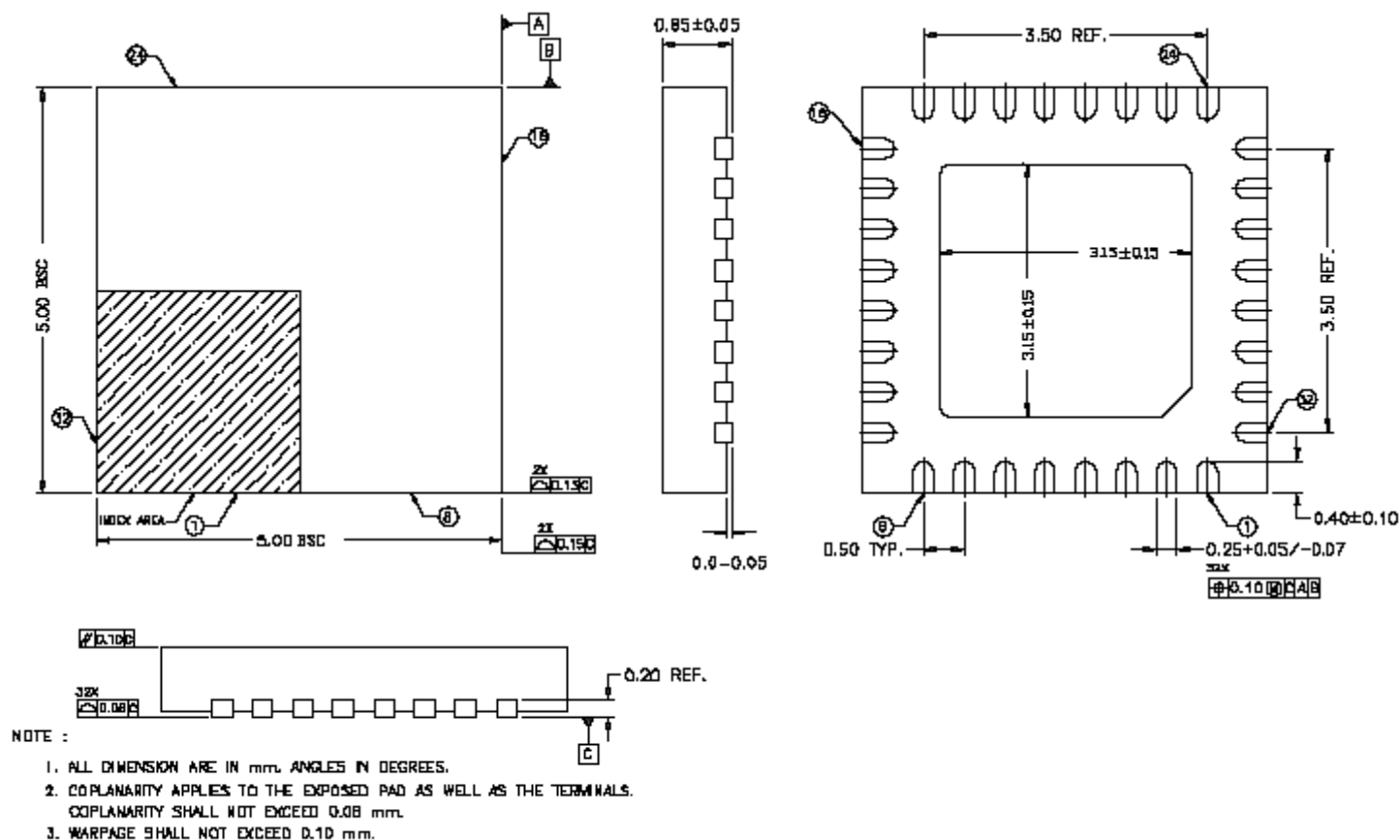
1. "#####" is the lot number.
2. YYWW is the last two digits of the year and week that the part was assembled.
3. "\$\$\$" is the assembly mark code..
4. "B" at the end of the part number is the device revision designator; does not correlate with the datasheet revision.
5. Bottom marking: country of origin if not USA.

Thermal Characteristics 32-pin VFQFPN

| Parameter | Symbol | Conditions | Min. | Typ. | Max. | Units |
|--|---------------|----------------|------|------|------|-------|
| Thermal Resistance Junction to Ambient | θ_{JA} | Still air | | 34 | | °C/W |
| | θ_{JA} | 1 m/s air flow | | 29 | | °C/W |
| | θ_{JA} | 3 m/s air flow | | 27 | | °C/W |
| Thermal Resistance Junction to Case | θ_{JC} | | | 32 | | °C/W |

Package Outline and Package Dimensions (32-pin VFQFPN, 0.50mm pitch)

Package dimensions are kept current with JEDEC Publication No. 95



Ordering Information

| Part / Order Number | Marking | Shipping Packaging | Package | Temperature |
|---------------------|-------------|--------------------|---------------|-------------|
| 9TCS1085BNLG | see page 36 | Trays | 32-pin VFQFPN | 0 to +70° C |
| 9TCS1085BNLG8 | | Tape and Reel | 32-pin VFQFPN | 0 to +70° C |

“G” after the two-letter package code are the Pb-Free configuration and are RoHS compliant.

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9TCS1085

MOBILE ACCESS™—CLOCK SYNTHESIZER, TEMPERATURE SENSOR, & PWM FAN CONTROLLER FOR PORTABLE DEVICES

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