Kernel driver lm93
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Supported chips:
  * National Semiconductor LM93
    Prefix 'lm93'
    Addresses scanned: I2C 0x2c-0x2e
    Datasheet: http://www.national.com/ds.cgi/LM/LM93.pdf

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Module Parameters
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* init: integer
  Set to non-zero to force some initializations (default is 0).
* disable_block: integer
  A "0" allows SMBus block data transactions if the host supports them. A "1"
  disables SMBus block data transactions. The default is 0.
* vccp_limit_type: integer array (2)
  Configures in7 and in8 limit type, where 0 means absolute and non-zero
  means relative. "Relative" here refers to "Dynamic Vccp Monitoring using
  VID" from the datasheet. It greatly simplifies the interface to allow
  only one set of limits (absolute or relative) to be in operation at a
  time (even though the hardware is capable of enabling both). There's
  not a compelling use case for enabling both at once, anyway. The default
  is "0,0".
* vid_agtl: integer
  A "0" configures the VID pins for V(ih) = 2.1V min, V(il) = 0.8V max.
  A "1" configures the VID pins for V(ih) = 0.8V min, V(il) = 0.4V max.
  (The latter setting is referred to as AGTL+ Compatible in the datasheet.)
  I.e. this parameter controls the VID pin input thresholds; if your VID
  inputs are not working, try changing this. The default value is "0".

Hardware Description

(from the datasheet)

The LM93 hardware monitor has a two wire digital interface compatible with
SMBus 2.0. Using an 8-bit ADC, the LM93 measures the temperature of two remote
diode connected transistors as well as its own die and 16 power supply
voltages. To set fan speed, the LM93 has two PWM outputs that are each
controlled by up to four temperature zones. The fancontrol algorithm is lookup
table based. The LM93 includes a digital filter that can be invoked to smooth
temperature readings for better control of fan speed. The LM93 has four
tachometer inputs to measure fan speed. Limit and status registers for all
measured values are included. The LM93 builds upon the functionality of
previous motherboard management ASICs and uses some of the LM85's features
(i.e. smart tachometer mode). It also adds measurement and control support
for dynamic Vccp monitoring and PROCHOT. It is designed to monitor a dual

processor Xeon class motherboard with a minimum of external components.

User Interface

#PROCHOT:

The LM93 can monitor two #PROCHOT signals. The results are found in the sysfs files prochot1, prochot2, prochot1_avg, prochot2_avg, prochot1_max, and prochot2_max. prochot1_max and prochot2_max contain the user limits for #PROCHOT1 and #PROCHOT2, respectively. prochot1 and prochot2 contain the current readings for the most recent complete time interval. The value of prochot1_avg and prochot2_avg is something like a 2 period exponential moving average (but not quite - check the datasheet). Note that this third value is calculated by the chip itself. All values range from 0-255 where 0 indicates no throttling, and 255 indicates > 99.6%.

The monitoring intervals for the two #PROCHOT signals is also configurable. These intervals can be found in the sysfs files prochot1_interval and prochot2_interval. The values in these files specify the intervals for #P1_PROCHOT and #P2_PROCHOT, respectively. Selecting a value not in this list will cause the driver to use the next largest interval. The available intervals are (in seconds):

#PROCHOT intervals: 0.73, 1.46, 2.9, 5.8, 11.7, 23.3, 46.6, 93.2, 186, 372

It is possible to configure the LM93 to logically short the two #PROCHOT signals. I.e. when #P1_PROCHOT is asserted, the LM93 will automatically assert #P2_PROCHOT, and vice-versa. This mode is enabled by writing a non-zero integer to the sysfs file prochot_short.

The LM93 can also override the #PROCHOT pins by driving a PWM signal onto one or both of them. When overridden, the signal has a period of 3.56 ms, a minimum pulse width of 5 clocks (at 22.5kHz => 6.25% duty cycle), and a maximum pulse width of 80 clocks (at 22.5kHz => 99.88% duty cycle).

The sysfs files prochot1_override and prochot2_override contain boolean integers which enable or disable the override function for #P1_PROCHOT and #P2_PROCHOT, respectively. The sysfs file prochot_override_duty_cycle contains a value controlling the duty cycle for the PWM signal used when the override function is enabled. This value ranges from 0 to 15, with 0 indicating minimum duty cycle and 15 indicating maximum.

#VRD_HOT:

The LM93 can monitor two #VRD_HOT signals. The results are found in the sysfs files vrdhot1 and vrdhot2. There is one value per file: a boolean for which 1 indicates #VRD_HOT is asserted and 0 indicates it is negated. These files are read-only.

Smart Tach Mode:

(from the datasheet)

If a fan is driven using a low-side drive PWM, the tachometer

output of the fan is corrupted. The LM93 includes smart tachometer circuitry that allows an accurate tachometer reading to be achieved despite the signal corruption. In smart tach mode all four signals are measured within 4 seconds.

Smart tach mode is enabled by the driver by writing 1 or 2 (associating the the fan tachometer with a pwm) to the sysfs file fan<n>_smart_tach. A zero will disable the function for that fan. Note that Smart tach mode cannot be enabled if the PWM output frequency is 22500 Hz (see below).

Manual PWM:

The LM93 has a fixed or override mode for the two PWM outputs (although, there are still some conditions that will override even this mode - see section 15.10.6 of the datasheet for details.) The sysfs files pwm1_override and pwm2_override are used to enable this mode; each is a boolean integer where 0 disables and 1 enables the manual control mode. The sysfs files pwm1 and pwm2 are used to set the manual duty cycle; each is an integer (0-255) where 0 is 0% duty cycle, and 255 is 100%. Note that the duty cycle values are constrained by the hardware. Selecting a value which is not available will cause the driver to use the next largest value. Also note: when manual PWM mode is disabled, the value of pwm1 and pwm2 indicates the current duty cycle chosen by the h/w.

PWM Output Frequency:

The LM93 supports several different frequencies for the PWM output channels. The sysfs files pwm1_freq and pwm2_freq are used to select the frequency. The frequency values are constrained by the hardware. Selecting a value which is not available will cause the driver to use the next largest value. Also note that this parameter has implications for the Smart Tach Mode (see above).

PWM Output Frequencies (in Hz): 12, 36, 48, 60, 72, 84, 96, 22500 (default)

Automatic PWM:

The LM93 is capable of complex automatic fan control, with many different points of configuration. To start, each PWM output can be bound to any combination of eight control sources. The final PWM is the largest of all individual control sources to which the PWM output is bound.

The eight control sources are: temp1-temp4 (aka "zones" in the datasheet), #PROCHOT 1 & 2, and #VRDHOT 1 & 2. The bindings are expressed as a bitmask in the sysfs files pwm<n>_auto_channels, where a "1" enables the binding, and a "0" disables it. The h/w default is 0x0f (all temperatures bound).

0x01 - Temp 1
0x02 - Temp 2
0x04 - Temp 3
0x08 - Temp 4
0x10 - #PROCHOT 1
0x20 - #PROCHOT 2
0x40 - #VRDHOT 1
0x80 - #VRDHOT 2

The function y = f(x) takes a source temperature x to a PWM output y. This

function of the LM93 is derived from a base temperature and a table of 12 temperature offsets. The base temperature is expressed in degrees C in the sysfs files temp<n>_auto_base. The offsets are expressed in cumulative degrees C, with the value of offset <i> for temperature value <n> being contained in the file temp<n>_auto_offset<i>. E.g. if the base temperature is 40C:

offset #	temp<n>_auto_offset<i>	range	pwm
1	0	-	25.00%
2	0	-	28.57%
3	1	40C - 41C	32.14%
4	1	41C - 42C	35.71%
5	2	42C - 44C	39.29%
6	2	44C - 46C	42.86%
7	2	48C - 50C	46.43%
8	2	50C - 52C	50.00%
9	2	52C - 54C	53.57%
10	2	54C - 56C	57.14%
11	2	56C - 58C	71.43%
12	2	58C - 60C	85.71%
		> 60C	100.00%

Valid offsets are in the range 0C <= x <= 7.5C in 0.5C increments.

There is an independent base temperature for each temperature channel. Note, however, there are only two tables of offsets: one each for temp[12] and temp[34]. Therefore, any change to e.g. temp1_auto_offset<i> will also affect temp2_auto_offset<i>.

The LM93 can also apply hysteresis to the offset table, to prevent unwanted oscillation between two steps in the offsets table. These values are found in the sysfs files temp<n>_auto_offset_hyst. The value in this file has the same representation as in temp<n>_auto_offset<i>.

If a temperature reading falls below the base value for that channel, the LM93 will use the minimum PWM value. These values are found in the sysfs files temp<n>_auto_pwm_min. Note, there are only two minimums: one each for temp[12] and temp[34]. Therefore, any change to e.g. temp1_auto_pwm_min will also affect temp2_auto_pwm_min.

PWM Spin-Up Cycle:

A spin-up cycle occurs when a PWM output is commanded from 0% duty cycle to some value > 0%. The LM93 supports a minimum duty cycle during spin-up. These values are found in the sysfs files pwm<n>_auto_spinup_min. The value in this file has the same representation as other PWM duty cycle values. The duration of the spin-up cycle is also configurable. These values are found in the sysfs files pwm<n>_auto_spinup_time. The value in this file is the spin-up time in seconds. The available spin-up times are constrained by the hardware. Selecting a value which is not available will cause the driver to use the next largest value.

Spin-up Durations: 0 (disabled, h/w default), 0.1, 0.25, 0.4, 0.7, 1.0,
2.0, 4.0

#PROCHOT and #VRDHOT PWM Ramping:

If the #PROCHOT or #VRDHOT signals are asserted while bound to a PWM output channel, the LM93 will ramp the PWM output up to 100% duty cycle in discrete steps. The duration of each step is configurable. There are two files, with one value each in seconds: pwm_auto_prochot_ramp and pwm_auto_vrdhot_ramp. The available ramp times are constrained by the hardware. Selecting a value which is not available will cause the driver to use the next largest value.

Ramp Times: 0 (disabled, h/w default) to 0.75 in 0.05 second intervals

Fan Boost:

For each temperature channel, there is a boost temperature: if the channel exceeds this limit, the LM93 will immediately drive both PWM outputs to 100%. This limit is expressed in degrees C in the sysfs files temp<n>_auto_boost. There is also a hysteresis temperature for this function: after the boost limit is reached, the temperature channel must drop below this value before the boost function is disabled. This temperature is also expressed in degrees C in the sysfs files temp<n>_auto_boost_hyst.

GPIO Pins:

The LM93 can monitor the logic level of four dedicated GPIO pins as well as the four tach input pins. GPIO0-GPIO3 correspond to (fan) tach 1-4, respectively. All eight GPIOs are read by reading the bitmask in the sysfs file gpio. The LSB is GPIO0, and the MSB is GPIO7.

LM93 Unique sysfs Files
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file	description
prochot<n>	current #PROCHOT %
prochot<n>_avg	moving average #PROCHOT %
prochot<n>_max	limit #PROCHOT %
prochot_short	enable or disable logical #PROCHOT pin short
prochot<n>_override	force #PROCHOT assertion as PWM
prochot_override_duty_cycle	duty cycle for the PWM signal used when #PROCHOT is overridden
prochot<n>_interval	#PROCHOT PWM sampling interval
vrdhot<n>	0 means negated, 1 means asserted
fan<n>_smart_tach	enable or disable smart tach mode
pwm<n>_auto_channels	select control sources for PWM outputs

pwm<n>_auto_spinup_min minimum duty cycle during spin-up

pwm<n>_auto_spinup_time duration of spin-up

pwm_auto_prochot_ramp   ramp time per step when #PROCHOT asserted

pwm_auto_vrdhot_ramp   ramp time per step when #VRDHOT asserted

temp<n>_auto_base   temperature channel base

temp<n>_auto_offset[1-12]
                        temperature channel offsets

temp<n>_auto_offset_hyst
                        temperature channel offset hysteresis

temp<n>_auto_boost   temperature channel boost (PWMs to 100%) limit

temp<n>_auto_boost_hyst temperature channel boost hysteresis

gpio   input state of 8 GPIO pins; read-only