Power Management of KeyStone II Devices

ABSTRACT

This application report lists the steps to enable Class 0 Temperature Compensation (Class 0 TC) mode of SmartReflex™ Subsystem (SRSS) module available on such devices.

For features that apply to various Keystone II devices, see Section 2.

Contents

1   SmartReflex

1.1   Acronyms

Table 1. Acronyms

Acronyms	Definitions
TCI6630K2L, 66AK2L0x, TCI6638K2K TCI6636K2H, 66AK2Hxx, 66AK2E0x, AM5K2E0x	Keystone II architecture Devices from Texas Instruments.
AVS	Adaptive Voltage Scaling
CVDD	Adjustable voltage supply used by core logic on Keystone II devices.
PAPLL	Pll for PA module on device
PSC	Power Sleep Controller on device
MCSDK	Multi Core Software Development Kit
R	Read Only Register
RW	Read/Write Register
SRSS	Smart Reflex Subsystem on device
SRSS Base	Base Address of SRSS module on device
TC	Temperature Compensation
TPS544Bxx	PMBus compatible voltage regulator from Texas Instruments.
VID	SmartReflex VID Value Mapping - *Hardware Design Guide for KeyStone II Devices* (SPRABV0)

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1.2   Smart Reflex Class 0

Keystone II devices have Smart Reflex Class 0 operation mode enabled by default. In this mode, the SmartReflex module determines value for CVDD voltage using adaptive voltage scaling (AVS) to compensate for variations in performance from die to die, and from wafer to wafer. Adaptive voltage scaling (AVS) is the adaptation or modification of the supply voltage for a processor voltage-domain given the process strength.

For more detailed information, see the *CVDD* section in the *Hardware Design Guide for KeyStone II Devices* (SPRABV0).

1.3   Smart Reflex Class 0 With Temperature Compensation Mode

On supported Keystone II devices the voltage on CVDD or AVS rail can be set dynamically based on the device temperature. Smart Reflex module on these devices needs to be enabled to support this feature. By default, the Smart Reflex module on these devices is setup for Class 0 mode of operation. To enable the Class 0 with Temperature Compensation mode, additional steps are needed after device boot. When this feature is enabled, the Smart Reflex module senses the instantaneous temperature of the device from on die sensors and determines appropriate voltage for the device. Steps to enable SRSS module for this mode are mentioned in the next section. Detection of voltage change request and setting the appropriate voltage are not covered here. MCSDK release supporting this feature would cover enabling, detection as well as response handling.

A comparison of CVDD voltage with Class 0 temperature compensation enabled is shown in Figure 1. It shows the reduction is voltage at higher temperatures versus the corresponding voltage value for a Class 0 only mode.

The voltage values and number of steps shown in Figure 1 are only for example purpose. Different device will have different voltage and number of steps based on its process strength.
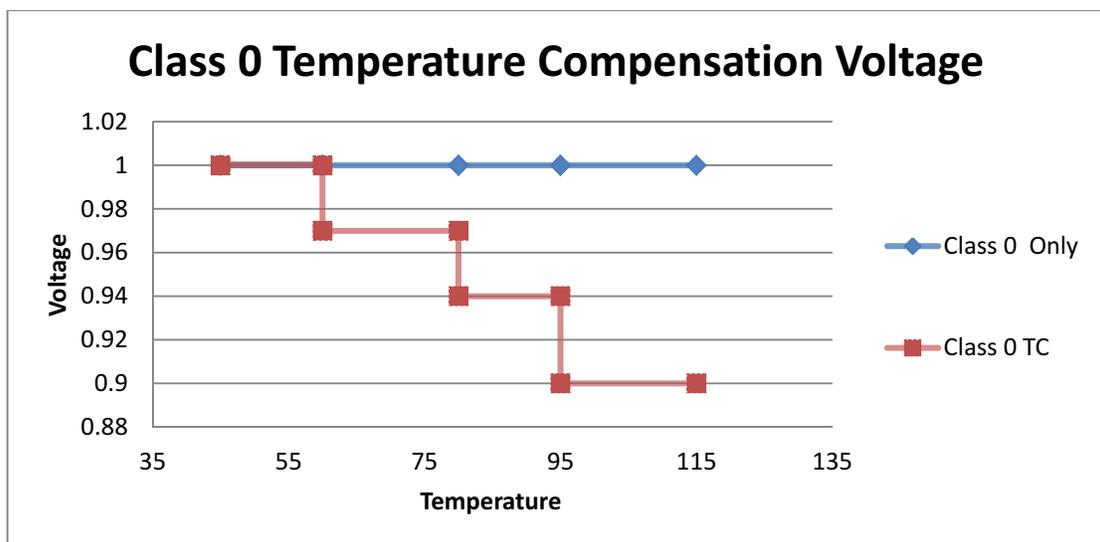

Figure 1. Class 0 Temperature Compensation Voltage

1.3.1   Steps to Enable SRSS Class0 Temperature Compensation Mode

1. Relevant Registers:

    The following are registers relevant for the Class 0 TC setup. Perform Read Modify Write and change only the value of required fields within the registers.

Table 2. Registers Relevant for Class 0 TC Setup

Register Name	Read/Write	Register Width (Bits)	Base Address Within SOC	Address Offset Within Module	Reset Value/ Comments
SRSS_TEMP_CTL0_REG	RW	32	SRSS Base	0x0000 001C	0x0
SRSS_TEMP_STAT0_REG	R	32	SRSS Base	0x0000 0028	0x0
SRSS_TEMP_STAT1_REG	R	32	SRSS Base	0x0000 002C	0x0
VPRM_STATUS0_REG	R	32	SRSS Base	0x0000 0088	0x0

2. Setup Parameters: (Thresholds for temperature, and so forth)

    (a) All Keystone II devices have this programmed by default. No additional setup is needed.

3. Enable Temperature Sensors:
    Keystone II devices have two on die sensors tm0 and tm1 that can be configured in order to be used by SRSS in the class 0 TC mode to sense temperature. These can be enabled by writing to SRSS_TEMP_CTL0_REG's bits[1:0].

    (a) Smart Reflex Sensor Power Domain should be turned on by programming the PSC (Power Sleep Controller) module.

    (b) SRSS_TEMP_CTL0_REG[0] = *srss_tm0_en*,
    Used for Temperature Sensor 0 SRSS_TEMP_CTL0_REG[1] = *srss_tm1_en*, used for Temperature Sensor 1
    0: Temperature Monitor disabled locally
    1: Temperature Monitor enabled locally

    (c) PAPLL should be Configured and kept on for sensors to work.

    (d) Only one of the two available sensors can be used at a time by the SRSS state machine to initiate voltage change.
    SRSS_TEMP_CTL0_REG[19] = *srss_tempm_sel*
    0: Select tm0 as the source of temperature-comparison used to compare vs threshold points.
    1: Select tm1 as the source of temperature-comparison used to compare vs threshold points

    All Keystone II devices have this bit programmed by default to 0.

    (e) Reading Temperature Value
    Enabled sensor's temperature can be read in Signed two compliment formats in the following register:
    SRSS_TEMP_STAT0_REG[7:0] = *srss_tm0_temp*
    SRSS_TEMP_STAT0_REG[23:16] = *srss_tm1_temp*

4. Enable SRSS Temperature Compensation mode

    (a) Make sure the SRSS state machine is not in State S0 or S1 by reading VPRM_STATUS0_REG
    VPRM_STATUS0_REG[2:0] = VID_FSM_STATUS
    Reflects the status of the VID FSM posting the voltage change request to the SMPS:
    "0x0" FSM in state *S0*
    "0x1" FSM in state *S1*

    (b) The final step is to enable the State machine to be in Class 0 TC mode by the following write:
    SRSS_TEMP_CTL0_REG[2] = *srss_c0temp_en = 1b1*
    SR-Class0 temperature compensated

5. Read temperature compensated voltage (VID)
    When Class0-TC mode is enabled, the suggested value of the voltage (based on the temperature of the device) is reflected in the following register field:
    SRSS_TEMP_STAT1_REG[29:24] = *srss_tempthp_vctl[5:0]*
    This value is the temperature compensated and calculated SR-Class0 voltage target in the 6-bit VID interface format.

6. Detecting voltage change request:

    (a) Read VID change by monitoring SRSS register

    (b) Interrupt triggered

7. Updating the Voltage output of the voltage controller (for example, TPS544Cxx type regulator)

    (a) VCNTLID bus

    (b) Generic I2C bus

Software support to be added MCSDK 3.1.0 onwards.

2 Device Applicability

Various Keystone II architecture devices support different features offered by Smart Reflex module. Some devices support only a select few features like allowing instantaneous temperature of device sensors to be read. Table 3 shows the various devices and SRSS features supported by them. Please note that for using supported device features appropriate software steps might be needed and refer to relevant sections in this document to enable those.

Table 3. Supporting Devices

Feature	Supporting Devices			Relevant Sections
	TCI6630K2L 66AK2L0x	TCI6638K2K TCI6636K2H 66AK2Hxx	66AK2E0x AM5K2E0x	
SRSS Class 0	Yes	Yes	Yes	Section 1.2
SRSS Class 0 TC	Yes	No	Yes	Section 1.3
Temperature Read	Yes	Yes	Yes	Section 1.3.1 (3)

3 Frequently Asked Questions for SRSS Class 0 TC Mode

1. **Question:** What is the voltage change step size when the device crosses a temperature threshold?

    Answer: Voltage step sizes are device specific and are preprogrammed in the device. Two different devices of same 'Device Type' may have different voltage step sizes.

2. **Question:** What is the expected maximum and minimum voltage values?

    Answer: Device can request any voltage between the CVDD range mentioned in the device-specific data sheet. Requested voltage will never exceed this bound.

3. **Question:** How many temperature threshold/ranges are expected in a device?

    Answer: SRSS can support up to five threshold points making it six temperature ranges max. Threshold points utilized are specific to device and not all threshold points would be necessarily used by every device.

4. **Question:** Does every device have the same number of temperature ranges/thresholds and voltage values?

    Answer: Not necessarily, the number of temperature ranges and temperature thresholds can vary from device to device.

5. **Question:** Usage of SRSS temperature reading in other applications?

    Answer: SRSS temperature sensors are primarily meant to be used by SRSS and not for application software use. Although the temperature reading from SRSS temperature sensors closely represents the device temperature the use of these readings in users/application software, precise device temperature measurement is not recommended.

6. **Question:** What happens if applied voltage to device does not match the SRSS suggested value?

    Answer: When the applied CVDD value does not match the SRSS recommended value, the device would be out of power spec but still functional as long as the applied voltage is higher or equal to the SRSS recommended value and is within the range specified for that device.

7. **Question:** What is expected voltage ramp up time requirement to ensure the silicon function and performance, minimal or maximal time requirement?

    Answer: Supply Max Rise/Fall Time: Applied voltage should reach new value within 10 msec. Supply Min Rise/Fall Time: >10 µSec

8. **Question:** Does Smart-Reflex Class0 work as a temperature compensator for DSP core rail in accordance with the measured DSP temperature, not with the DSP load?
    Or, do the temperature values represent the temperature of DSP or ARM core?

    Answer: Smart-Reflex Class 0 TC mode takes into account the instantaneous device temperature, and this instantaneous temperature does not necessarily correspond to temperature of DSP or ARM core.

9. **Question:** Do VID values mean the DSP temperature?

    Answer: VID values are enumerated voltage values that represent the recommended voltage for device by the SRSS module of that device. VID to voltage conversion is mentioned in the *Hardware Design Guide for KeyStone II Devices* (SPRABV0).

10. **Question:** What is the expected power saving with SRSS class 0 TC mode?

    Answer: In general with SRSS class 0 TC mode enabled, the CVDD voltage at higher temperatures will be lower than without class 0 TC mode enabled, this should result in power saving at higher temperature. Exact saving will depend on device and device load.

11. **Question:** Is it ok to apply fixed voltage before SRSS class 0 TC mode is enabled?

    Answer: By default the device will boot is SRSS Class 0 only mode and will request a fixed voltage value and that should be applied to device until SRSS class 0 TC mode is enabled. As long as device is supplied with CVDD voltage value higher or equal to the SRSS recommended value and is within the range of Data Sheet limits, device will not be harmed. Only drawback of not using SRSS class 0 TC is that device might be out of power specification during that duration.

4   References

- *Hardware Design Guide for KeyStone II Devices* (SPRABV0)

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from B Revision (January 2016) to C Revision **Page**

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