Engineer-to-Engineer Note EE-361

ADSP-CM40x Power Supply Transistor Selection Guidelines

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Introduction

ADSP-CM40x Mixed-Signal Control Processors operate from a single voltage supply (VDD_EXT/VDD_ANA), generating its own internal voltage supply (VDD_INT) using an on-chip voltage regulator and an external pass transistor.

This processor family offers low static power consumption and is produced with a low-power and low-voltage design methodology, delivering world class performance with lower power consumption.

This EE-Note provides the guidelines for selecting an appropriate external transistor for the ADSP-CM40x power supply design. Note, however, that depending on the system resources, a separate voltage regulator may be used, if available.

Overview

The on-chip linear voltage regulator supplies 1.2 Volts to the digital section (core) of the chip (VDD_INT). Its primary purpose is to support the processor's dynamic current. The regulator's input voltage is the external I/O supply (VDD_VREG = 3.3V), which is then used to generate the appropriate core domain supply (VDD_INT) of 1.2 Volts.

As mentioned earlier, the user may choose to bypass it at the added expense of an external regulator.

The on-chip voltage regulator provides current to the digital portion of the chip only. It is NOT recommended to connect any other external circuitry to the regulated output voltage of this block.

Implementation

For proper operation, the on-chip voltage regulator requires several external components:

- A PNP bipolar junction transistor. This component will act as an external pass device to bring the higher VDD_VREG voltage down to the lower VDD_INT voltage, thus dissipating power external to the IC package.
- A 1 kOhm resistor. This component should be placed between the transistor's emitter and base to aid in stabilizing the regulator for varying loads. This ensures that current is always flowing into the VREG_BASE pin, even for minimal regulator loads.
- Decoupling capacitors. The capacitor load range is 10 uF – 220 uF. This range may be refined and must have a minimum Equivalent Series Resistance (ESR) of 0.5 Ohm. The ESR is for stability purposes and preventing ringing.

Therefore, a possible implementation would look as follows:

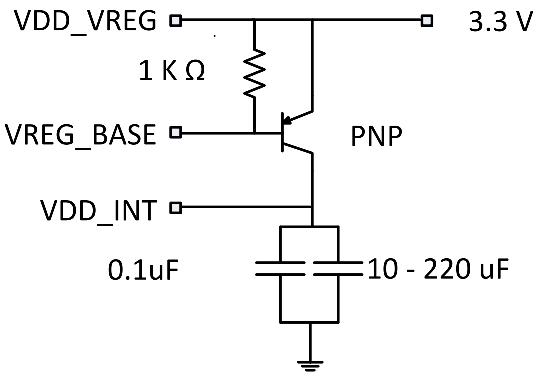

Figure 1. Voltage Regulator External Circuitry Design

External Regulator

As discussed, using an external 1.2 Volt source to power `VDD_INT` permits bypassing of the internal voltage regulator, thus omitting the need of an external transistor.

When using an external regulator, `VDD_VREG` and `VREG_BASE` must be tied to ground for zero current consumption.

Transistor Selection Criteria

In this section, the main criteria for selecting a proper transistor are discussed:

1. High Beta.
2. Thermal characteristics.
3. Power dissipation.
4. Voltage and current requirements.

The maximum current consumption of the ADSP-CM40x core powered by the on-chip voltage regulator is 400 mA[1]. Based on this requirement, to minimize the current from the base into the `VREG_BASE` pin, a PNP transistor with a minimum Beta of 150 is recommended.

As an example, for a current requirement of 400 mA and a power requirement of 3.3 Volts, the selected transistor must be able to handle a load of: (3.3 V -1.2 V) * 400 mA = 840 mW.

Therefore, in this case, Vce = 2.1 V, Ic = 400 mA, and power dissipation = 840 mW.

With the above criteria, the DXTP19020DP5 transistor[3], with the following specifications, is selected:

- Power dissipation of 1.3W
- Thermal Resistance, Junction to Ambient Air @ 25ºC, $R_{\theta JA}$ = 96.1 ºC/W
- Max operating temperature 150 ºC

Operating with 400 mA at 1.2 Volts, the maximum operating ambient temperature can be calculated as follows: 150 - (0.84 * 96.1) = 69 ºC

Furthermore, the DXTP19020DP5 transistor can also operate at higher ambient temperatures by adding copper to the pad area, as described in the device datasheet[3].

From Figure 2, Thermal Resistance, Junction to Ambient Air @ 25ºC, $R_{\theta JA}$ = 41.7 C/W. Thus: 150 – (0.84 * 41.7) = 115 ºC.

Maximum Ratings @T_A = 25°C unless otherwise specified

Characteristic	Symbol	Value	Unit
Collector-Base Voltage	V_{CBO}	-25	V
Collector-Emitter Voltage	V_{CEO}	-20	V
Emitter-Collector Voltage (Reverse Blocking)	V_{ECO}	-4	V
Emitter-Base Voltage	V_{EBO}	-7	V
Continuous Collector Current	I_C	-8	A
Base Current	I_B	-1	A
Peak Pulse Current	I_{CM}	-15	A

Thermal Characteristics

Characteristic	Symbol	Value	Unit
Power Dissipation @ T_A = 25°C (Note 4)	P_D	1.3	W
Thermal Resistance, Junction to Ambient Air (Note 4) @T_A = 25°C	$R_{\theta JA}$	96.1	°C/W
Power Dissipation @ T_A = 25°C (Note 5)	P_D	3	W
Thermal Resistance, Junction to Ambient Air (Note 5) @T_A = 25°C	$R_{\theta JA}$	41.7	°C/W
Operating and Storage Temperature Range	T_J, T_{STG}	-55 to +150	°C

Notes: 4. Device mounted on FR-4 PCB, 2 oz. copper, minimum recommended pad layout.
5. Device mounted on FR-4 PCB, 2 oz. copper, collector pad dimensions 0.42inch^2.

Figure 2. DXTP19020DP5 High Gain PowerDI®5 Transistor Specifications

References

[1] *ADSP-CM40x ARM Cortex-M4 Mixed-Signal Control Processor Data Sheet.* Rev PrD, September 2013. Analog Devices, Inc.

[2] *ADSP-CM40x Mixed-Signal Control Processor Hardware Reference.* Preliminary Rev 0.2, September 2013. Analog Devices, Inc.

[3] *DXTP19020DP5 High Gain PowerDI®5 Transistor Data Sheet.* Rev 3-2, March 2010. Diodes, Inc.

Document History

Revision	Description
Rev 1 – September 5, 2013 by J. Mangino	Initial release.