Application Report
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TPS57112-Q1 High Frequency (2.35 MHz) Operation

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ABSTRACT

This document describes the TPS57112-Q1 High Frequency (2.35 MHz) operation and (2.5 MHz) simulation test results. This application report is applicable to TPS57114-Q1 and TPS54388-Q1 devices also as these two devices belong to the same family as TPS57112-Q1 device.

1 Introduction

The TPS57112-Q1 device is a full-featured 6-Vin, 2-A, synchronous step-down current-mode DC-DC converter with two integrated metal–oxide–semiconductor field-effect transistors (MOSFETs). The TPS57112-Q1 device can operate in a wide range of switching frequencies from 200-KHz to 2-MHz. The switching frequency can be set using a pulldown resistor or an externally applied signal at the RT pin as shown in Figure 1. Refer to *Interfacing TPS57xxx-Q1,TPS65320-Q1 Family, and TPS65321-Q1 Devices With Low Impendence External Clock Drivers*,SLVA755, for more information regarding interfacing an external clock to TPS57112-Q1 family of devices.

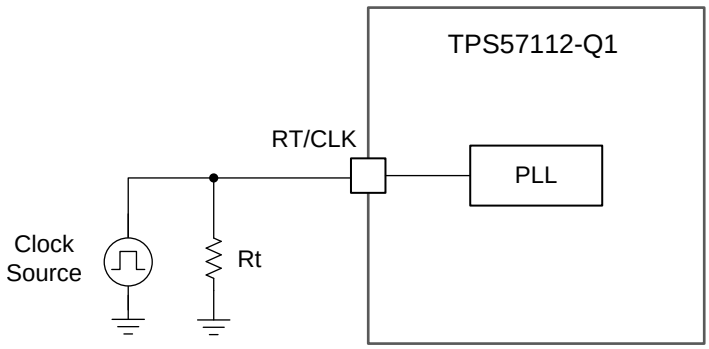

Figure 1. Synchronizing to a High-Impedance External Clock Source

The regulated output voltage at no load is given by Equation 1:

$$V_{out} = V_{in} \times t_{ON} \times f_{SW} \quad (1)$$

where

- V_{in} = input voltage
- V_{out} = output voltage
- t_{ON} = ON time

and

- f_{SW} = switching frequency

For given input and output voltages, as switching frequency is increased, t_{ON} will reduce. If t_{ON} falls below the minimum value allowed by the internal circuit design, the output voltage may not track the internal 0.8 V reference and would therefore not be regulated. To maintain the regulation at higher switching frequencies, t_{ON} must be kept above a minimum value. If the switching frequency is less than or equal to the data sheet maximum value of 2 MHz, t_{ON} will always be above designed minimum value and the output would be regulated.

2 2.35-MHz Operation

Bench test and chip level simulations were done to check whether TPS57112-Q1 can remain in regulation while switching at a frequency higher than 2.0 MHz.

The test conditions for the bench test and chip level simulation were as follows:

- Supply Input Voltage: 5.33 V
- Regulated Output Voltage: 1.35 V
- Operating Switching Frequency in bench setup: 2.35 MHz
- RT resistor value used in bench measurement: 72 kΩ

Under these test conditions, the on time at no load for TPS57112-Q1 to maintain regulation was verified by bench measurements to be as in Equation 2:

$$(1.35\ V / 5.33\ V) \times (1 / 2.35\ MHz) = 107.8\ ns \quad (2)$$

3 2.5-MHz Operation Simulation Results

A full chip breaking-point simulation is performed at 2.5-MHz clock frequency with the input and output voltages specified above to determine the minimum controllable t_{ON} allowed by internal circuit design. The 2.5-MHz clock frequency is chosen to have some margin for oscillator tolerances and to be sure that it works for 2.35-MHz clock frequency.

Simulation results:

- Transient turn on behavior appears normal
- Output tracks the bandgap when t_{ON} is above 99 ns

Table 1 lists the simulation results across process corners and across temperature with 10 mA load current.

Table 1. Breaking Point Simulation Data with 10 mA Load @ 2.5MHz

Process Corner / Temperature	Actual V_{out} (V)	t_{ON} (ns)	Calculated V_{out} (V)
Nominal / 27°C	1.328	99.8	1.327
Weak / 150°C	1.323	100.1	1.322
STRONG / 150°C	1.303	98.6	1.297
STRONG / –40°C	1.331	98.9	1.329

Table 2 lists the simulation results at STRONG / 150°C with no load current.

Table 2. Breaking Point Simulation Data with No Load @ 2.5MHz (Worst Case)

Process Corner / Temperature	Actual V_{out} (V)	t_{ON} (ns)	Calculated V_{out} (V)
STRONG / 150°C	1.343	100.9	1.341

Based on the simulation results, the minimum controllable on-time is found to be 105 ns at no load (with around 5% tolerance).

4 Conclusion

The switching ON time for an input voltage of 5.33 V and a regulated output voltage of 1.35 V and a switching frequency of 2.35 MHz is calculated to be 107.8 ns during no load conditions. This is higher than the minimum controllable ON time of 105 ns allowed by internal circuit design based on simulations. The TPS57112-Q1 is expected to be capable of maintaining regulation without entering pulse-skipping mode up to 2.35-MHz switching frequency under this operating condition. This result has been verified by bench measurements to be accurate under extreme temperature corners on typical devices.

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