TLE7368 Frequently Asked Questions

Next Generation Microcontroller Supply

About this document

Scope and purpose

This Application Note is intended to provide additional information for implementing the TLE7368 as a multiple voltage supply into new applications. Frequently asked questions by designers are listed here, which occurred during design-in of the TLE7368.

Intended audience

This document is intended for power supply design engineers, application engineers, students, etc., who want to use the TLE7368-family as a power supply in their application.

Note: The following information is given as a hint for the implementation of the device only and shall not be regarded as a description of warranty of a certain functionality, condition or quality to the device.

The Application note is intended to provide important information about the usage of the device in the application and what to consider during hard- and software development.

This document is a compilation of important topics and hints, which have been collected during the product introduction. It does not cover all topics or features of the device.

Table of Contents **Page**

1 Introduction 3
2 Questions and Answers 5
2.1 Input voltage, Quiescent current etc. 5
2.2 DC/DC converter (preregulator) 6
2.3 LDOs (Linear regulators) 7
2.4 Voltage Trackers 8
2.5 Standby Regulator 10
2.6 Reset Signals 11
2.7 Window Watchdog 11
2.8 Electromagnetic Compatibility (EMC) 11
2.9 Internal Architecture 12
3 Revision history 14

1 Introduction

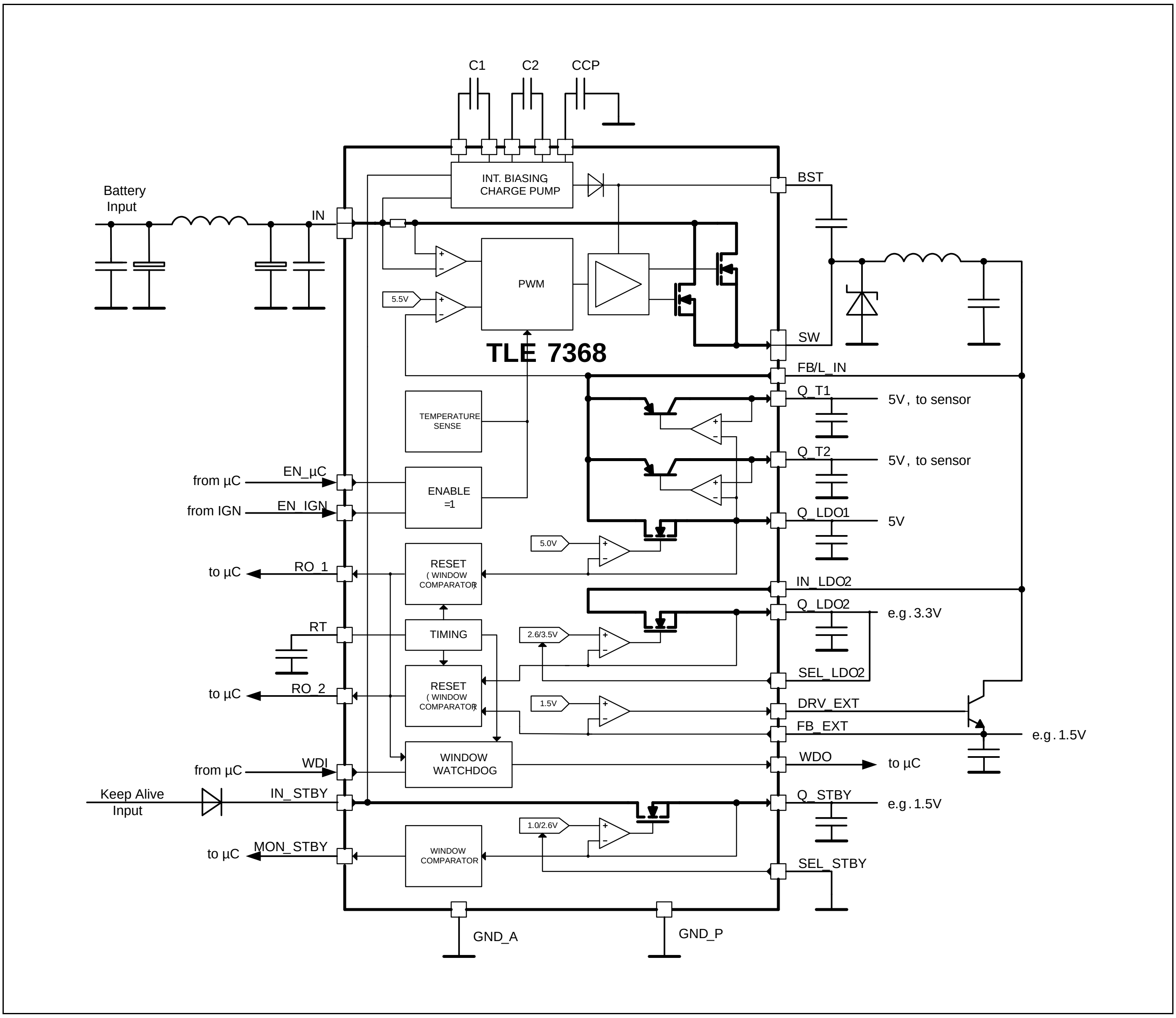

Figure 1 TLE7368 Application circuit

Introduction

The TLE7368 is a microcontroller power supply system. A step down converter operates as a preregulator with a fixed 370 kHz switching frequency. The pre regulator supplies:

- LDO_1 with 5 V ± 2% output voltage and 800 mA current capability
- LDO_2 with 3.3 V or 2.6 V ± 2% output voltage and 700 mA current capability
- LDO_3 with 1.5 V ± 2% (TLE7368) or 1.2 V± 2% (TLE7368-2) output voltage, external power stage
- Tracker 1 with 5 V output voltage and 105 mA output current capability following LDO_1
- Tracker 2 with 5 V output voltage and 50 mA output current capability following LDO_1

An additional standby regulator (output voltage selectable 1.0 V or 2.6 V) with a current capability of 30 mA is included to supply e.g. memories.

All regulators are fully over current protected.

LDOs 1 to 3 are monitored by two Reset signals; a window watchdog is included to supervise the micro controller.

(For closer details please refer to the datasheet)

2 Questions and Answers

2.1 Input voltage, Quiescent current etc.

Q: The Ignition pull-down current is at minimum –100µA, what is the maximum?

Assuming a variation of the pull down resistor of 30%, the maximum value is assumed to be -130µA-

Q: What is the test level of the Enable Inputs?

The Enable signals “EN_IGN” and “EN_µC” are testes according the following table

Table 1 Result: Injection @ V_{BAT_IGN}

TEST PULSE	Max Test Level V_S	Functional Status	Pulse Duration	Pulse Cycle Time and Generator Impedance
1	-200 V (10 min)	C	2 ms	500 ms; 10 Ω
2a	+200 V (10 min)	C	50 µs	500 ms; 10 Ω
3a	-300 V (10 min)	C	100 ns	100 ms; 50 Ω
3b	+200 V (5 min)	C	100 ns	100 ms; 50 Ω

Functional status C says, that the function might be interrupted, but the device has to operate without any degradation after being restarted.

Q: For what use is the recommended 10 kΩ resistor in the enable inputs?

The resistor is necessary to limit the incoming currents (ESD-pulses applied to the connectors) during ESD testing of the device to protect the structure.

Q: What is the maximum current consumption of IN_STBY?

Measurements have shown, that with increasing V_IN (at around 3.0 V coming from 0 V) the current consumption of IN_STBY rises up to 2 – 3 am, with a further increase of V_IN the current consumption reduces to around 120 µA.

The expected quiescent currents are:

120uA = I_IN_STBY-I_Q_STBY, if both Enable = Low and MONSTBY=H

130uA = I_IN_STBY-I_Q_STBY, if both Enable = Low, MONSTBY=H and SEL_STBY=GND.

If both Enable signals are high, V_BAT = 13.5 V (at IN_STBY), the device is on (meaning reregulate is active, charge pump is active, LDOs and trackers are on but with no load) a current consumption of about 18 to 22 mA is expected.

The higher current consumption only at lower input voltages (1.5 to 2.0 V, which is far below the operation range) is occurring due to the fact, that the internal power supplies and control electronics, but mostly the Standby regulator, are activated. These devices do not have a power on reset. Therefore the increased current consumption will not occur at higher input voltages within the specified operation range.

2.2 DC/DC converter (preregulator)

Q: Is it possible to use the bootstrap voltage to drive an additional MOSFET?

No, it is not recommended to use the bootstrap voltage otherwise than to supply the TLE7368 itself. The internal charge pump is not designed (or capable) to drive additional loads than the internal transistor. If the bootstrap voltage will be used for additional loads, this mode is out of specification and has to be evaluated by the user.

Q: What is the recommended value for the bootstrap capacitor?

The bootstrap capacitor is used to supply the preregulator driver; a higher value will stabilize the voltage supply and thus ensure a proper ramp up. The minimum recommended value is 100 nF. During start up the capacitor is charged with 3 mA.

Q: How does the input FB/L_IN behave during change to 100% duty cycle (Switch mode > constant on)?

The voltage at FB/L_IN will always stay within the specified value from 5.4 to 6.4 V. There might be a slight increase between switch mode and constant on, however this will not be visible at the LDO outputs.

2.3 LDOs (Linear regulators)

Q: What should be considered choosing an external transistor for LDO_3?

This regulator was developed for quick response to load variation, especially for fast load current increase to avoid a reset at the µC due to a relating voltage decrease. The regulator response time Δt is approximately 400 ns (tolerances ± 20%); the Reset headroom is ≥ 40 mV. At a nominal output voltage of 1.530 V the tolerance of the output voltage is only ± 1.7%, the minimum Reset threshold is at minimum 1.425 V. To achieve these values a very fast transistor (comparable to the type mentioned in the datasheet) has to be taken. The transitor datasheet gives the values for transit frequency and current gain.

Q: How do the LDOs 1 to 3 behave at short circuit or overload? Do LDOs 1 and 2 have an individual temperature sense?

The output currents are limited to the specified values. The LDOs do not have individual temperature senses, there is a central temperature sensor, the position is shown in chapter 2.9 of this appnote.

Q: What is the recommended minimum Equivalent Serial Resistance (ESR) for output capacitors?

The recommended minimum ESR values for output capacitors of the LDOs are given in the following table

Table 2 Recommended ESR values for LDOs

Parameter	Symbol	Min. Value	Test condition
LDO_1 output capacitor	ESR C_{Q_LDO1}	20 mΩ	at 1MHz
LDO_2 output capacitor	ESR C_{Q_LDO2}	20 mΩ	at 1MHz
External Voltage Regulator Control output capacitor	ESR C_{FB_EXT}	20 mΩ	at 1MHz
LDO_STBY output capacitor	ESR C_{Q_STBY}	20 mΩ	at 1MHz

2.4 Voltage Trackers

Q: What happens, if one or both Trackers are shorted to Ground?

The tracker current will be limited to max. current. Depending on the location of the short circuit the tracker voltage may be reduced to zero. The function of the LDOs and the other trackers will not be degraded; no Reset-signal will be applied. However it has to be considered that additional power dissipation will contribute to the heating of the TLE 7368. The power dissipation may be at maximum the intermediate circuit voltage multiplied by the maximum current of the tracker.

Q: What happens, if one or both Trackers are shorted to Battery Voltage?

The tracker is short circuit proven against a connection to battery voltage. A small current of some hundred micro Amps to some milliamps may flow into the pin, but will not affect the preregulator or degrade the function of the other LDOs and the other tracker. No Reset signal will be applied.

Q: If one or both Trackers are shorted to Battery Voltage, battery voltage is switched off at Pins IN, but present at IN_STBY and EN_µC and EN_IGN are off, will the LDOs supply voltage?

No. If the device is switched off, neither the LDOs nor the trackers could be enabled by a so called reverse charging.

Q: If one or both Trackers are used to supply smaller currents than the max specified, is it possible to decrease the size of the output capacitors accordingly?

The datasheet specifies for the tracker output capacitors a minimum value of 4.7 µF and a maximum ESR of 3 Ω for this capacitor. This value is specified to guarantee the stability of the tracker under all conditions. Using a smaller capacitor may also be sufficient for the application, but stability is not guaranteed under these conditions. The user has to evaluate the stability on own responsibility.

Q: If one or both Trackers are shorted to ground, do they have their own temperature sensing?

No, there is only one temperature sense on the chip. The temperature sense is located, that every overheating might be detected. Case if an overheating occurs the preregulator (DC/DC-stage) will be disabled. It will restart as soon as the chip temperature has decreased under the specified values. For location of the temperature sense please refer to chapter 2.9 of this appnote.

Q: What is the Test Level of the tracker outputs?

The Trackers 1 and 2 are testes according the following table

Table 3 Result: Injection @ V_{BAT_IGN}

TEST PULSE	Max Test Level V_S	Functional Status	Pulse Duration	Pulse Cycle Time and Generator Impedance
1	-200 V (10 min)	C	2 ms	500 ms; 10 Ω
2a	+200 V (10 min)	C	50 µs	500 ms; 10 Ω
3a	-300 V (10 min)	C	100 ns	100 ms; 50 Ω
3b	+200 V (5 min)	C	100 ns	100 ms; 50 Ω

Functional status C says, that the function might be interrupted, but the device has to operate without any degradation after being restarted. Tracker 1 output capacitor

Q: What is the recommended minimum Equivalent Serial Resistance (ESR) for output capacitors?

The recommended minimum ESR values for output capacitors of the trackers are given in the following table

Table 4 Recommended ESR values for LDOs

Parameter	Symbol	Min. Value	Test condition
Tracker 1 output capacitor	ESR C_{Q_T1}	20 mΩ	at 1MHz
Tracker 2 output capacitor	ESR C_{Q_T2}	20 mΩ	at 1MHz

2.5 Standby Regulator

Q: Signal MON_STBY: How does this signal behave if the input voltage decreases?

If the Input voltage at pins IN and IN_STDBY is continuously lowered from 4 V to 0 V, the MON_STBY detects under voltage. If the input voltage is further lowered, at a value of below 1.25 V the signal gets "high" (current value of V_IN) again. This behavior is shown in figure 2

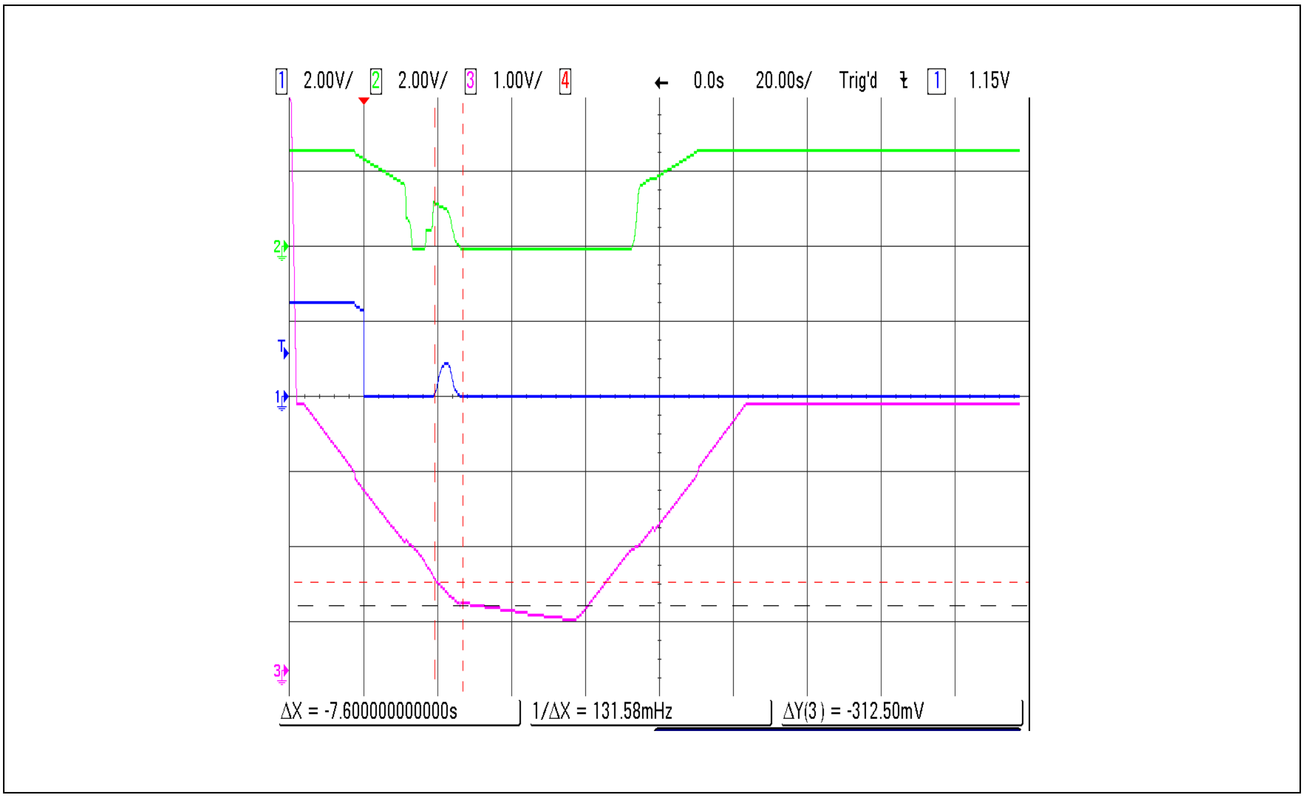

Figure 2 Behavior of the MON_STBY at decreasing input voltage (Q_STBY = 2.6 V)

Channel 1 (blue):	MON_STBY
Channel 2 (green):	Q_STBY
Channel 3 (pink):	V_IN

The operation range of the regulator is between 3.0 and 45 V. Within these thresholds the output voltage is guaranteed, therefore between 2.75 and 3.00 V the under voltage detection is activated. The detection is done via an open-drain structure pulling the output to ground. The device used is a DMOS with a threshold of about 1.4 V. Below the 1.4 V the behavior is strongly depending on the external pull-up resistor. The Standby regulator has its own bandgap, but at very low input voltages the bandgap will not work properly. The effect of the opening open drain structure (MON_STDBY goes high again) is depending on this.

2.6 Reset Signals

Q: Reset Signals RO_1 and RO_2: At which input voltage are they active? Can they be deactivated by EN_µC or by EN_IGN?

The signals RO_1 and RO_2 are only depending on the values of the output voltages. If they are inside the specified values (please refer to datasheet lines 4.4.79 to 4.4.128), the signals will be inactive.

2.7 Window Watchdog

Q: Is there additional information about the function of the window watchdog available?

There is an application note describing the window watchdog function in detail available. Please contact your local Infineon representative.

2.8 Electromagnetic Compatibility (EMC)

Q: Is there an EMC test report available?

The EMC test report is available on request. Please contact your local Infineon representative.

Q: Where can I get additional support for designing an EMC appropriate layout?

There is an application note available about filter design, which provides EMC information. In addition you may take the demoboard as a reference and last not least the EMC test report contains details about filtering and emission levels.

2.9 Internal Architecture

Q: Where is the temperature sense located?

The following figure shows the location of the temperature sense between LDOs 1 and 2 and close to the trackers, where the maximum power dissipation is expected

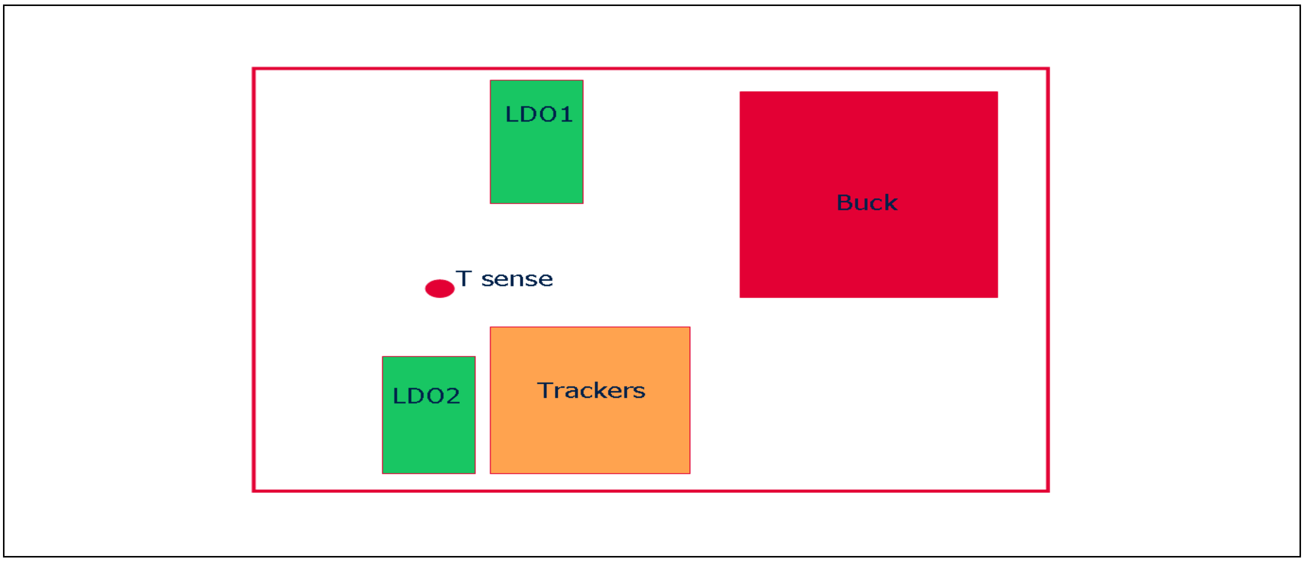

Figure 3 Location of temperature sense

Q: How many bandgaps are in the TLE7368?

The TLE7368 has one central bandgap, which is temperature compensated. All reference voltages for the regulators and reset signals are derived from this bandgap

Q: How is ensured, that at ramping up the overvoltage (reset) references will not be effected?

Please refer to the following block diagram showing how the references for the LDOs 1 to 3 are derived

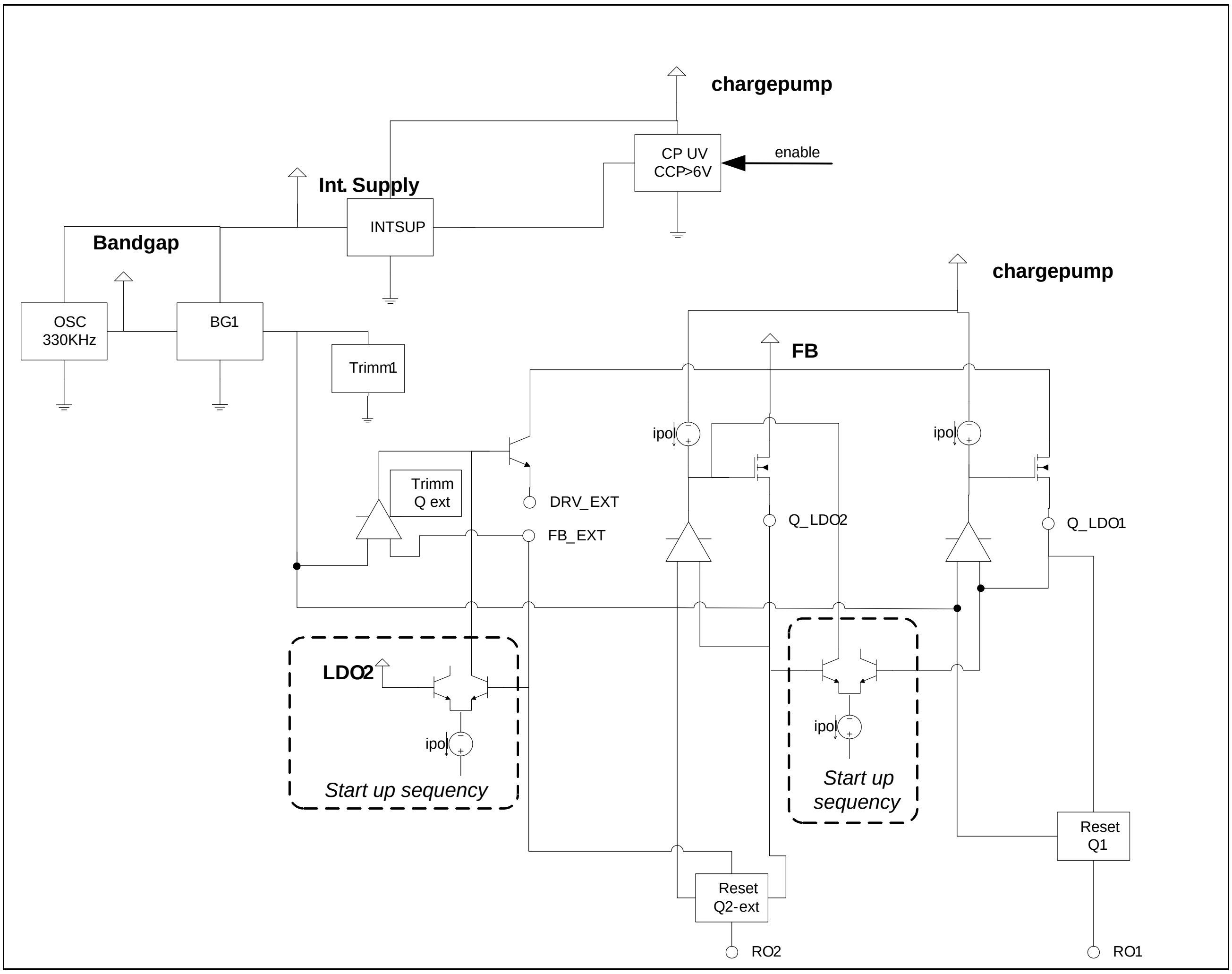

Figure 4 Internal architecture reset and power sequencing

LDO 1 has its own reset block; LDO 2 and the external LDO 3 are monitored together. An additional monitoring of the bandgap is not included in the TLE7368. During the design of the bandgap special attention was paid to the stability to avoid an overshoot during ramping up. The function was verified by several simulations as well as by testing.

All reference voltages are derived from one single bandgap, thus it is ensured that during ramping up no LDO or tracker voltage will rise faster than another or the relating reset-threshold. (Power sequencing).

3 Revision history

Major changes since the last revision

Page or Reference	Description of change
2020-03-31	Updated revision 1.1
2008-09-30	First revirsion 1.0

Trademarks
All referenced product or service names and trademarks are the property of their respective owners.

Trademarks
All referenced product or service names and trademarks are the property of their respective owners.

Edition 2020-03-31

Published by

Infineon Technologies AG

81726 Munich, Germany

Do you have a question about this document?

Email: erratum@infineon.com

Document reference
Z8F52274263