

EZ-PD™ CCG7SCF single-port USB Type-C with PD, buck-boost controller, and two buck FETs

General description

EZ-PD™ CCG7SCF is a highly integrated single-port USB Type-C Power Delivery (PD) solution with an integrated buck-boost controller and two switching FETs targeting consumer charging and dock applications. It complies to the latest USB Type-C and PD specifications, and is targeted for single-port consumer charging and dock applications. Integration offered by EZ-PD™ CCG7SCF not only reduces the BOM but also provides a footprint optimized solution for single-port consumer charging and dock needs. It also includes hardware-controlled protection features on the VBUS. EZ-PD™ CCG7SCF supports a wide input voltage range (4 V to 24 V with 40 V tolerance) and programmable switching frequency (150 kHz to 600 kHz) in an integrated PD solution.

EZ-PD™ CCG7SCF is a highly programmable USB PD solution with an on-chip 32-bit Arm® Cortex®-M0 processor, 128-KB flash, 16-KB RAM and 32-KB ROM that leaves most flash available for user application use. It also includes various analog and digital peripherals such as NFET VBUS Gate Drivers, ADC, PWM, timers, GPIOs, and 2 buck switching FETs. The inclusion of a fully programmable MCU with analog and digital peripherals allows the implementation of custom system management functions such as power throttling, load sharing, temperature monitoring, and fault logging.

Applications

- PC/Mobile Dock charging port
- Chargers and adapters

Features

- USB PD
 - Supports one USB PD port
 - Supports latest USB PD 3.1 including programmable power supply (PPS) mode
 - Extended data messaging
- Type-C
 - Configurable resistors R_p and R_d
 - VBUS provider NFET gate driver
 - Integrated 100-mW VCONN power supply and control
- 1x buck-boost controller
 - 150 to 600 kHz switching frequency
 - 4.5 to 24 V input, 40 V tolerant
 - 3.3 to 21.5 V output
 - 20-mV voltage and 50-mA current steps for PPS
 - Supports selectable pulse skipping mode (PSM) and forced continuous current/conduction mode (FCCM)
 - Supports soft start
 - Programmable spread spectrum frequency modulation for low EMI
 - Two buck switching FETs
- 1x legacy/proprietary charging block
 - Supports Qualcomm QC 2.0/3.0/4.0/5.0, Apple charging 2.4A/3A, Samsung adaptive fast charging (AFC), USB BC 1.2

Features

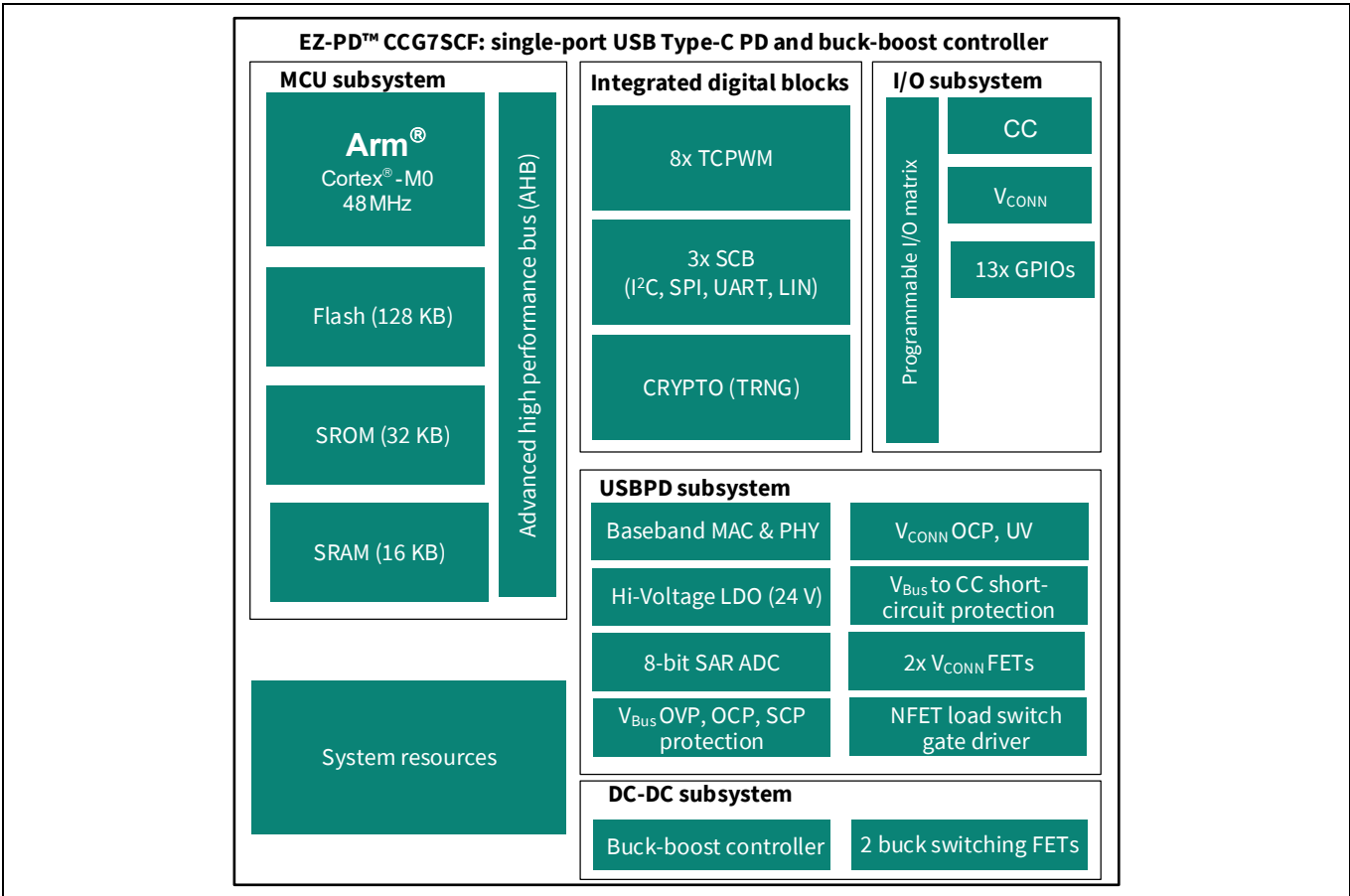
- System-level fault protection
 - On-chip VBUS overvoltage protection (OVP), overcurrent protection (OCP), undervoltage protection (UVP)
 - VBUS to CC short protection
 - Under-voltage lockout (UVLO)
 - Supports over-temperature protection through integrated ADC circuit and internal temperature sensor
 - Supports connector and board temperature measurement using external thermistors
- 32-bit MCU subsystem
 - 48-MHz Arm® Cortex®-M0 CPU
 - 128-KB flash
 - 16-KB SRAM
 - 32-KB ROM
- Peripherals and GPIOs
 - Up to 13 GPIOs including two overvoltage GPIOs
 - 2x 8-bit ADC
 - 8x 16-bit timer/counter/PWMs (TCPWM)
- Communication interfaces
 - 3x SCBs (I²C/SPI/UART/LIN)
- Clocks and oscillators
 - Integrated oscillator eliminating the need for an external clock
- Power supply
 - 4 to 24 V input (40 V tolerant)
 - 3.3 to 21.5 V output
 - Integrated LDO capable of 5 V @ 75 mA
- Package
 - 39-lead LGA (6 mm × 7 mm) package with –40°C to +105°C extended industrial temperature range

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Logic block diagram

Logic block diagram



Functional block diagram

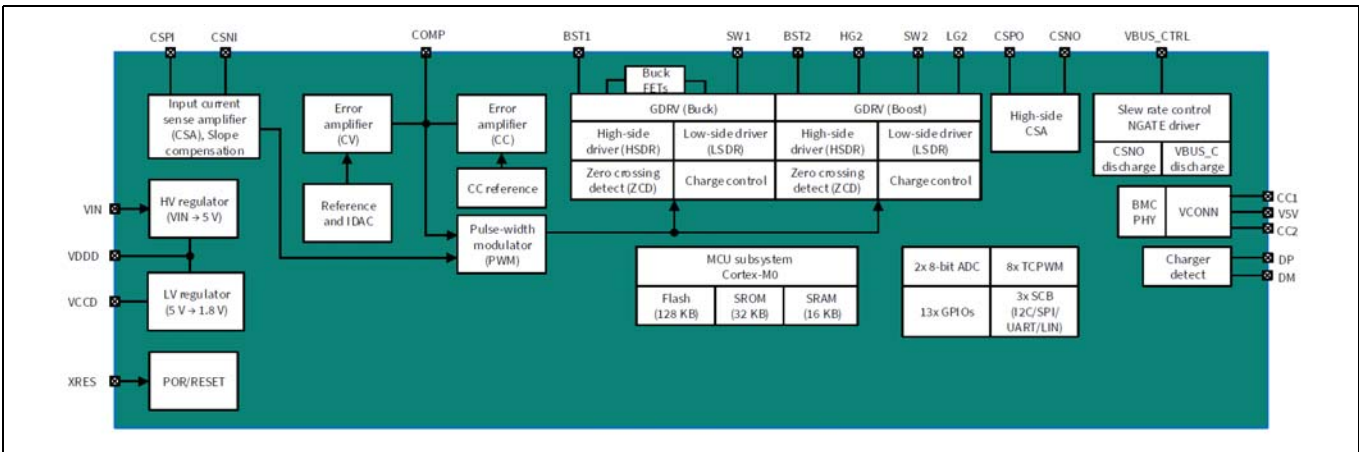


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1 Functional overview

1.1 MCU subsystem

1.1.1 CPU

The Cortex®-M0 in EZ-PD™ CCG7SCF devices is a 32-bit MCU, which is optimized for low-power operation with extensive clock gating. It mostly uses 16-bit instructions and executes a subset of the Thumb-2 instruction set. It also includes a hardware multiplier, which provides a 32-bit result in one cycle. It includes an Interrupt controller (the NVIC block) with 32 interrupt inputs and a wakeup interrupt controller (WIC), which can wake the processor up from deep sleep mode.

1.1.2 Flash ROM and SRAM

EZ-PD™ CCG7SCF devices have 128-KB flash and 32-KB ROM for non-volatile storage. ROM stores libraries for authentication and device drivers such as I²C, SPI, and so on. That spares flash for user application. Flash provides the flexibility to store code for any customer feature and allows firmware upgrades to meet the latest **USB Power Delivery specification** and application needs.

The 16-KB RAM is used under software control to store the temporary status of system variables and parameters. A supervisory ROM that contains boot and configuration routines is provided.

1.2 USB PD subsystem

This subsystem provides the interface to the Type-C USB port. This subsystem comprises:

- USBPD physical layer
- VCONN switches and 100mW VCONN source
- Undervoltage protection (UVP), overvoltage protection (OVP) on VBUS
- Output high-side current sense amplifier (HS CSA) for VBUS
- VBUS discharge control
- Gate driver for VBUS provider NFET
- Charger detection block for legacy charging (for example: BC1.2, Apple charging, and so on)
- VBUS to CC short-circuit protection

1.2.1 USBPD physical layer

The USBPD subsystem contains the USBPD physical layer block and supporting circuits. The USBPD physical layer consists of a transmitter and receiver that communicate BMC encoded data over the CC channel per the PD 3.1 standard. All communication is half-duplex. The physical layer or PHY implements collision avoidance to minimize communication errors on the channel. The USBPD block includes all termination resistors (R_p and R_d) and their switches as required by the USB Type-C spec. R_p and R_d resistors are required to implement connection detection, plug orientation detection and for the establishment of the USB source/sink roles. The R_p resistor is implemented as a current source. EZ-PD™ CCG7SCF devices support R_p under HW control in unconnected (standby) state to minimize standby power.

The CCG7SCF device family along with the accompanying firmware is fully complaint with revision 3.1 of the **USB Power Delivery specification**. The device supports programmable power supply (PPS) operation at all valid voltages from 3.3 V to 21 V.

EZ-PD™ CCG7SCF devices support USB PD extended messages containing data of up to 260 bytes. The extended messages are larger than expected by USB PD 2.0 hardware. As per the USB PD protocol specification, USB PD 3.1 compliant devices implement a chunking mechanism; messages are limited to revision 2.0 sizes unless both source and sink confirm and negotiate compatibility with longer message lengths.

1.2.2 VCONN switches

EZ-PD™ CCG7SCF internal LDO voltage regulator is capable of powering a 100 mW VCONN supply for electronically marked cable assemblies (EMCA), VCONN-powered devices (VPD), and VCONN-powered accessories (VPA) as defined in the USB Type-C specification. All circuitry including VCONN switches and overcurrent protection is integrated in the device. In the event the VCONN current exceeds the VCONN OCP limit, CCG7SCF can be configured to shut down the Type-C port after a certain number of user configurable retries. The port can be re-enabled after a physical disconnect.

1.2.3 VBUS UVP and OVP

VBUS under-voltage and overvoltage faults are monitored using internal resistor dividers. The fault thresholds and response times are user configurable. Refer to the [EZ-PD™ configuration utility](#) for more details. In the event of a UVP or OVP, EZ-PD™ CCG7SCF can be configured to shut down the Type-C port after a certain number of user configurable retries. The port can be re-enabled after a physical disconnect.

1.2.4 VBUS OCP and SCP

VBUS overcurrent and short-circuit faults are monitored using internal current sense amplifiers. Similar to OVP and UVP, the OCP and SCP fault thresholds and response times are configurable as well. Refer to the [EZ-PD™ configuration utility](#) for more details. In the event of OCP or SCP, CCG7SCF can be configured to shut down the Type-C port after a certain number of user configurable retries. The port can be re-enabled after a physical disconnect.

1.2.5 HS-CSA for VBUS

EZ-PD™ CCG7SCF device family supports VBUS current measurement and control using an external resistor (5 mΩ) in series with the VBUS path. The voltage drop across this resistor is used to measure the average output current. The same resistor is also used to sense and precisely control the output current in the PPS current foldback mode of operation.

1.2.6 VBUS discharge control

The chip supports high-voltage (21.5 V) VBUS discharge circuitry. Upon the detection of device disconnection, faults, or hard resets, the chip will discharge the output VBUS terminals to vSafe5V and/or vSafe0V within the time limits specified in the [USB Power Delivery specification](#).

1.2.7 Gate driver for VBUS provider NFET

EZ-PD™ CCG7SCF devices have an integrated high-voltage gate driver to drive the gate of an external high-side NFET on the VBUS provider path. The gate driver drives the load switch that controls the connection between CSNO and VBUS_C. VBUS_CTRL is the output of this integrated high-voltage gate driver. To turn off the external NFET, the gate driver drives VBUS_CTRL low to 0 V. To turn on the external NFET, it drives the gate to CSNO + 8 V. There is an optional slow turn-on feature which reduces the high-current spikes on the output. For a typical gate capacitance of 3 nF, a slow turn-on time of 2 ms to 10 ms is configurable using firmware.

1.2.8 Legacy charge detection and support

EZ-PD™ CCG7SCF implements battery charger emulation and detection (source and sink) for USB BC.1.2, legacy Apple charging, Qualcomm quick charge 2.0/3.0/4.0/5.0, and Samsung AFC protocols.

1.2.9 VBUS to CC short protection

CC pins have integrated protection from accidental shorts to high-voltage VBUS and VBAT. EZ-PD™ CCG7SCF devices can handle up to 24 V external voltage on its CC pins without damage. In the event, an overvoltage is detected on the CC pin, it can be configured to shut down the Type-C port completely. The port will resume normal operation once the CC voltage detected is within normal range.

1.3 Buck-boost subsystem

The buck-boost subsystem in EZ-PD™ CCG7SCF devices can be configured to operate in buck-boost mode, buck-only mode or boost-only mode. Buck-Boost mode requires four switching FETs, out of which two Buck FETs are internal and two Boost FETs are external. The Buck-only mode uses the two internal FETs and does not require any external FETs, while the Boost-only mode requires two external FETs. **Figure 1** shows the buck-boost subsystem's main external components and connections.

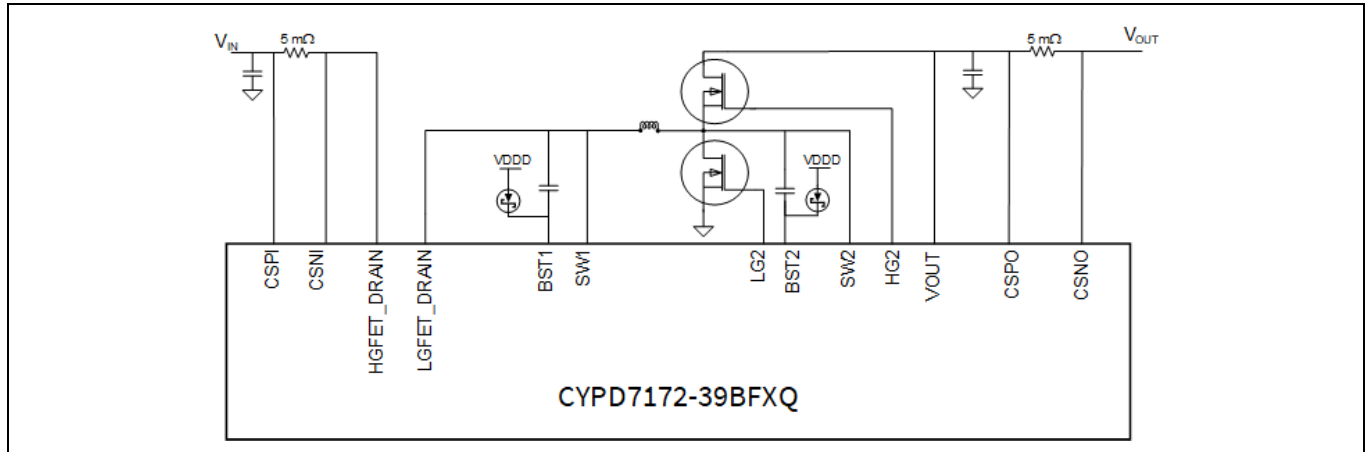


Figure 1 Buck-boost schematic showing external components

Buck-boost subsystem in EZ-PD™ CCG7SCF devices have the following key functional blocks:

- High side (cycle-by-cycle) current sense amplifier
- High side and low side gate driver
- Pulse width modulator
- Error amplifier

1.3.1 High side (cycle-by-cycle) current sense amplifier (CSA)

EZ-PD™ CCG7SCF device's buck-boost controller implements peak current control in both boost and buck modes. A high side current sense amplifier (CSA) is used for peak current sensing through an external resistor (5 mΩ; see CSR1 in **Figure 1**) placed in series with the buck control FET. This current sense amplifier has a high bandwidth and a very wide common mode range. This current sense resistor is connected to the CSA block through pins CSPI and CSNI as shown in **Figure 1**. This block implements slope compensation to avoid sub-harmonic oscillation for the internal current loop. In addition to peak current sensing, it provides a current limit comparator for shutting off the buck-boost converter if the current hits an upper threshold which is programmable.

1.3.2 High-side gate driver and low-side gate driver (HG/LG)

EZ-PD™ CCG7SCF buck-boost controller provides two N-channel MOSFET gate drivers: one floating high-side gate driver at the HG2 pin, and one ground referenced low-side driver at the LG2 pin. The high side gate drivers drive the high side external FET with a nominal VGS of 5V. The High-side gate driver has a programmable drive strength to drive external FET. An external capacitor and Schottky diode form a bootstrap network to collect and store the high voltage source ($V_{OUT} + \sim 5\text{ V}$ for HG2) needed to drive the high-side FET. The low side gate driver drives the low side external FET with a nominal VGS of 5 V using energy sourced from EZ-PD™ CCG7SCF internal LDO regulator and stored in the capacitor between PVDD and PGND. Low-side gate driver has programmable drive strength to drive external FET. In addition to drive strength, the high-side gate driver and the low-side gate driver have programmable options for deadtime control and zero-crossing levels. High-side gate driver and low-side gate driver blocks include zero-crossing detector (ZCD) to implement discontinuous-conduction mode (DCM) mode with diode emulation.

The gate drivers for the switching FETs function at their nominal drive voltage levels (5 V) provided the VIN voltage is between 4.5 V and 24 V.

1.3.3 Error amplifier (EA)

EZ-PD™ CCG7SCF buck-boost controller contains two error amplifiers for output voltage and current regulation. The error amplifier is a trans-conductance type amplifier with single compensation pin (COMP) to ground for both the voltage and current loops. In voltage regulation, the output voltage is compared with the internal reference voltage and the output of EA is fed to the PWM block. In current regulation, the average current is sensed by VBUS high side current sense amplifier through the external resistor. The output of the VBUS CSA is compared with an internal reference in error amplifier block and EA output is fed to the PWM block. EZ-PD™ CCG7SCF firmware configures and controls the integrated programmable error amplifier circuit for achieving the required VBUS voltage output from the power section.

1.3.4 Pulse width modulator (PWM)

EZ-PD™ CCG7SCF device family's PWM block generates the control signals for the gate drivers driving the external FETs in peak current mode control. There are many programmable options for minimum/maximum pulse width, minimum/maximum period, frequency and pulse skip levels to optimize the system design.

EZ-PD™ CCG7SCF devices have two firmware-selectable operating modes to optimize efficiency and reduce losses under light load conditions: pulse skipping mode (PSM) and forced continuous conduction mode (FCCM).

1.3.5 Pulse skipping mode (PSM)

In pulse skipping mode, the controller reduces the total number of switching pulses without reducing the active switching frequency by working in “bursts” of normal nominal-frequency switching interspersed with intervals without switching. The output voltage thus increases during a switching burst and decreases during a quiet interval. This mode results in minimal losses at the cost of higher output voltage ripple. When in this mode, EZ-PD™ CCG7SCF devices monitor the voltage across the buck or boost sync FET to detect when the inductor current reaches zero; when this occurs, the EZ-PD™ CCG7SCF devices switch off the buck or boost sync FET to prevent reverse current flow from the output capacitors (i.e. diode emulation mode). Several parameters of this mode are programmable through firmware, allowing the user to strike their own balance between light load efficiency and output ripple.

1.3.6 Forced continuous conduction mode (FCCM)

In Forced continuous conduction mode (FCCM), the nominal switching frequency is maintained at all times, with the inductor current going below zero (i.e. “backwards” or from the output to the input) for a portion of the switching cycle as necessary to maintain the output voltage and current. This keeps the output voltage ripple to a minimum at the cost of light-load efficiency.

1.3.7 Integrated Buck MOSFETs

Two power MOSFET are integrated in CCG7SCF. The PWM gate drive signals to these built-in buck MOSFETs are terminated internally, however SW1 termination and Bootstrap circuit needs to be added external to the CCG7SCF as shown in [Figure 1](#) Buck-boost schematic showing external components.

1.4 Buck-boost controller operation regions

The input-side CSA's output is compared with the output of the error amplifier to determine the pulse width of the PWM. PWM block compares the input voltage and output voltage to determine the buck, boost, and buck-boost regions. The switching time/period of the four gate drivers (HG2, LG2) depends upon the region in which the block is operating as well as the mode such as DCM or FCCM. The exact VIN vs VOUT thresholds for transitions into and out of each region are adjustable in firmware including the hysteresis.

1.4.1 Buck region operation (VIN >> VBUS)

When the VIN voltage is significantly higher than the required VBUS voltage, EZ-PD™ CCG7SCF devices operate in the buck region. In this region, the boost side FETs are inactivated, with the boost control FET (connected to LG2) turned off and the boost sync FET (connected to HG2) turned on. The buck side FETs are controlled as a buck converter with synchronous rectification as shown in [Figure 2](#).

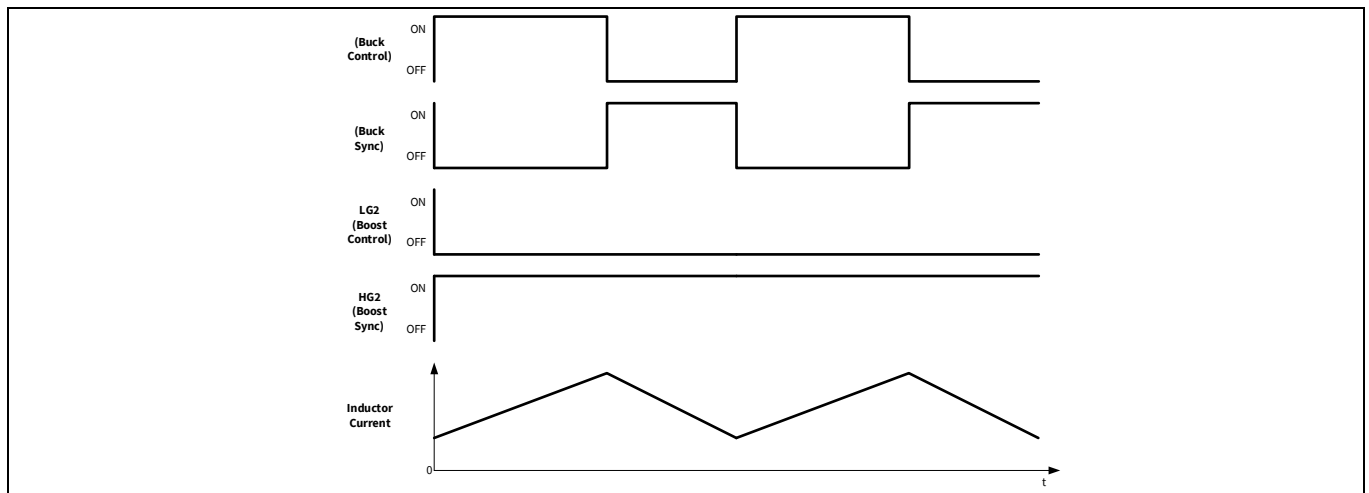


Figure 2 Buck operation waveforms

1.4.2 Boost region operation (VIN << VBUS)

When the VIN voltage is significantly lower than the required VBUS voltage, EZ-PD™ CCG7SCF devices operate in the boost region. In this region, the buck side FETs are inactivated, with the sync FET turned off and the buck control FET turned on. The boost side FETs are controlled as a boost converter with synchronous rectification as shown in [Figure 3](#).

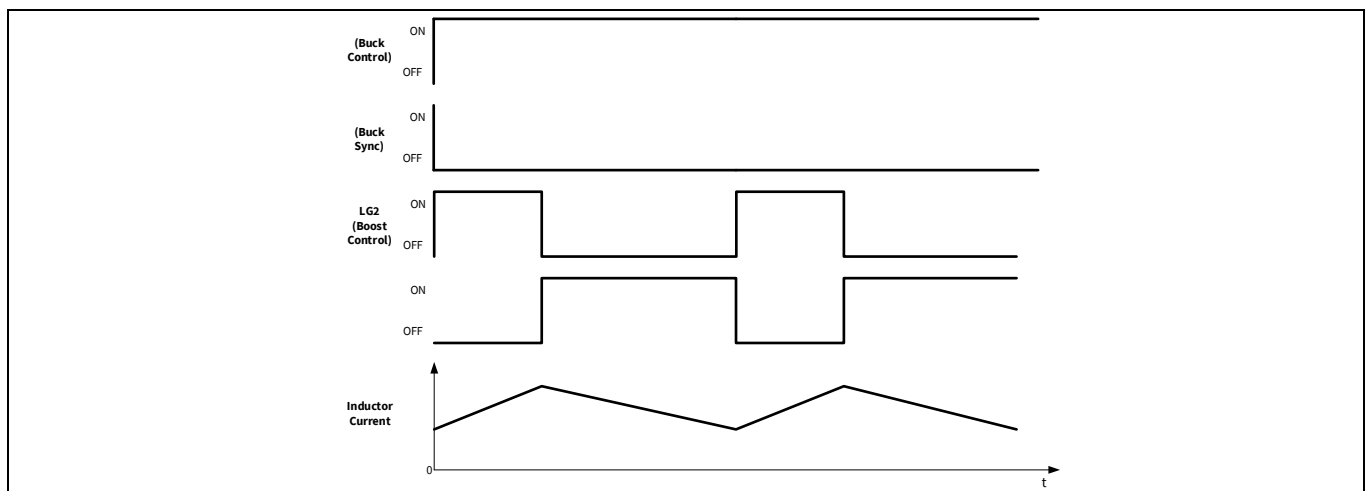


Figure 3 Boost operation waveforms

1.4.3 Buck-boost region 1 operation ($V_{IN} \sim V_{BUS}$)

When the V_{IN} voltage is slightly higher than the required V_{BUS} voltage, EZ-PD™ CCG7SCF devices operate in the buck-boost region 1. In this region, the boost side works at a fixed 20% duty cycle (programmable) while the buck side duty cycle is modulated to control the output voltage. All four FETs are switching every cycle in this operating region as shown in [Figure 4](#).

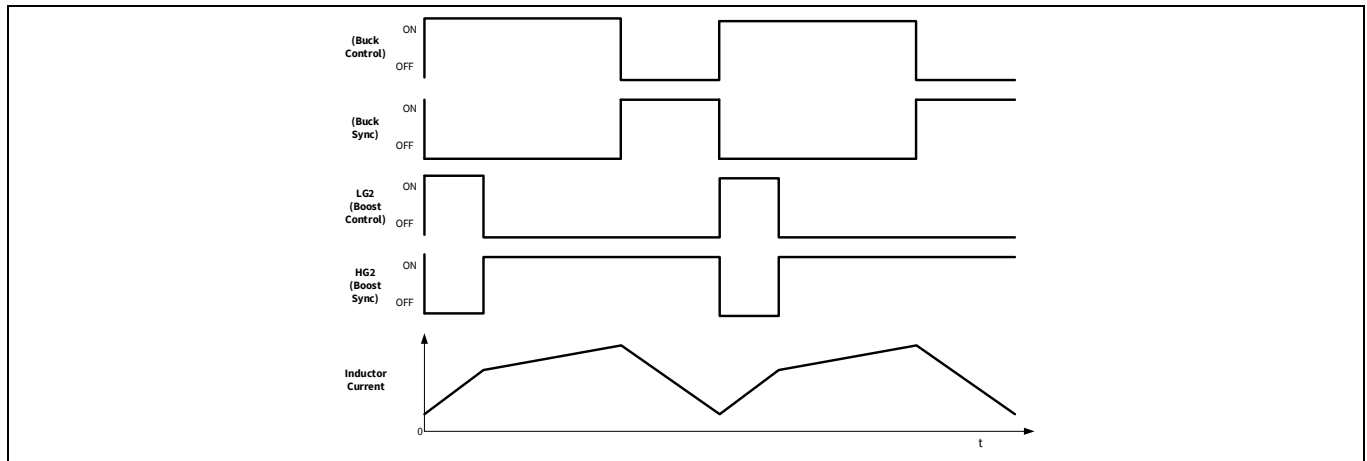


Figure 4 Buck-boost region 1 ($V_{IN} \sim V_{BUS}$) operation waveforms

1.4.4 Buck-boost region 2 operation ($V_{IN} \sim V_{BUS}$)

When the V_{IN} voltage is slightly lower than the required V_{BUS} voltage, EZ-PD™ CCG7SCF devices operate in the buck-boost region 2. In this region, the buck side works at a fixed 80% duty cycle (programmable) while the boost side (LG2) duty cycle is modulated to control the output voltage. All four FETs are switching every cycle in this operating region as shown in [Figure 5](#).

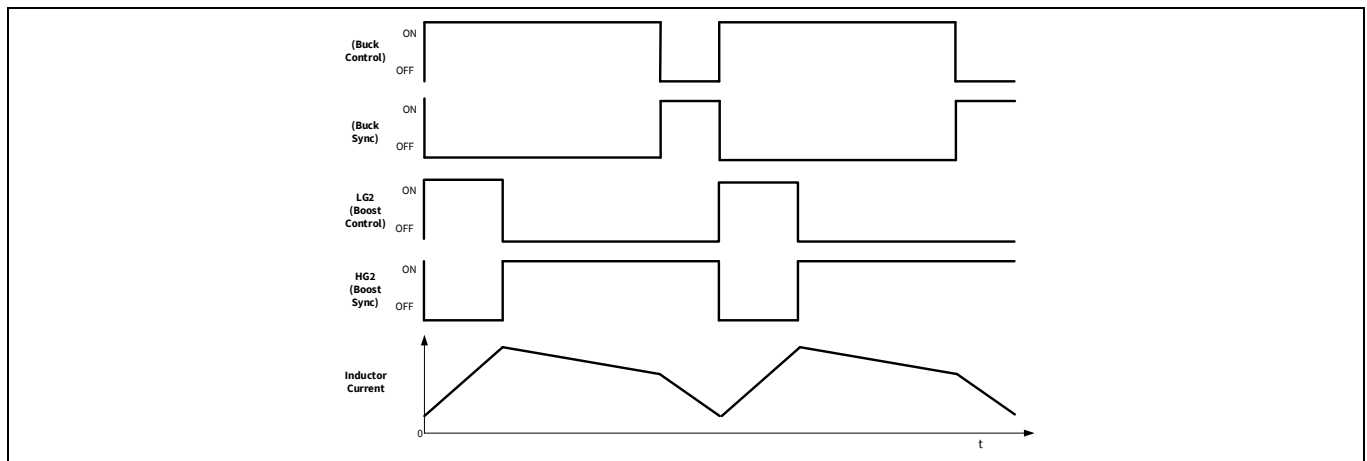


Figure 5 Buck-boost region 2 ($V_{IN} \sim V_{BUS}$) operation waveforms

1.4.5 Switching frequency and spread spectrum

EZ-PD™ CCG7SCF devices offer programmable switching frequency between 150 kHz and 600 kHz. The controller supports spread spectrum clocking within the operating frequency range in all operating modes. Spread spectrum is essential for charging applications to meet EMC/EMI requirements by spreading emissions caused by switching over a wide spectrum instead of a fixed frequency, thereby reducing the peak energy at any particular frequency. Both the switching frequency and the spread spectrum span are firmware programmable.

1.5 Analog blocks

1.5.1 ADC

EZ-PD™ CCG7SCF devices have two 8-bit SAR ADCs for general purpose A-D conversion applications in the chip. The ADCs can be accessed from the GPIOs through an on-chip analog mux. See [Table 27](#) for detailed specs on the ADCs.

1.6 Integrated digital blocks

1.6.1 Serial communication block (SCB)

EZ-PD™ CCG7SCF devices have three SCB blocks that can be configured for I²C, SPI, UART or LIN. These blocks implement full multi-master and slave I²C interfaces capable of multi-master arbitration. This I²C implementation is compliant with the standard Philips I²C specification v3.0. These blocks operate at speeds of up to 1 Mbps and have flexible buffering options to reduce interrupt overhead and latency for the CPU. The SCB blocks support 8-byte deep FIFOs for receive and transmit, which, by increasing the time given for the CPU to read data, greatly reduces the need for clock stretching caused by the CPU not having read data on time. The I²C port I/Os for SCB0 are overvoltage tolerant (OVT). The I²C ports for SCB1-2 are not OVT tolerant.

1.6.2 Timer, counter, pulse-width modulator (TCPWM)

The TCPWM block of EZ-PD™ CCG7SCF devices support eight timers or counters or pulse-width modulators. These timers are available for internal timer use by firmware or for providing PWM-based functions on the GPIOs.

1.7 I/O subsystem

The EZ-PD™ CCG7SCF devices have 13 GPIOs including the I²C and SWD pins which can also be used as GPIOs. The GPIO block implements the following:

- Eight output drive modes
 - Input only
 - Weak pull-up with strong pull-down
 - Strong pull-up with weak pull-down
 - Open drain with strong pull-down
 - Open drain with strong pull-up
 - Strong pull-up with strong pull-down
 - Disabled
 - Weak pull-up with weak pull-down
- Input threshold select (CMOS or LVTTTL)
- Individual control of input and output disables
- Hold mode for latching previous state (used for retaining I/O state in deep sleep mode)
- Selectable slew rates for dV/dt related noise control.
- Overvoltage tolerance (OVT) on one pair of GPIOs

During power-on and reset, the blocks are forced to the disable state so as not to crowbar any inputs and/or cause excess turn-on current. A multiplexing network known as a high-speed I/O matrix (HSIOM) is used to multiplex between various signals that may connect to an I/O pin. Pin locations for fixed-function peripherals such as USB Type-C port are also fixed in order to reduce internal multiplexing complexity. Data output registers and pin state register store, respectively, the values to be driven on the pins and the states of the pins themselves.

The configuration of the pins can be done by the programming of registers through software for each digital I/O port. Every I/O pin can generate an interrupt if so enabled and each I/O port has an interrupt request (IRQ) and interrupt service routine (ISR) vector associated with it.

The I/O ports can retain their state during deep sleep mode or remain ON. If the operation is restored using reset, then the pins shall go the high-Z state. If operation is restored by an interrupt event, then the pin drivers shall retain their state until firmware chooses to change it. The IOs (on data bus) do not draw current on power down.

1.8 System resources

1.8.1 Watchdog timer

EZ-PD™ CCG7SCF devices have a watchdog timer running from the internal low-speed oscillator (ILO). This allows Watchdog operation during Deep sleep and generate a watchdog reset if not serviced before the timeout occurs. The watchdog reset is recorded in the reset cause register.

1.8.2 Reset

EZ-PD™ CCG7SCF devices can be reset from a variety of sources including a software reset. Reset events are asynchronous and guarantee reversion to a known state. The reset cause is recorded in a register, which is preserved through reset and allows application firmware to determine the cause of the reset. XRES pin is the dedicated pin for asserting an external hardware reset.

1.8.3 Clock system

EZ-PD™ CCG7SCF devices have a fully integrated clock with no external crystal required. EZ-PD™ CCG7SCF device's clock system is responsible for providing clocks to all sub-systems that require clocks (SCB and PD) and for switching between different clock sources.

The HFCLK signal can be divided down as shown to generate synchronous clocks for the digital peripherals. The clock dividers have 8-bit, 16-bit and 16-bit fractional divide capability. The 16-bit capability allows a lot of flexibility in generating fine-grained frequency values. The clock dividers generate either enabled clocks (that is, 1 in N clocking where N is the divisor) or an approximately 50% duty cycle clock (exactly 50% for even divisors, one clock difference in the high and low values for odd divisors).

In [Figure 6](#), PERXYZ_CLK represents the clocks for different peripherals.

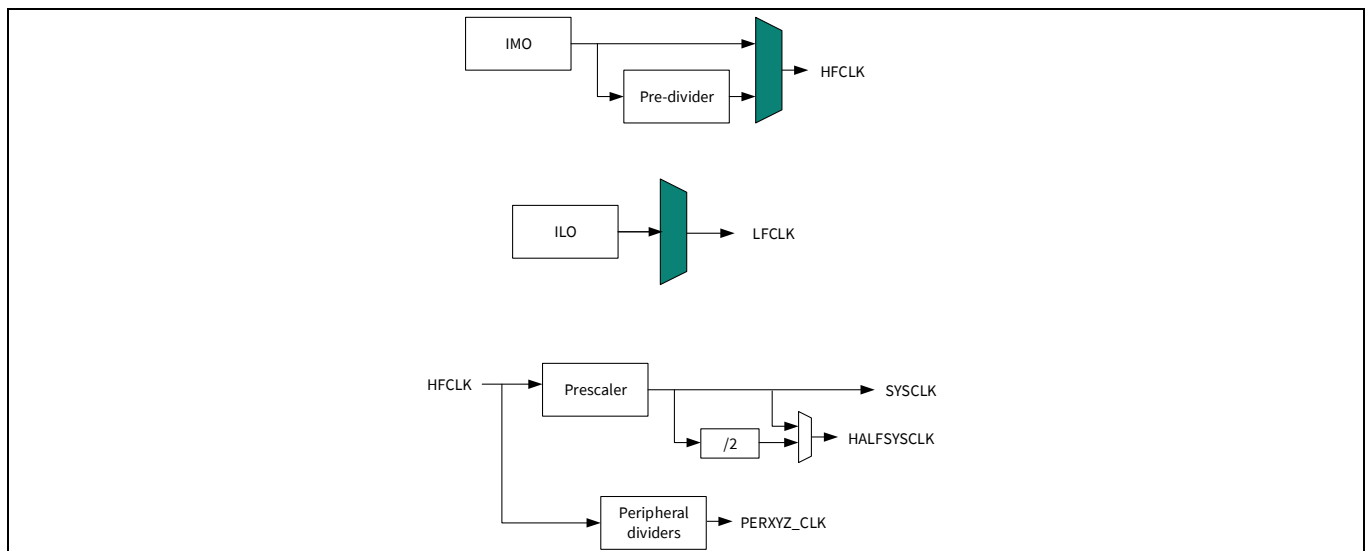


Figure 6 Clocking architecture of EZ-PD™ CCG7SCF devices

1.8.4 IMO clock source

The internal main oscillator is the primary source of internal clocking in EZ-PD™ CCG7SCF devices. IMO default frequency for EZ-PD™ CCG7SCF devices is 48 MHz $\pm$ 2%.

1.8.5 ILO clock source

The internal low-power oscillator is a very low power, relatively inaccurate, oscillator, which is primarily used to generate clocks for peripheral operation in USB suspend (deep sleep) mode.

2 Power subsystem

Figure 7 shows an overview of the power subsystem architecture for EZ-PD™ CCG7SCF devices. The power subsystem of EZ-PD™ CCG7SCF devices operate from VIN supply which can vary from 4 V to 24 V. The VDDD pin, the output of an internal 5V LDO, gets input from VIN supply. The current capability of the VDDD pin is up to 75 mA including internal as well as external loads. EZ-PD™ CCG7SCF devices have two different power modes: Active and Deep sleep, transitions between which are managed by the power system. The VCCD pin, the output of the core (1.8 V) regulator, is brought out for connecting a 0.1-μF capacitor for the regulator stability only. This pin is not supported as a power supply for external load.

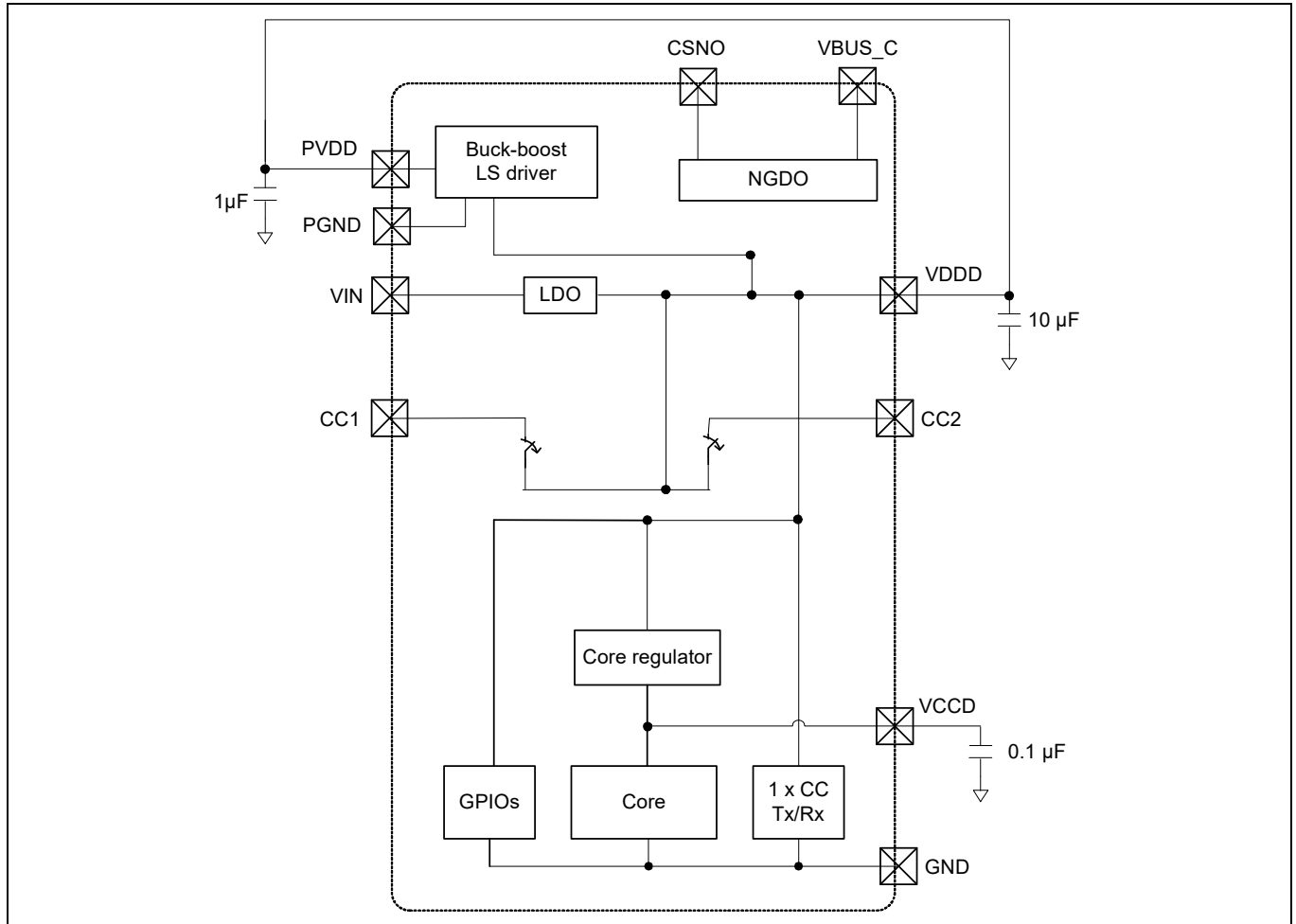


Figure 7 Power system requirement block diagram

2.1 VIN under-voltage lockout (UVLO)

EZ-PD™ CCG7SCF supports UVLO to allow the device to shut down when the input voltage is below the reliable level. It guarantees predictable behavior when the device is up and running.

2.2 Using external VDDD supply

By default, external VDDD is not supported for EZ-PD™ CCG7SCF devices. However, usage of external VDDD supply can be enabled using firmware. The prerequisite for enabling external forcing of VDDD is to always maintain VIN higher than VDDD.

2.3 Power modes

The Power modes of the device accessible and observable by the user are listed in [Table 1](#).

Table 1 **Power modes**

Mode	Description
RESET	Power is valid and XRES is not asserted. An internal reset source is asserted or Sleep controller is sequencing the system out of reset
ACTIVE	Power is valid and CPU is executing instructions.
SLEEP	Power is valid and CPU is not executing instructions. All logic that is not operating is clock gated to save power.
DEEP SLEEP	Main regulator and most hard-IP are shut off. Deep sleep regulator powers logic, but only low-frequency clock is available.
XRES	Power is valid and XRES is asserted. Core is powered down.

3 Pin list

Table 2 39-LGA package pinout

Pin no.	Pin name	Absolute minimum (V)	Absolute maximum (V)	Description
1	NC	–	–	Floating, do not connect
2	SW1	–0.7	35	Negative power rail of the buck high side gate driver. This is also connected to one input terminal of zero current detection of buck low side gate driver. Connect to the switch node (inductor) on the buck (input) side. Use a short and wide trace to minimize the inductance and resistance of this connection.
3	NC	–	–	Floating, do not connect
4	PVDD	–	VDDD	Supply of low side gate driver. Connect to VDDD. Use 1 μ F and 0.1 μ F bypass capacitors as close to the EZ-PD™ CCG7SCF IC as possible.
5	LG2	–0.5	PVDD + 0.5 ^[1]	Boost low side gate driver output. Connect to the boost (output) side control (low side) FET gate. Use a wide trace to minimize inductance of this connection.
6	VOUT	–0.3	24	Output of the Buck-boost converter. This is also connected to one input terminal of reverse current protection of Boost high side gate driver. Connect to the boost sync (high side) FET's drain. Use a dedicated (Kelvin) trace for this connection.
7	SW2	–0.3	24	Negative power rail of the boost high side gate driver. This is also connected to one input terminal of reverse current protection of boost high side gate driver. Connect to the switch node (inductor) on the boost (output) side. Use a short and wide trace to minimize the inductance and resistance of this connection.
8	HG2	–0.5	VOUT + PVDD + 0.5 ^[2]	Boost high side gate driver output. Connect to the boost (output) side sync (high side) FET gate. Use a wide trace to minimize inductance of this connection.

Notes

1. Max voltage must not exceed 6 V.
2. Max absolute voltage wrt GND must not exceed 40 V.

Table 2 39-LGA package pinout (continued)

Pin no.	Pin name	Absolute minimum (V)	Absolute maximum (V)	Description
9	BST2	–	PVDD + 0.5 ^[1]	Boosted power supply of the boost high side gate driver. Bootstrap capacitor node. Connect Schottky diode from VDDD to BST2. Also, connect a bootstrap capacitor from this pin to SW2.
10	VBUS_CTRL	–0.5	32	VBUS NFET gate driver output. Connect to the provider NFET's gate.
11	COMP	–0.5	PVDD + 0.5 ^[1]	Error amplifier output pin. Connect a compensation network to GND. Contact Infineon® for assistance in designing the compensation network.
12	VBUS_C	–0.3	24	Type-C connector VBUS voltage. Connect to the Type-C connector's VBUS pin.
13	CSPO	–0.3	24	Positive input of output current sensing amplifier. Connect to positive terminal of the output current sense resistor.
14	CSNO	–0.3	24	Negative input of output current sensing amplifier. Connect to negative terminal of the output current sense resistor.
15	CC2	–0.5	24	Type-C connector configuration channel 2. Connect directly to the CC2 pin on the port's Type-C connector. Also connect a 390-pF capacitor to ground.
16	CC1	–0.5	24	Type-C connector configuration channel 1. Connect directly to the CC2 pin on the port's Type-C connector. Also connect a 390-pF capacitor to ground.
17	DP_GPIO0	–0.5	PVDD + 0.5 ^[1]	USB D+/GPIO: D+ for implementing BC 1.2, AFC, QC or Apple charging. EZ-PD™ CCG7S does not support USB data transmission on this pin.
18	DM_GPIO1	–0.5	PVDD + 0.5 ^[1]	USB D+/GPIO: D– for implementing BC 1.2, AFC, QC or Apple charging. EZ-PD™ CCG7S does not support USB data transmission on this pin.
19	VDDD	–	6	5-V LDO output. Connect a 1-μF ceramic bypass capacitor to this pin.

Notes

1. Max voltage must not exceed 6 V.
2. Max absolute voltage wrt GND must not exceed 40 V.

Table 2 39-LGA package pinout (continued)

Pin no.	Pin name	Absolute minimum (V)	Absolute maximum (V)	Description
20	CSP_GPIO2	-0.5	PVDD + 0.5 ^[1]	GPIO/positive input terminal of VBAT – GND protection circuit. Connect to the positive terminal of the VBAT – GND short protection current sense resistor.
21	CSN_GPIO3	-0.5	PVDD + 0.5 ^[1]	GPIO/negative input terminal of VBAT – GND protection circuit/hot plug detect. Connect to the negative terminal of the VBAT – GND short protection current sense resistor. For single-ended current sensing, this pin need not be connected to the current sense resistor. For applications supporting DisplayPort (for example, Rear seat entertainment (RSE)), this is the Hotplug Detect output pin.
22	GPIO4	-0.5	PVDD + 0.5 ^[1]	GPIO
23	CGND	-0.3	0.5	CC block ground. Connect to the exposed pad (EPAD).
24	GPIO5	-0.5	PVDD + 0.5 ^[1]	GPIO
25	GPIO6	-0.5	PVDD + 0.5 ^[1]	GPIO
26	GPIO7	-0.5	PVDD + 0.5 ^[1]	GPIO/SWD programming and debug clock signal
27	GPIO8	-0.5	PVDD + 0.5 ^[1]	GPIO/SWD programming and debug data signal
28	GPIO9	-0.5	PVDD + 0.5 ^[1]	GPIO
29	GPIO10	-0.5	PVDD + 0.5 ^[1]	GPIO
30	XRES	-0.5	PVDD + 0.5 ^[1]	External reset – active low. Contains a 3.5-kΩ to 8.5-kΩ internal pull-up.
31	GPIO11	-0.5	PVDD + 0.5 ^[1]	GPIO
32	GPIO12	-0.5	PVDD + 0.5 ^[1]	GPIO
33	VDDD	–	6	5-V LDO output. Connect a 10-μF bypass capacitor to this pin.
34	VCCD	–	–	1.8-V core LDO output. Connect a 0.1-μF bypass capacitor to ground. Do not connect anything else to this pin.
35	VIN	-0.3	40	4V–24V input supply. Connect a ceramic bypass capacitor to GND close to this pin.

Notes

1. Max voltage must not exceed 6 V.
2. Max absolute voltage wrt GND must not exceed 40 V.

Pin list

Table 2 39-LGA package pinout (continued)

Pin no.	Pin name	Absolute minimum (V)	Absolute maximum (V)	Description
36	CSPI	-0.3	40	Positive input of input current sense amplifier. Connect to the positive terminal of the input current sense resistor. Use a dedicated (Kelvin) connection.
37	CSNI	-0.3	40	Negative input of Input current sense amplifier. Connect to the negative terminal of the input current sense resistor. Use a dedicated (Kelvin) connection.
38	BST1	-	PVDD + 0.5 ^[1, 2]	Boosted power supply of the buck high side gate driver. Bootstrap capacitor node. Connect Schottky diode from VDDD to BST1. Also, connect a bootstrap capacitor from this pin to SW1.
39	PGND	-0.3	0.3	Ground of low side gate driver. This is also connected to one input terminal of zero current detection of buck low side gate driver. Connect directly to the port's board ground plane.
EPAD P1	LGFET_DRAIN	-	40	Exposed drain of LG1FET
EPAD P2	HGFET_DRAIN	-	40	Exposed drain of HG1FET

Notes

1. Max voltage must not exceed 6 V.
2. Max absolute voltage wrt GND must not exceed 40 V.

Pin list

Table 3 GPIO ports, pins, and their functionality

39-LGA		SCB function			TCPWM		
Pin #	GPIO #	UART	SPI	I2C	ACT#0	ACT#1	ACT#3
17	DP_GPIO0	–	–	–	–	–	–
18	DM_GPIO1	–	–	–	–	–	–
20	CSP_GPIO2	–	–	–	tcpwm0_line	tcpwm.tr_compare_match[0]:0	tcpwm.tr_in[0]
21	CSN_GPIO3	–	–	–	tcpwm.line[1]:0	tcpwm.tr_compare_match[1]:0	tcpwm.tr_in[1]
22	GPIO4	–	–	–	tcpwm.line[2]:0	tcpwm.tr_compare_match[2]:0	tcpwm.tr_in[2]
24	GPIO5	scb[1].uart_rts:0	scb[1].spi_select0:0	–	tcpwm.line[7]:0	tcpwm.tr_compare_match[7]:0	tcpwm.tr_in[7]
25	GPIO6	scb[1].uart_rx:0	scb[1].spi_clk:0	scb[1].i2c_scl:0	tcpwm.line[6]:0	tcpwm.tr_compare_match[6]:0	–
26	GPIO7	scb[1].uart_tx:0	scb[1].spi_miso:0	scb[1].i2c_sda:0	tcpwm.line[5]:0	tcpwm.tr_compare_match[5]:0	–
27	GPIO8	scb[0].uart_rts:0	scb[0].spi_select0:0	scb[2].i2c_scl:0	tcpwm.line[4]:0	tcpwm.tr_compare_match[4]:0	–
28	GPIO9	scb[0].uart_cts:0	scb[0].spi_mosi:0	scb[2].i2c_sda:0	tcpwm.line[3]:0	tcpwm.tr_compare_match[3]:0	–
29	GPIO10	scb[1].uart_cts:0	scb[0].spi_miso:0	–	–	–	tcpwm.tr_in[6]
31	GPIO11	scb[0].uart_tx:0	scb[1].spi_mosi:0	scb[0].i2c_sda:0	–	–	–
32	GPIO12	scb[0].uart_rx:0	scb[0].spi_clk:0	scb[0].i2c_scl:0	srss.ext_clk:0	–	–

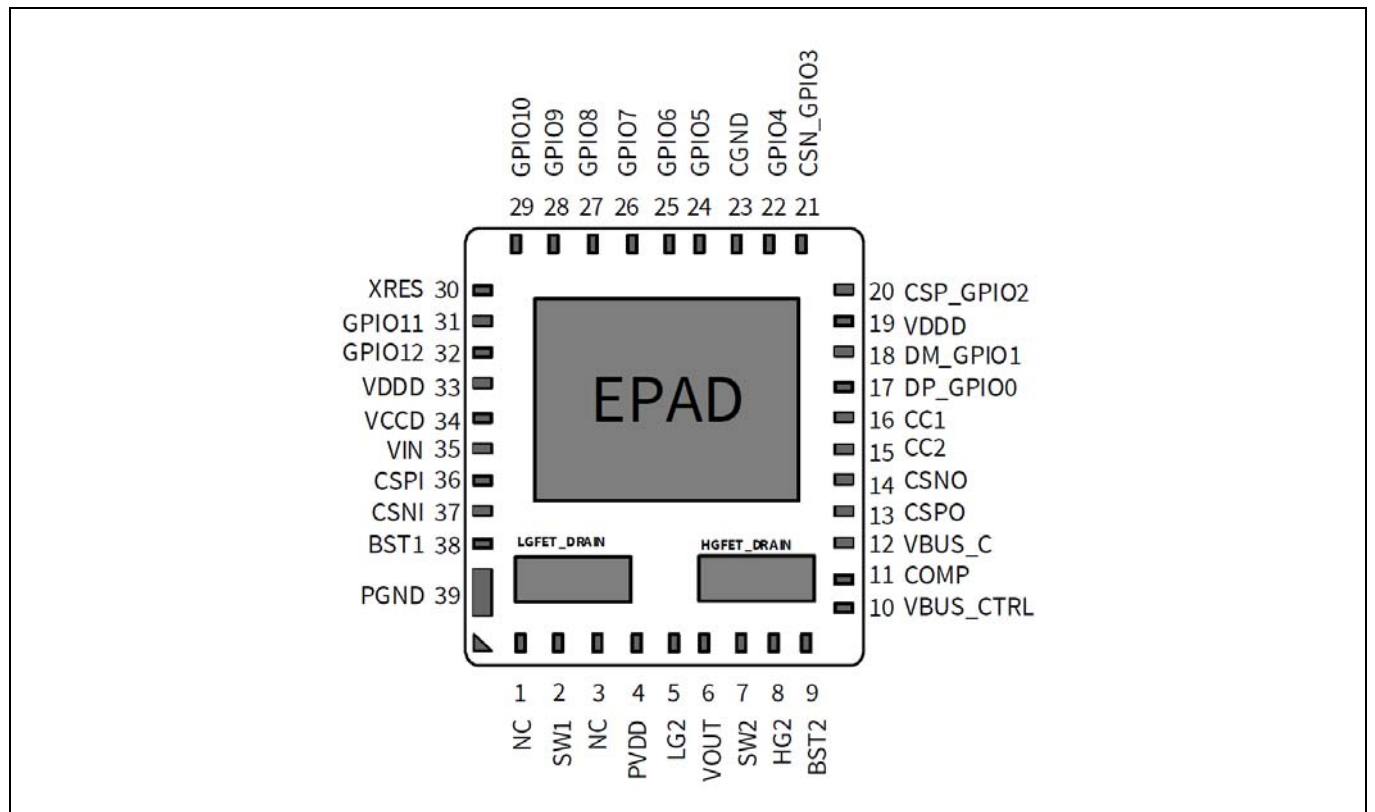


Figure 8 EZ-PD™ CCG7SCF 39-lead LGA pinout

4 EZ-PD™ CCG7SCF programming and bootloading

There are two ways to program application firmware into a EZ-PD™ CCG7SCF device:

1. Programming the device flash over SWD Interface
2. Application firmware update over specific interfaces (CC, I2C)

Generally, the EZ-PD™ CCG7SCF devices are programmed over SWD interface only during development or during the manufacturing process of the end-product. Once the end-product is manufactured, the EZ-PD™ CCG7SCF device's application firmware can be updated via the appropriate bootloader interface. By default, the EZ-PD™ CCG7SCF devices ship with a combined I2C/CC bootloader. Infineon strongly recommends customers to use the [EZ-PD™ configuration utility](#) to turn off the application FW update over CC (consumer and dock applications) and I2C interface (consumer application) into EZ-PD™ CCG7SCF's flash before mass production. For dock application I2C interface can be used to update the firmware using the Dock Management Controller (DMC). This prevents unauthorized firmware from being updated over CC interface in the field. If you desire to retain the application firmware update over CC/ I2C interfaces feature post-production for on-field firmware updates, contact [Infineon Sales](#) for further guidelines.

4.1 Programming the device flash over SWD interface

The EZ-PD™ CCG7SCF family of devices can be programmed using the SWD interface. Infineon provides programming hardware called [CY8CKIT-005 MiniProg4 Kit](#), which can be used to program the flash as well as debug firmware. The flash is programmed by downloading the information from a hex file.

As shown in the block diagram (see [Figure 9](#)), the SWD_DAT and SWD_CLK pins are connected to the host programmer's SWDIO (data) and SWDCLK (clock) pins respectively. During SWD programming, the device can be powered by the host programmer by connecting its VTARG (power supply to the target device) to VDDD pins of EZ-PD™ CCG7SCF device. If the EZ-PD™ CCG7SCF device is powered using an on-board power supply, it can be programmed using the "reset programming" option. For more details, refer the [CCGx \(CYPDxxxx\) programming specifications](#).

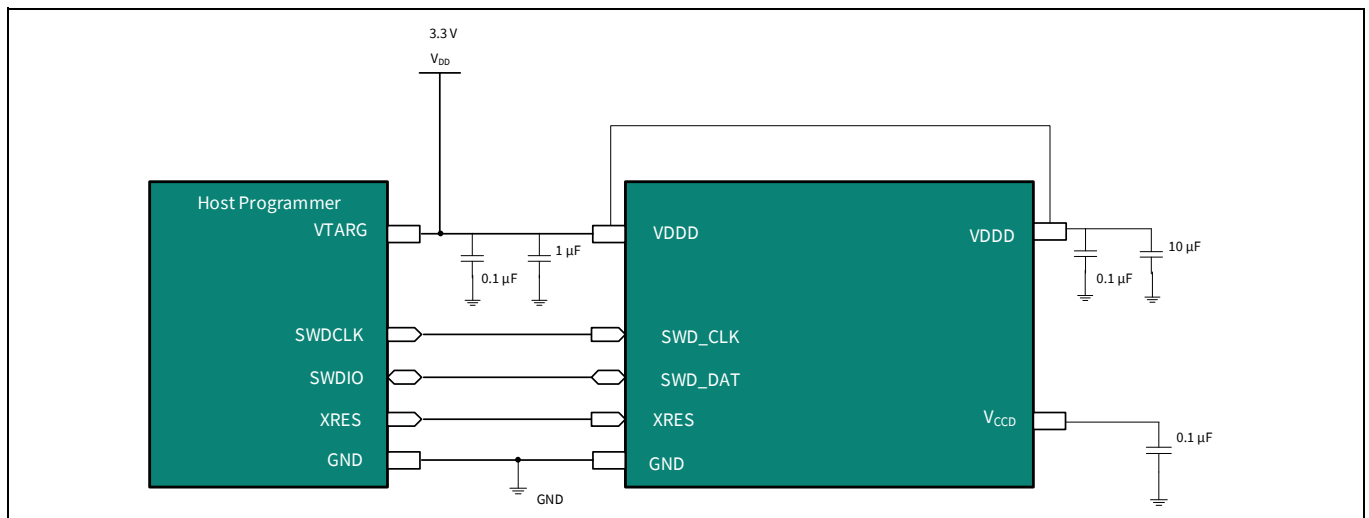


Figure 9 Connecting the programmer to CYPD7XXX device

4.2 Application firmware update using Bootloader

The CCG7SCF silicon ships with the CC bootloader programmed at the factory. VBUS_CTRL pin in the bootloader is disabled by default therefore the default bootloader cannot be used for designs with Provider FET.

4.2.1 Application firmware update over CC interface

For boot loading CCG7SCF applications over the CC interface, the [CY4532 EVK](#) or [CCPROG PAT: USB-C Power Adapter Programmer and Tester](#) can be used to send programming and configuration data as Infineon specific vendor defined messages (VDMs) over the CC line. The CY4532 EVK's power board or PAT tester is connected to the system containing CCG7SCF device on one end and a Windows PC running the [EZ-PD™ Configuration Utility](#) as shown in [Figure 10](#) on the other end to boot load the CCG7SCF device.

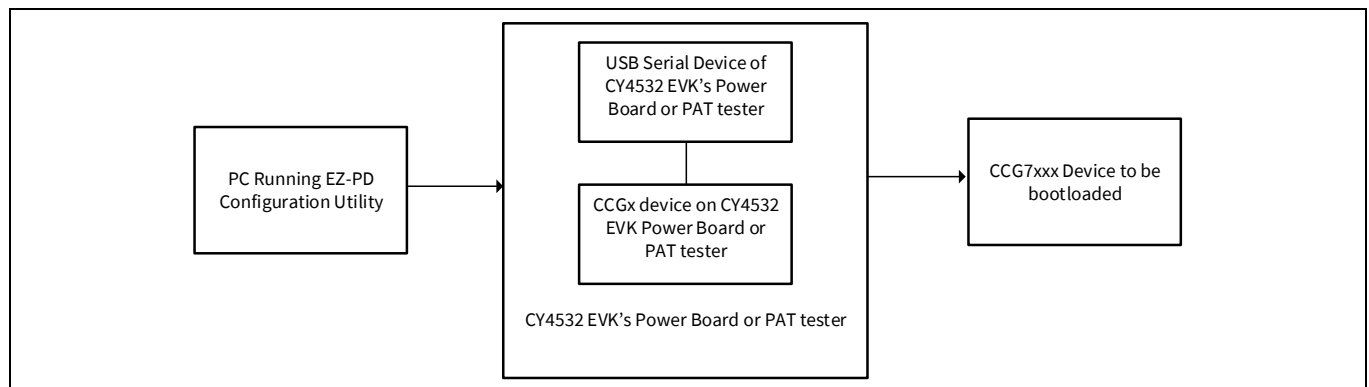


Figure 10 Application firmware update over CC interface

Application firmware (FW) update feature over CC interface is intended for use during development and manufacturing. Infineon strongly recommends customers to use the EZ-PD™ Configuration Utility to turn off the application FW update over CC interface in the firmware that is updated into CCG7SCF's flash before mass production. This prevents unauthorized firmware from being updated over CC-interface in the field. Refer to the knowledge base article [KBA230192](#) on how to configure this in EZ-PD™ Configuration Utility. If you desire to retain the application firmware update over CC interface feature post-production for on-field firmware updates, contact [Infineon support](#) for further guidelines on how to use authenticated CC bootloader.

4.2.2 Application firmware update over I2C interface

The default bootloader supports both CC and I2C interface. For boot loading CCG7SCF applications over the I2C interface, any host processor can implement the legacy boot commands. Contact [Infineon support](#) for further details regarding the host processor implementation.

The connections between the host processor and CCG7SCF for the bootloading via I2C interface is shown in [Figure 11](#).

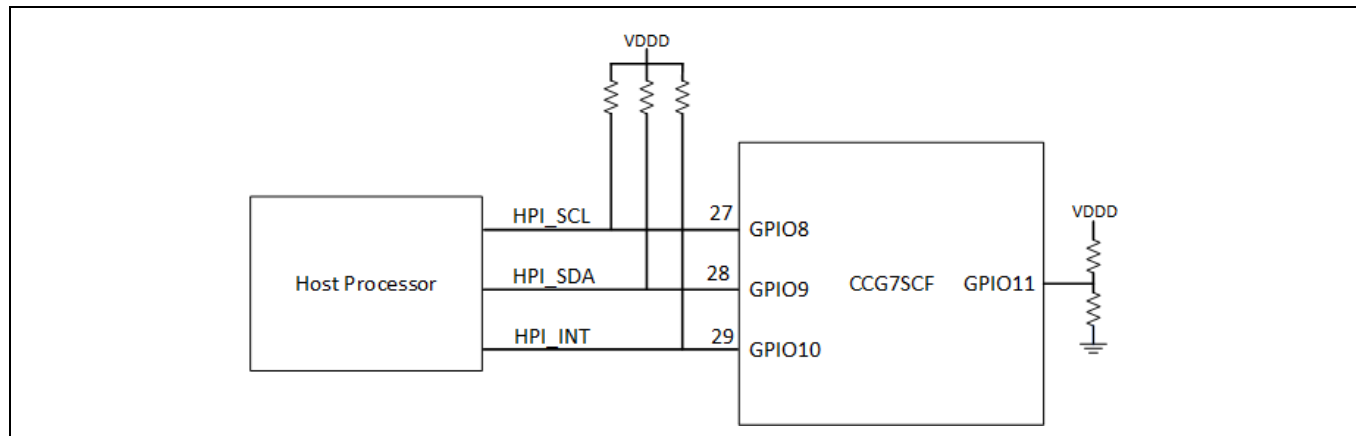


Figure 11 GPIO mapping for the application firmware update over I2C interface

Table 4 HPI_I2C Address Configuration

GPIO11	HPI_I2C Address
Floating	0x08
Pulled up to VDDD with a 2.2K resistor	0x42
Pulled down to GND with a 2.2K resistor	0x40

5 Applications

Figure 12 illustrates a single-port cigarette lighter adapter (CLA) application block diagram using EZ-PD™ CCG7SCF. CLA is powered by the car battery and is used for charging the mobile/tablet/notebook. In this application, CCG7SCF will always be in DFP role supporting the charging of the device. It negotiates the power with the connected device and uses the integrated buck-boost controller to supply the required voltage and current.

The DP/DM lines of the Type-C receptacles are connected to CCG7SCF to support legacy charging protocols such as QC3.0, Samsung AFC, Apple 2.4A charging, BC v1.2, and so on. When no load is connected to the USB Type-C port, CCG7SCF remains in Standby mode without switching on the buck-boost controller.

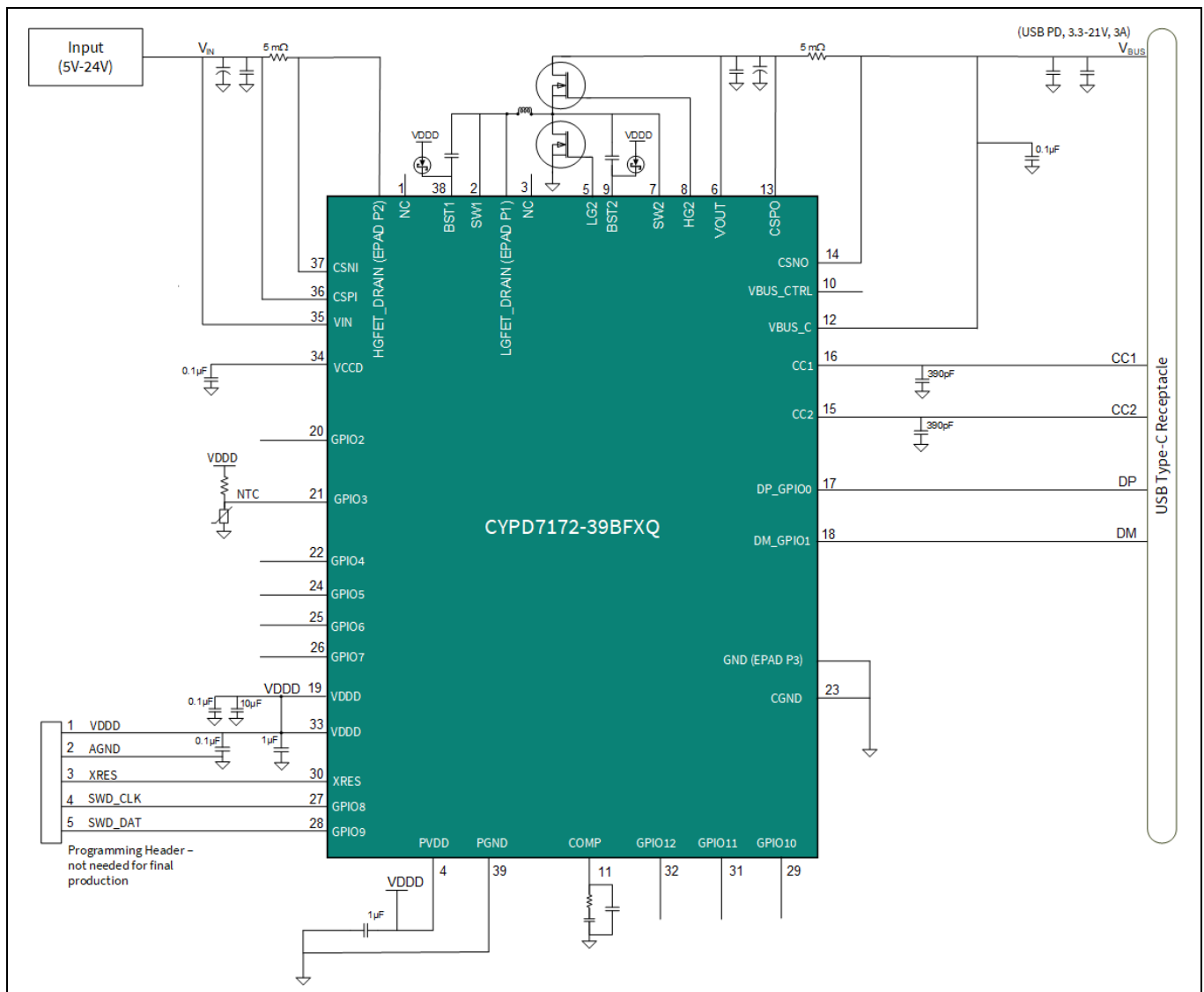


Figure 12 EZ-PD™ CCG7SCF CLA applications diagram

Figure 13 shows a buck only mode application block diagram using CCG7SCF. This application uses the integrated buck controller to supply the required voltage and current to the connected device. This application is identical to the CLA application, except that this application uses only buck topology when compared to the

Applications

buck-boost topology in the CLA application. In a buck application, the negotiated voltage should always be lower than the input voltage.

If the input voltage drops lower than the output voltage, then the output voltage will not be maintained and the port will shut down. This application can also be configured to support the legacy charging protocols – BC1.2 DCP, Qualcomm QC2.0/3.0, Apple charging, and Samsung AFC.

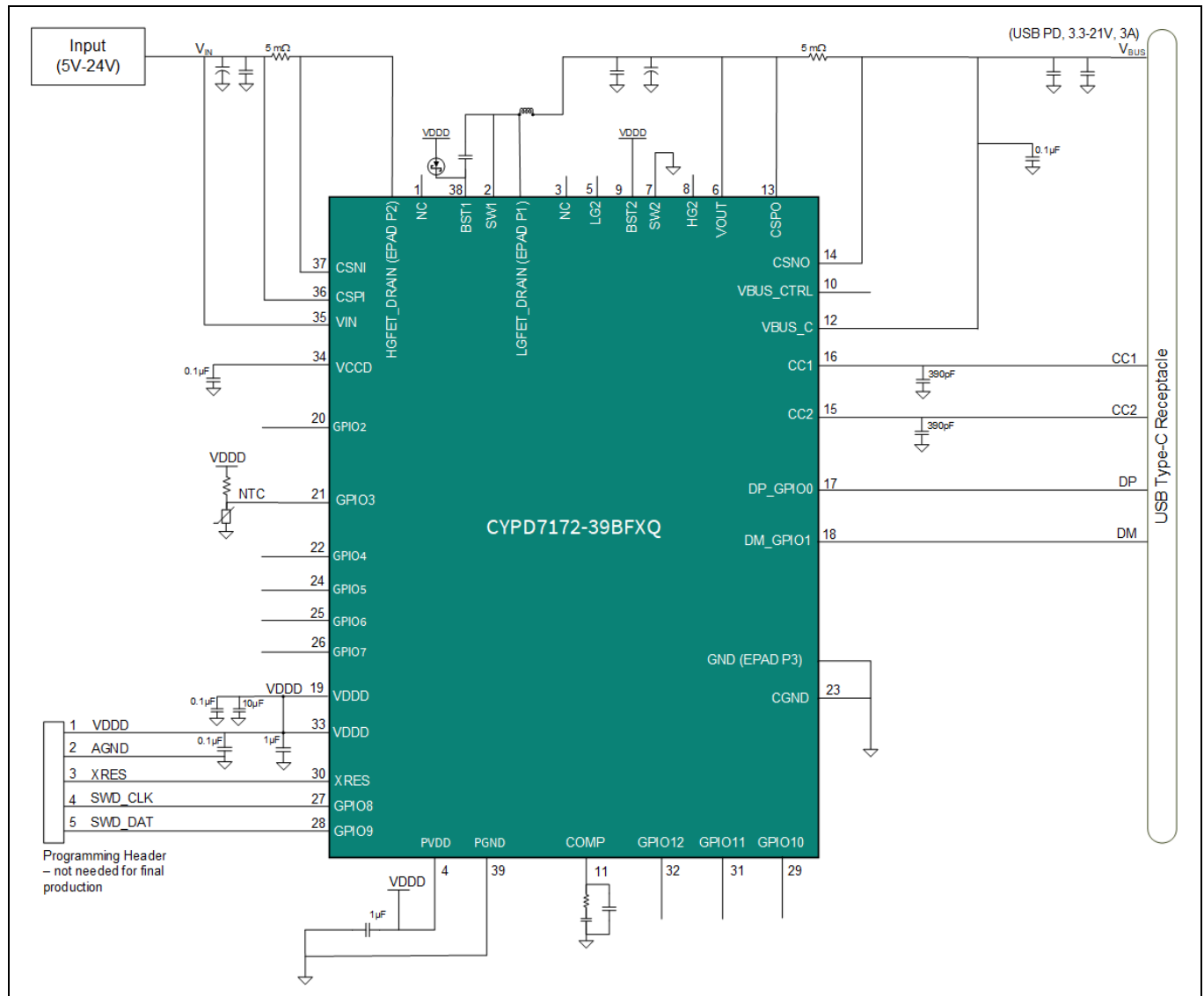


Figure 13 EZ-PD™ CCG7SCF charger and adapter application diagram - Step-down (buck) DCDC converter only

Applications

The USB-PD multi (3)-port charger and adapter solution for AC-DC power application can be achieved with three individual CCG7SCF controllers. **Figure 14** illustrates USB-PD multi (3)-port charger and adapter solution for AC-DC power application block diagram using EZ-PD™ CCG7SCF. Here three CCG7SCF controllers will support to provide required voltage current for three ports.

The front-end AC-DC converter has the capability to produce the requested output voltage and the buck converter ensures that the defined **USB Power Delivery specification** and performance are met for multiport adapter applications.

In this application, CCG7SCF will always be in DFP role supporting the charging of the device. It negotiates the power with the connected device and uses the integrated buck controller to supply the required voltage and current.

The DP/DM lines of the Type-C receptacles are connected to CCG7SCF to support legacy charging protocols such as QC3.0, Samsung AFC, Apple 2.4A charging, BC v1.2, and so on. When no load is connected to the USB Type-C port, CCG7DC remains in Standby mode without switching the buck converter.

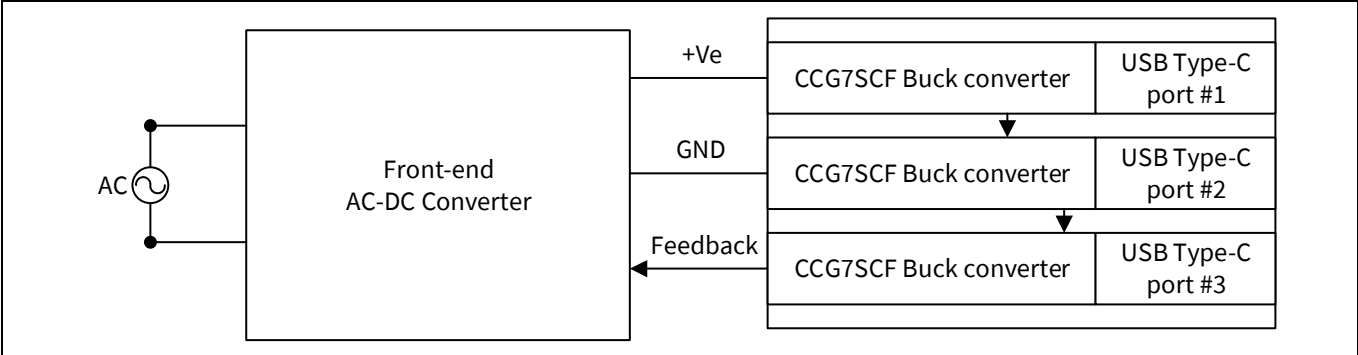


Figure 14 CCG7SCF-based 3 port charger and adapter solution

Applications

Figure 15 shows a buck only mode dock application block diagram using CCG7SCF. This application uses the integrated buck controller to supply the required voltage and current to the connected device. This is identical to the CLA application, except that this uses only buck topology when compared to the buck-boost topology in the CLA application. In a buck topology, the negotiated voltage should always be lower than the input voltage. If the input voltage drops lower than the output voltage, then the output voltage will not be maintained and the port will shut down.

In dock application, CCG7SCF's firmware can be updated using the HPI I2C and the slave address of the HPI_I2C can be configured using GPIO11 (Refer section 4.2.2.2). USB mux that is used to switch the USB3.0 lines can also be controlled using GPIOs (MUX_EN and MUX_CTRL).

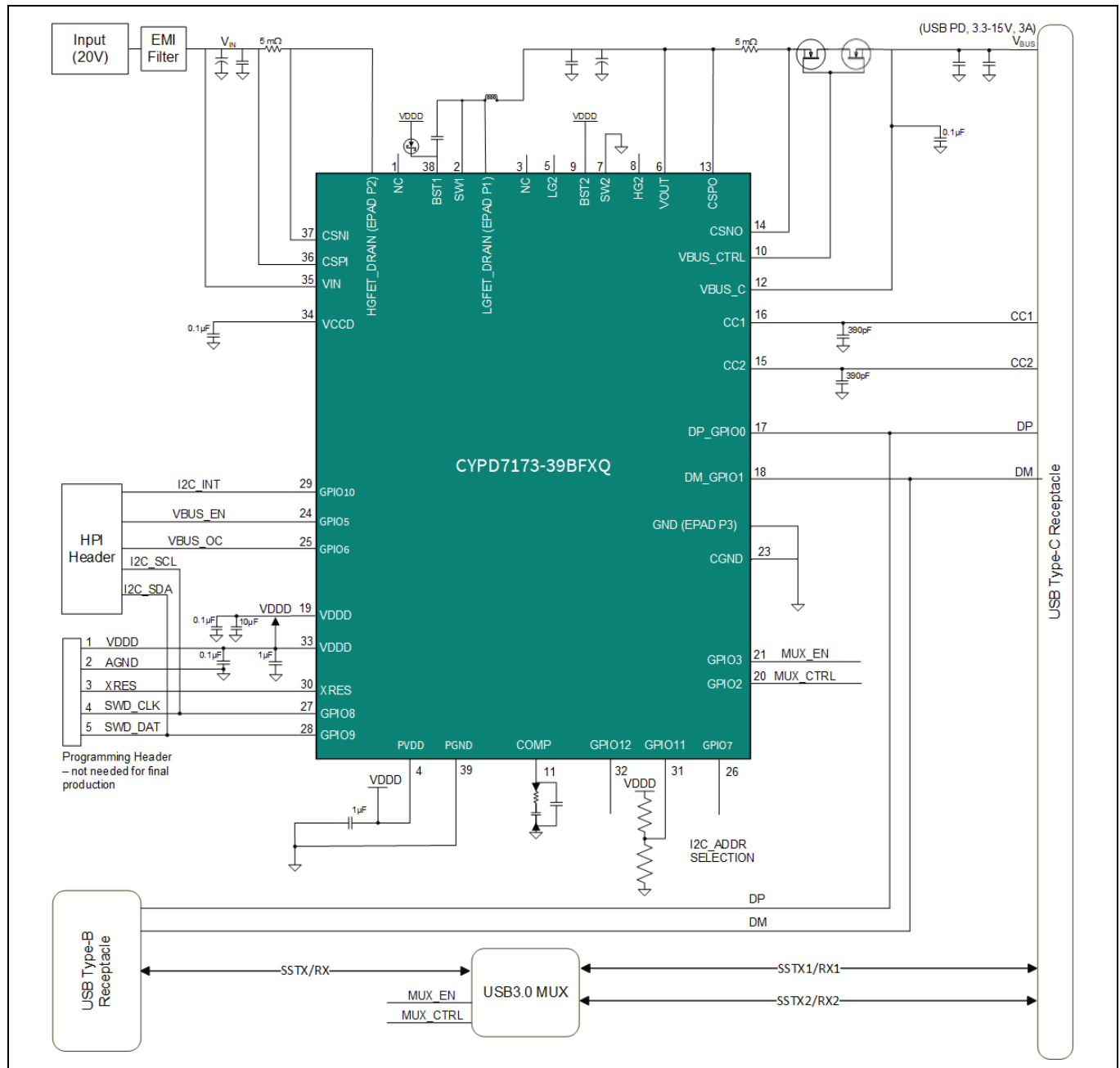


Figure 15 EZ-PD™ CCG7SCF dock application diagram

Table 5 provides the consumer charging applications GPIO pin mapping for the application diagram in **Figure 12**.

Table 5 Consumer charging applications, dock applications, GPIO pin mapping for application diagram in Figure 12, Figure 15

Pin #	Pin name	Function	GPIO	Consumer charging applications	Dock applications
17	DP_GPIO0	USB DP of Type-C port. Supports BC 1.2, QC, Apple charging and AFC.	P0.0	DP	USB_DP
18	DM_GPIO1	USB DM of Type-C port. Supports BC 1.2, QC, Apple charging and AFC.	P0.1	DM	USB_DM
20	GPIO2	To select the channel of USB3.0 Mux	P0.2	–	MUX_CTRL
21	GPIO3	Thermistor	P0.3	NTC	–
		MUX_EN to enable or disable USB3.0 Mux		–	MUX_EN
24	GPIO5	Used as input to CCG7SCF to enable or disable VBUS	P1.4	–	VBUS_EN_CTRL_5V
25	GPIO6	Used for over current warning	P1.3	–	VBUS_OC_CCG7SCF
27	GPIO8	Connect to the host programmer's SWDCLK (clock) for programming the EZ-PD™ CCG7SCF device.	P1.1	GPIO	SWD_CLK/HPI_I2C_SCL1
28	GPIO9	Connect to the host programmer's SWDDAT (data) for programming the EZ-PD™ CCG7SCF device.	P1.0		SWD_DAT/HPI_I2C_SDA1
29	GPIO10	Connect to HPI master for interrupt handling	P2.2	–	HPI_INT1
31	GPIO11	Used to select the I2C address	P3.0	–	I2C_ADDR

6 Electrical specifications

6.1 Absolute maximum ratings

Table 6 Absolute maximum ratings^[3]

Parameter	Description	Min	Typ	Max	Unit	Details/conditions
V_{IN_MAX}	Maximum input supply voltage	–	–	40	V	–
V_{DDD_MAX}	Maximum supply voltage relative to V_{SS}	–	–	6		–
V_{5V_MAX}	Maximum supply voltage relative to V_{SS}	–	–	6		–
$V_{BUS_C_MAX}$	Max V_{BUS_C} (P0/P1) voltage relative to V_{SS}	–	–	24		–
$V_{CC_PIN_ABS}$	Max voltage on CC1 and CC2 pins	–	–	24		–
V_{GPIO_ABS}	Inputs to GPIO	–0.5	–	$V_{DDD} + 0.5$		–
$V_{GPIO_OVT_ABS}$	OVT GPIO voltage	–0.5	–	6		–
I_{GPIO_ABS}	Maximum current per GPIO	–25	–	25	mA	–
$I_{GPIO_INJECTION}$	GPIO injection current, max for $V_{IH} > V_{DDD}$, and min for $V_{IL} < V_{SS}$	–0.5	–	0.5		Absolute max, current injected per pin
ESD_HBM	Electrostatic discharge human body model	–	–	2000	V	All pins except P1 and P2
		–	–	500		All pins except P1 and P2
ESD_CDM	Electrostatic discharge charged device model	–	–	500		Charged device model ESD
LU	Pin current for latch-up	–100	–	100	mA	–
T_J	Junction temperature	–40	–	125	°C	–

Note

- Usage above the absolute maximum conditions listed in **Table 6** may cause permanent damage to the device. Exposure to absolute maximum conditions for extended periods of time may affect device reliability. The maximum storage temperature is 150°C in compliance with JEDEC Standard JESD22-A103, high temperature storage life. When used below absolute maximum conditions but above normal operating conditions, the device may not operate to specification.

6.2 Device-level specifications

All specifications are valid for $-40^{\circ}\text{C} \leq T_A \leq 105^{\circ}\text{C}$ and $T_J \leq 125^{\circ}\text{C}$, except where noted. Specifications are valid for 3.0 V to 5.5 V except where noted.

6.2.1 DC specifications

Table 7 DC specifications (operating conditions)

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID.PWR#1	V _{IN}	Input supply voltage	4.0	–	24	V	–
SID.PWR#1A	V _{IN_BB}	Buck-boost operating input supply voltage	4.5	–	24		–
SID.PWR#2	V _{DDD_REG}	VDDD output with VIN 5.5 V to 24 V, max load = 75 mA	4.6	–	5.5		–
SID.PWR#2A	V _{DDD_BYPASS}	VDDD output with VIN 4.5 V to 5.5 V, max load = 75 mA	V _{IN} – 0.7		5.5		–
SID.PWR#3	V _{DDD_MIN}	VDDD output with VIN 4 V to 4.5 V, max load = 20mA	V _{IN} - 0.2	–	–		–
SID.PWR#20	VBUS	VBUS_C valid range	3.3	–	21.5		–
SID.PWR#5	V _{CCD}	Regulated output voltage (for core Logic)	–	1.8	–		–
SID.PWR#16	C _{EFC_VCCD}	External regulator voltage bypass for VCCD	80	100	120	nF	X5R ceramic
SID.PWR#17	C _{EXC_VDDD}	Power supply decoupling capacitor for V _{DDD}	–	10	–	μF	
SID.PWR#18	C _{EXV}	Bootstrap supply capacitor (BST1, BST2)	–	0.1	–		
SID.PWR#24	I _{DD_ACT}	Supply current at 0.4 MHz switching frequency	–	50	–	mA	T _A = 25°C, VIN = 12 V. CC IO IN transmit or receive, no I/O sourcing current, No VCONN load current, CPU at 24 MHz, PD port active. Buck-boost converter on, 3-nF gate driver capacitance.

Electrical specifications

Table 7 DC specifications (operating conditions) (continued)

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
Deep Sleep mode							
SID_DS1	I _{DD_DS1}	V _{IN} = 12 V. CC wakeup on, Type-C not connected, Source mode	–	80	–	μA	Type-C not attached, CC enabled for wakeup. R _p connection should be enabled for the PD port. T _A = 25°C. All faults disabled.
SID_DS2	I _{DD_DS2}	V _{IN} = 12 V, GPIO wake-up	–	50	–		USB PD disabled. Wake-up from GPIO. T _A = 25°C. All faults disabled.
SID_DS3	I _{DD_DS3}	V _{IN} = 12 V. CC wakeup on, Type-C not connected, Source mode	–	300	–		Type-C not attached, CC enabled for wakeup. R _p connection should be enabled for the PD port. T _A = 25°C. All faults disabled.

6.2.2 CPU

Table 8 CPU specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID.CLK#4	F _{CPU}	CPU input frequency	–	–	48	MHz	–40°C ≤ T _A ≤ +105°C, all V _{DDD}
SID.PWR#19	T _{DEEPSLEEP}	Wake-up from Deep Sleep mode	–	35	–	μs	–
SYS.XRES#5	T _{XRES}	External reset pulse width	5	–	–		

6.2.3 GPIO

Table 9 GPIO DC specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID.GIO#9	V _{IH_CMOS}	Input voltage high threshold	0.7 × V _{DDD}	–	–	V	CMOS input
SID.GIO#10	V _{IL_CMOS}	Input voltage low threshold	–	–	0.3 × V _{DDD}		
SID.GIO#11	V _{IH_TTL}	LVTTL input	2.0	–	–		–40°C ≤ T _A ≤ +105°C
SID.GIO#12	V _{IL_TTL}	LVTTL input	–	–	0.8		–40°C ≤ T _A ≤ +105°C
SID.GIO#7	V _{OH_3V}	Output voltage high level	V _{DDD} – 0.6	–	–		I _{OH} = –4 mA, –40°C ≤ T _A ≤ +105°C
SID.GIO#8	V _{OL_3V}	Output voltage low level	–	–	0.6		I _{OL} = 10 mA, –40°C ≤ T _A ≤ +105°C
SID.GIO#2	R _{pu}	Pull-up resistor when enabled	3.5	5.6	8.5	kΩ	–40°C ≤ T _A ≤ +105°C
SID.GIO#3	R _{pd}	Pull-down resistor when enabled	3.5	5.6	8.5		
SID.GIO#4	I _{IL}	Input leakage current (absolute value)	–	–	2	nA	+25°C T _A , 3-V V _{DDD}
SID.GIO#5	C _{PIN_A}	Max pin capacitance	–	–	22	pF	–40°C ≤ T _A ≤ +105°C, capacitance on DP, DM pins
SID.GIO#6	C _{PIN}	Max pin capacitance	–	3	7		–40°C ≤ T _A ≤ +105°C, all V _{DDD} , all other I/Os
SID.GIO#13	V _{HYSTTL}	Input hysteresis, LVTTL, V _{DDD} > 2.7 V	100	–	–	mV	V _{DDD} > 2.7 V
SID.GIO#14	V _{HYSCMOS}	Input hysteresis CMOS	0.1 × V _{DDD}	–	–		–

Table 10 GPIO AC specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID.GIO#16	T _{RISEF}	Rise time in fast strong mode	2	–	12	ns	C _{load} = 25 pF, –40°C ≤ T _A ≤ +105°C
SID.GIO#17	T _{FALLF}	Fall time in fast strong mode	2	–	12		
SID.GIO#18	T _{RISES}	Rise time in slow strong mode	10	–	60		
SID.GIO#19	T _{FALLS}	Fall time in slow strong mode	10	–	60		
SID.GIO#20	F _{GPIO_OUT1}	GPIO F _{OUT} ; 3.0 V ≤ V _{DD} ≤ 5.5 V. Fast strong mode.	–	–	16	MHz	–40°C ≤ T _A ≤ +105°C
SID.GIO#21	F _{GPIO_OUT2}	GPIO F _{OUT} ; 3.0 V ≤ V _{DD} ≤ 5.5 V. Slow strong mode.	–	–	7		
SID.GIO#22	F _{GPIO_IN}	GPIO input operating frequency; 3.0 V ≤ V _{DD} ≤ 5.5 V.	–	–	16		

Table 11 GPIO OVT DC specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID.GPIO_20VT_GIO#4	GPIO_20VT_I_LU	GPIO_20VT latch up current limits	-140	-	140	mA	Max/min current in to any input or output, pin-to-pin, pin-to-supply
SID.GPIO_20VT_GIO#5	GPIO_20VT_RPU	GPIO_20VT pull-up resistor value	3.5	-	8.5	kΩ	-40°C ≤ T _A ≤ +105°C, all V _{DDD}
SID.GPIO_20VT_GIO#6	GPIO_20VT_RPD	GPIO_20VT pull-down resistor value	3.5	-	8.5		-40°C ≤ T _A ≤ +105°C, all V _{DDD}
SID.GPIO_20VT_GIO#16	GPIO_20VT_IIL	GPIO_20VT input leakage current (absolute value)	-	-	2	nA	+25°C T _A , 3-V V _{DDD}
SID.GPIO_20VT_GIO#17	GPIO_20VT_CPIN	GPIO_20VT pin capacitance	-	-	10	pF	-40°C ≤ T _A ≤ +105°C, all V _{DDD}
SID.GPIO_20VT_GIO#33	GPIO_20VT_Voh	GPIO_20VT output voltage high level	V _{DDD} -0.6	-	-	V	I _{OH} = -4 mA
SID.GPIO_20VT_GIO#36	GPIO_20VT_Vol	GPIO_20VT output voltage low level	-	-	0.6		I _{OL} = 8 mA
SID.GPIO_20VT_GIO#41	GPIO_20VT_Vih_LVTTL	GPIO_20VT LVTTL input	2	-	-		-40°C ≤ T _A ≤ +105°C, all V _{DDD}
SID.GPIO_20VT_GIO#42	GPIO_20VT_Vil_LVTTL	GPIO_20VT LVTTL input	-	-	0.8		-40°C ≤ T _A ≤ +105°C, all V _{DDD}
SID.GPIO_20VT_GIO#43	GPIO_20VT_Vhysttl	GPIO_20VT input hysteresis LVTTL	100	-	-	mV	-40°C ≤ T _A ≤ +105°C, all V _{DDD}
SID.GPIO_20VT_GIO#45	GPIO_20VT_ITOT_GPIO	GPIO_20VT maximum total sink pin current to ground	-	-	95	mA	V (GPIO_20VT pin) > V _{DDD}

Table 12 GPIO OVT AC specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID.GPIO_20VT_70	GPIO_20VT_TriseF	GPIO_20VT rise time in fast strong mode	1	–	15	ns	All V_{DD} , $C_{load} = 25 \text{ pF}$
SID.GPIO_20VT_71	GPIO_20VT_TfallF	GPIO_20VT fall time in fast strong mode	1	–	15		
SID.GPIO_20VT_GIO#46	GPIO_20VT_TriseS	GPIO_20VT rise time in slow strong mode	10	–	70		
SID.GPIO_20VT_GIO#47	GPIO_20VT_TfallS	GPIO_20VT Fall time in slow strong mode	10	–	70		
SID.GPIO_20VT_GIO#48	GPIO_20VT_FGPIO_OUT1	GPIO_20VT GPIO Fout; $3 \text{ V} \leq V_{DD} \leq 5.5 \text{ V}$. Fast strong mode.	–	–	33	MHz	All V_{DD}
SID.GPIO_20VT_GIO#50	GPIO_20VT_FGPIO_OUT3	GPIO_20VT GPIO Fout; $3 \text{ V} \leq V_{DD} \leq 5.5 \text{ V}$. Slow strong mode.	–	–	7		
SID.GPIO_20VT_GIO#52	GPIO_20VT_FGPIO_IN	GPIO_20VT GPIO input operating frequency; $3 \text{ V} \leq V_{DD} \leq 5.5 \text{ V}$	–	–	8		

6.2.4 XRES

Table 13 XRES DC specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID.XRES#1	V_{IH_XRES}	Input voltage high threshold on XRES pin	$0.7 \times V_{DD}$	–	–	V	CMOS input
SID.XRES#2	V_{IL_XRES}	Input voltage low threshold on XRES pin	–	–	$0.3 \times V_{DD}$		
SID.XRES#3	C_{IN_XRES}	Input capacitance on XRES pin	–	–	7	pF	–
SID.XRES#4	$V_{HYSXRES}$	Input voltage hysteresis on XRES pin	–	$0.05 \times V_{DD}$	–	mV	–

6.3 Digital peripherals

The following specifications apply to the timer/counter/PWM peripherals in the timer mode.

6.3.1 Pulse width modulation (PWM) for GPIO pins

Table 14 PWM AC specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID.TCPWM.1	TCPWM _{FREQ}	Operating frequency	–	–	Fc	MHz	Fc max = CLK_SYS
SID.TCPWM.3	T _{PWMEXT}	Output trigger pulse width	2/Fc	–	–	ns	Minimum possible width of overflow, underflow, and CC (Counter equals compare value) outputs
SID.TCPWM.4	T _{CRES}	Resolution of counter	1/Fc	–	–		Minimum time between successive counts
SID.TCPWM.5	PWM _{RES}	PWM resolution	1/Fc	–	–		Minimum pulse width of PWM output

6.3.2 I²C

Table 15 Fixed I²C AC specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID153	F _{I2C1}	Bit rate	–	–	1	Mbps	–

6.3.3 UART

Table 16 Fixed UART AC specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID162	F _{UART}	Bit rate	–	–	1	Mbps	–

6.3.4 SPI

Table 17 Fixed SPI AC specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID166	F_{SPI}	SPI operating frequency (master; 6X oversampling)	–	–	8	MHz	–

Table 18 Fixed SPI master mode AC specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID167	T_{DMO}	MOSI valid after SClk driving edge	–	–	15	ns	–
SID168	T_{DSI}	MISO valid before SClk capturing edge	20	–	–		Full clock, late MISO sampling
SID169	T_{HMO}	Previous MOSI data hold time	0	–	–		Referred to slave capturing edge

Table 19 Fixed SPI Slave Mode AC specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID170	T_{DMI}	MOSI valid before Sclck capturing edge	40	–	–	ns	–
SID171	T_{DSO}	MISO valid after Sclck driving edge	–	–	$48 + (3 \times T_{CPU})$		$T_{CPU} = 1/F_{CPU}$
SID171A	T_{DSO_EXT}	MISO valid after Sclck driving edge in ext clk mode	–	–	48		–
SID172	T_{HSO}	Previous MISO data hold time	0	–	–		–
SID172A	$T_{SSELSCK}$	SSEL valid to first SCK valid edge	100	–	–		–

6.3.5 Memory

Table 20 Flash AC specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID.MEM#2	FLASH_WRITE	Row (block) write time (Erase and program)	–	–	20	ms	–40°C ≤ T _A ≤ +85°C, all V _{DDD}
SID.MEM#1	FLASH_ERASE	Row erase time	–	–	15.5		
SID.MEM#5	FLASH_ROW_PGM	Row program time after erase	–	–	7		
SID178	T _{BULKERASE}	Bulk erase time (32 KB)	–	–	35		
SID180	T _{DEVPROG}	Total device program time	–	–	7.5	s	–
SID.MEM#6	FLASH_ENPB	Flash write endurance	100k	–	–	cycles	25°C ≤ T _A ≤ 55°C, all V _{DDD}
SID182	F _{RET1}	Flash retention, T _A ≤ 55°C, 100K P/E cycles	20	–	–	years	–
SID182A	F _{RET2}	Flash retention, T _A ≤ 85°C, 10K P/E cycles	10	–	–		

6.4 System resources

6.4.1 Power-on-reset (POR) with brown out

Table 21 Imprecise power-on reset (IPOR)

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID185	V _{RISEIPOR}	Power-on reset (POR) rising trip voltage	0.80	–	1.50	V	–40°C ≤ T _A ≤ +105°C, all V _{DDD}
SID186	V _{FALLIPOR}	POR falling trip voltage	0.70	–	1.4		

Table 22 Precise POR

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID190	V _{FALLPPOR}	Brown-out detect (BOD) trip voltage in active/sleep modes	1.48	–	1.62	V	–40°C ≤ T _A ≤ +105°C, all V _{DDD}
SID192	V _{FALLDPSLP}	BOD trip voltage in deep sleep mode	1.1	–	1.5		

6.4.2 SWD interface

Table 23 SWD interface specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID.SWD#1	F_SWDCCLK1	$3.0\text{ V} \leq V_{\text{DDIO}} \leq 5.5\text{ V}$	–	–	14	MHz	–
SID.SWD#2	T_SWDI_SETUP	$T = 1/f\text{ SWDCCLK}$	$0.25 \times T$	–	–	ns	
SID.SWD#3	T_SWDI_HOLD	$T = 1/f\text{ SWDCCLK}$	$0.25 \times T$	–	–		
SID.SWD#4	T_SWDO_VALID	$T = 1/f\text{ SWDCCLK}$	–	–	$0.50 \times T$		
SID.SWD#5	T_SWDO_HOLD	$T = 1/f\text{ SWDCCLK}$	1	–	–		

6.4.3 Internal main oscillator

Table 24 IMO AC specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID.CLK#13	F _{IMOTOL}	Frequency variation at 48 MHz (trimmed)	–	–	±2	%	3.0 V ≤ V _{DD} < 5.5 V. –40°C ≤ T _A ≤ 105°C
SID226	T _{STARTIMO}	IMO start-up time	–	–	7	μs	–40°C ≤ T _A ≤ +105°C, all V _{DD}
SID.CLK#1	F _{IMO}	IMO frequency	24	–	48	MHz	

6.4.4 Internal low-speed oscillator

Table 25 ILO AC specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID234	T _{STARTILO1}	ILO start-up time	–	–	2	ms	–40°C ≤ T _A ≤ +105°C, all V _{DD}
SID238	T _{ILODUTY}	ILO duty cycle	40	50	60	%	
SID.CLK#5	F _{ILO}	ILO frequency	20	40	80	kHz	–

Electrical specifications

6.4.5 PD

Table 26 PD DC specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID.DC.cc_shvt.1	vSwing	Transmitter output high voltage	1.05	-	1.2	V	-
SID.DC.cc_shvt.2	vSwing_low	Transmitter output low voltage	-		0.075		
SID.DC.cc_shvt.3	zDriver	Transmitter output impedance	33		75	W	
SID.DC.cc_shvt.4	zBmcRx	Receiver input impedance	10		-	MΩ	
SID.DC.cc_shvt.5	Idac_std	Source current for USB standard advertisement	64		96	μA	
SID.DC.cc_shvt.6	Idac_1p5a	Source current for 1.5A at 5V advertisement	166		194		
SID.DC.cc_shvt.7	Idac_3a	Source current for 3A at 5V advertisement	304		356		
SID.DC.cc_shvt.8	Rd	Pull down termination resistance when acting as UFP (upstream facing port)	4.59		5.61	kΩ	
SID.DC.cc_shvt.10	zOPEN	CC impedance to ground when disabled	108		-		
SID.DC.cc_shvt.11	DFP_default_0p2	CC voltages on DFP side - standard USB	0.15		0.25	V	
SID.DC.cc_shvt.12	DFP_1.5A_0p4	CC voltages on DFP side - 1.5 A	0.35		0.45		
SID.DC.cc_shvt.13	DFP_3A_0p8	CC voltages on DFP side - 3 A	0.75		0.85		
SID.DC.cc_shvt.14	DFP_3A_2p6	CC voltages on DFP side - 3 A	2.45		2.75		
SID.DC.cc_shvt.15	UFP_default_0p66	CC voltages on UFP side - standard USB	0.61		0.7		
SID.DC.cc_shvt.16	UFP_1.5A_1p23	CC voltages on UFP side - 1.5 A	1.16		1.31		
SID.DC.cc_shvt.17	Vattach_ds	Deep sleep attach threshold	0.3		0.6	%	
SID.DC.cc_shvt.18	Rattach_ds	Deep sleep pull-up resistor	10		50	kΩ	
SID.DC.cc_shvt.19	VTX_step	TX drive voltage step size	80		120	mV	

6.4.6 Analog-to-digital converter

Table 27 ADC DC specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID.ADC.1	Resolution	ADC resolution	–	8	–	Bits	–
SID.ADC.2	INL	Integral non-linearity	–1.5	–	1.5	LSB	Reference voltage generated from bandgap.
SID.ADC.3	DNL	Differential non-linearity	–2.5		2.5		Reference voltage generated from V_{DD} .
SID.ADC.4	Gain Error	Gain error	–1.5		1.5		Reference voltage generated from bandgap.
SID.ADC.5	VREF_ADC1	Reference voltage of ADC	V_{DDmin}		V_{DDmax}	V	Reference voltage generated from V_{DD} .
SID.ADC.6	VREF_ADC2	Reference voltage of ADC	1.96	2.0	2.04		Reference voltage generated from Deep sleep reference.

6.4.7 HS CSA

Table 28 HS CSA DC specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID.HSCSA.1	Csa_Acc1	CSA accuracy 5 mV < Vsense < 10 mV	-15	-	15	%	Active mode
SID.HSCSA.2	Csa_Acc2	CSA accuracy 10 mV < Vsense < 15 mV	-10		10		
SID.HSCSA.3	Csa_Acc3	CSA accuracy 15 mV < Vsense < 25 mV	-5		5		
SID.HSCSA.4	Csa_Acc4	CSA accuracy 25 mV < Vsense	-3		3		
SID.HSCSA.7	Csa_SCP_Acc1	CSA SCP at 6 A with 5-mΩ sense resistor	-10		10		
SID.HSCSA.8	Csa_SCP_Acc2	CSA SCP at 10 A with 5-mΩ sense resistor	-10		10		
SID.HSCSA.9	Csa_OCP_1A	CSA OCP at 1 A with 5-mΩ sense resistor	104	130	156		
SID.HSCSA.10	Csa_OCP_5A	CSA OCP for 5 A with 5-mΩ sense resistor	123	130	137		

Table 29 HS CSA AC specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID.HSCSA.AC.1	T _{SCP_GATE}	Delay from SCP threshold trip to external NFET power gate turn off	-	3.5	-	μs	1 nF NFET gate
SID.HSCSA.AC.2	T _{SCP_GATE_1}	Delay from SCP threshold trip to external NFET power gate turn off		8			3 nF NFET gate

6.4.8 UV/OV

Table 30 UV/OV specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID.UVOV.1	VTHOV1	Overvoltage threshold Accuracy, 4 V to 11 V	-3	-	3	%	Active mode
SID.UVOV.2	VTHOV2	Overvoltage threshold Accuracy, 11 V to 21.5 V	-3.2		3.2		
SID.UVOV.3	VTHUV1	Undervoltage threshold Accuracy, 3 V to 3.3 V	-4		4		
SID.UVOV.4	VTHUV2	Undervoltage threshold Accuracy, 3.3 V to 4.0 V	-3.5		3.5		
SID.UVOV.5	VTHUV3	Undervoltage threshold Accuracy, 4.0 V to 21.5 V	-3		3		

6.4.9 VCONN switch

Table 31 VCONN switch DC specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
DC.VCONN.1	VCONN_OUT	VCONN output voltage with 20 mA load current	4.5	-	5.5	V	-
DC.VCONN.2	I _{LEAK}	Connector side pin leakage current	-	-	10	μA	
DC.VCONN.3	I _{OCP}	VCONN overcurrent protection threshold	22.5	30	42.5	mA	

Table 32 VCONN switch AC specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
AC.VCONN.1	T _{ON}	VCONN switch turn-on time	-	-	600	μs	-
AC.VCONN.2	T _{OFF}	VCONN switch turn-off time			10		

6.4.10 V_{BUS}

Table 33 V_{BUS} discharge specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID.VBUS.DISC.1	R1	20-V NMOS ON resistance for DS = 1	500	–	2000	Ω	Measured at 0.5 V.
SID.VBUS.DISC.2	R2	20-V NMOS ON resistance for DS = 2	250		1000		
SID.VBUS.DISC.3	R4	20-V NMOS ON resistance for DS = 4	125		500		
SID.VBUS.DISC.4	R8	20-V NMOS ON resistance for DS = 8	62.5		250		
SID.VBUS.DISC.5	R16	20-V NMOS ON resistance for DS = 16	31.25		125		
SID.VBUS.DISC.6	Vbus_stop_error	Error percentage of final VBUS value from setting	–		10	%	When VBUS is discharged to 5 V.

6.4.11 Voltage regulation

Table 34 Voltage regulation DC specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID.DC.VR.1	VOUT	CSNO output voltage range	3.3	–	21.5	V	–
SID.DC.VR.2	VR	CSNO voltage regulation accuracy	–	± 3	± 5	%	
SID.DC.VR.3	VIN_UVLO	VIN supply below which chip will get reset	1.7	–	3.0	V	

Table 35 Voltage regulator specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID.VREG.1	T _{START}	Total startup time for the regulator supply outputs	–	–	200	μs	–

6.4.12 VBUS gate driver

Table 36 VBUS gate driver DC specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID.GD.1	GD_VGS	Gate to source overdrive during ON condition	4.5	5	10	V	NFET driver is ON.
SID.GD.2	GD_RPD	Resistance when pull-down enabled	–	–	2	kΩ	Applicable on VBUS_CTRL to turn off external NFET.
SID.GD.5	GD_drv	Programmable typical gate current	0.3		9.75	μA	–

Table 37 VBUS gate Driver AC specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID.GD.3	T _{ON}	VBUS_CTRL low to high (1V to VBUS + 1 V) with 3 nF external capacitance	2	5	10	ms	CSNO = 5 V
SID.GD.4	T _{OFF}	VBUS_CTRL high to low (90% to 10%) with 3 nF external capacitance	–	7	–	μs	CSNO = 21.5 V

6.4.13 PWM controller

Table 38 Buck-boost PWM controller specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
PWM.1	F _{SW}	Switching frequency	150	–	600	kHz	–
PWM.2	FSS	Spread spectrum frequency dithering span	–	10	–	%	
PWM.3	Ratio_buck_BB	Buck to buck boost ratio		1.16		V/V	
PWM.4	Ratio_boost_BB	Boost to buck boost ratio		0.84			

6.4.14 NFET gate driver

Table 39 Buck-boost NFET gate driver specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
DR.1	R_HS_PU	Top-side gate driver on-resistance-gate pull-up	-	2	-	Ω	-
DR.2	R_HS_PD	Top-side gate driver on-resistance-gate pull-down		1.5			
DR.3	R_LS_PU	Bottom-side gate driver on-resistance-gate pull-up		2			
DR.4	R_LS_PD	Bottom-side gate driver on-resistance-gate pull-down		1.5			
DR.5	Dead_HS	Dead time before high-side rising edge		30		ns	
DR.6	Dead_LS	Dead time before low-side rising edge		30			
DR.7	Tr_HS	Top-side gate driver rise time		25			
DR.8	Tf_HS	Top-side gate driver fall time		20			
DR.9	Tr_LS	Bottom-side gate driver rise time		25			
DR.10	Tf_LS	Bottom-side gate driver fall time		20			

6.4.15 Buck switching FETs

Table 40 Buck switching FET specifications

Spec Id	Parameter	Min	Typ	Max	Unit	Details/conditions
FET.DC.1	Drain-source breakdown voltage ($V_{(BR)DSS}$)	40	–	–	V	$V_{GS} = 0\text{ V}$, $I_D = 1\text{ mA}$
FET.DC.2	Gate threshold voltage $V_{GS(TH)}$	1.2	1.6	2	V	$V_{DS} = V_{GS}$, $I_D = 10\text{ }\mu\text{A}$
FET.DC.3	LGFET ON resistance Buck converter low side MOSFET ($R_{DS(ON)}$)	–	10	–	m Ω	$V_{GS} = 5\text{ V}$, $I_D = 8\text{ A}$
FET.DC.4	HGFET ON resistance Buck converter high side MOSFET ($R_{DS(ON)}$)	–	10	–	m Ω	$V_{GS} = 5\text{ V}$, $I_D = 8\text{ A}$
FET.AC.1	Turn-on delay time ($t_{d(on)}$)	–	2	–	ns	$V_{DS} = 6\text{ V}$, $V_{GS} = 5\text{ V}$, $I_D = 5\text{ A}$
FET.AC.2	Rise time (t_r)	–	2	–	ns	
FET.AC.3	Turn-off delay time ($t_{d(off)}$)	–	6	–	ns	
FET.AC.4	Fall time (t_f)	–	5	–	ns	
FET.DC.5	Gate plateau voltage ($V_{plateau}$)	–	3	–	V	$V_{DS} = 6\text{ V}$, $V_{GS} = 0\text{ V to } 5\text{ V}$, $I_D = 5\text{ A}$

6.4.16 LS-SCP

Table 41 LS-SCP DC specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID.LSSCP.DC.1	SCP_6A	Short circuit current detect @ 6 A	5.4	6	6.6	A	Using differential inputs (CSP_GPIO2, CSN_GPIO3)
SID.LSSCP.DC.1A	SCP_6A_SE	Short circuit current detect @ 6 A	4.5	6	7.5		Using single ended inputs (CSP_GPIO2) and internal ground
SID.LSSCP.DC.2	SCP_10A	Short circuit current detect @ 10 A	9	10	11		Using differential inputs (CSP_GPIO2, CSN_GPIO3)
SID.LSSCP.DC.2A	SCP_10A_SE	Short circuit current detect @ 10 A	7.5	10	12.5		Using single ended inputs (CSP_GPIO2) and internal ground

6.4.17 Thermal

Table 42 Thermal specifications

Spec ID	Parameter	Description	Min	Typ	Max	Unit	Details/conditions
SID.OTP.1	OTP	Thermal shutdown	120	125	130	°C	–

7 Ordering information

Table 43 lists the EZ-PD™ CCG7SCF part numbers and features.

Table 43 EZ-PD™ CCG7SCF ordering information

Product	Application	Termination resistor	Role	Switching frequency	Package type
CYPD7172-39BFXQ	Charger and adapter application	R _P	DFP (Power source only)	150 kHz–600 kHz	39-lead LGA
CYPD7172-39BFXQT					
CYPD7173-39BFXQ	Dock application				
CYPD7173-39BFXQT					

7.1 Ordering code definitions

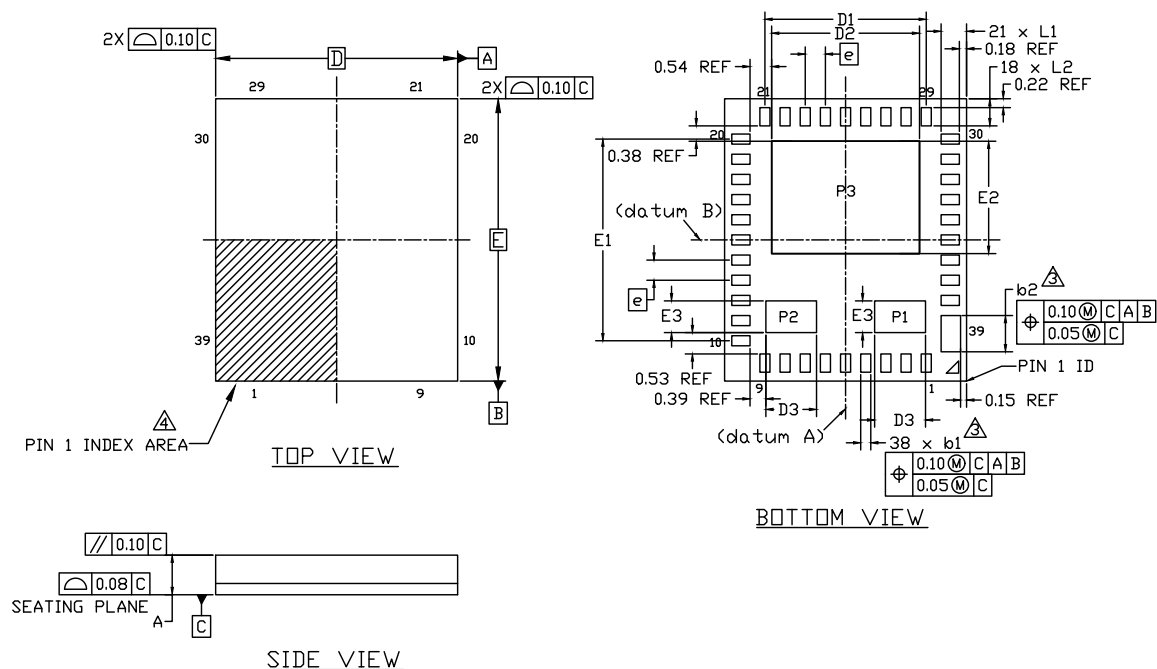
CY	PD	X	X	XX	-	XX	XX	X	X	X	
											T = Tape and reel (optional)
											Grade/temperature range: Q = Extended industrial grade (-40°C to + 105°C)
											Lead: X = Pb-free
											Package type: BF = LGA
											Number of pins in the package
											Application and feature combination designation
											Number of Type-C ports: 1 = 1 Port
											Product type: 7 = Seventh-generation product family
											Marketing code: PD = Power delivery product family
											Company ID: CY = Cypress (an Infineon company)

8 Packaging

Table 44 Package characteristics

Parameter	Description	Conditions	Min	Typ	Max	Unit
T_J	Operating junction temperature	-	-40	25	125	°C
T_{JA}	Package θ_{JA}		-	-	17.7	°C/W
T_{JC}	Package θ_{JC}		-	-	5.17	

8.1 Package diagram



SYMBOL	DIMENSIONS		
	MIN.	NOM.	MAX.
A	-	-	1.00
b1	0.20	0.25	0.30
b2	0.85	0.90	0.95
D	6.00 BSC		
E	7.00 BSC		
D1	3.90	4.00	4.10
D2	3.57	3.67	3.77
D3	1.16	1.26	1.36
E1	4.90	5.00	5.10
E2	2.68	2.78	2.88
E3	0.69	0.79	0.89
L1	0.58	0.63	0.68
L2	0.62	0.67	0.72
e	0.50 BSC		
N	39		

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. N IS THE TOTAL NUMBER OF LANDS.
3. DIMENSION "b" IS MEASURED AT THE MAXIMUM LAND WIDTH IN A PLANE PARALLEL TO DATUM C.
4. PIN #1 ID ON TOP WILL BE LOCATED WITHIN THE INDICATED ZONE.
5. P1 - LGFET_DRAIN
P2 - HGFET_DRAIN
P3 - GND

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Figure 16 39-lead LGA (6.00 × 7.00 × 1.00 mm) BF39A package outline, 002-38571

9 Acronyms

Table 45 Acronyms used in this document

Acronym	Description
ADC	analog-to-digital converter
AFC	Samsung adaptive fast charging
Arm®	advanced RISC machine, a CPU architecture
CPU	central processing unit
CSA	current sense amplifier
DAC	digital-to-analog converter
FCCM	forced continuous current/conduction mode
GPIO	general-purpose input/output
HSDR	high-side driver
I ² C, or IIC	inter-integrated circuit, a communications protocol
IDAC	current DAC
I/O	input/output, see also GPIO
LSDR	low-side driver
MCU	microcontroller unit
OCP	overcurrent protection
OVP	overvoltage protection
PD	Power Delivery
POR	power-on reset
PSoC™	programmable system-on-chip
PSM	pulse skipping mode
PWM	pulse-width modulator
RAM	random-access memory
SPI	serial peripheral interface, a communications protocol
SRAM	static random access memory
TCPWM	timer/counter/PWM
Type-C	a new standard with a slimmer USB connector and a reversible cable, capable of sourcing up to 100 W of power
UART	universal asynchronous transmitter receiver, a communications protocol
UFP	upstream facing port
UVP	undervoltage protection
USB	universal serial bus
UVLO	under-voltage lockout
VPA	VCONN powered accessories
ZCD	zero crossing detector

10 Document conventions

10.1 Units of measure

Table 46 Units of measure

Symbol	Unit of measure
°C	degrees Celsius
Hz	hertz
KB	1024 bytes
kHz	kilohertz
kΩ	kilohm
Mbps	megabits per second
MHz	megahertz
MΩ	mega-ohm
Msps	megasamples per second
μA	microampere
μF	microfarad
μs	microsecond
μV	microvolt
μW	microwatt
mA	milliampere
mΩ	milliohm
ms	millisecond
mV	millivolt
nA	nanoampere
ns	nanosecond
W	ohm
pF	picofarad
ppm	parts per million
ps	picosecond
s	second
sps	samples per second

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Document revision	Date	Description of changes
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