



### DESCRIPTION

The MPQ5031 is a USB power delivery controller compatible with Type-C 2.0 and USB PD3.0 specifications. It targets DFP (provider) applications, such as charging-only USB PD ports and USB hubs.

The device is backward compatible, supporting DCP schemes for Quick Charge 3.0, battery charging specifications (BC1.2), Apple divider mode, Huawei FCP, and 1.2V/1.2V mode without outside user interaction. It also supports BC1.2 CDP handshaking. The I<sup>2</sup>C interface and GPIO pins provide good communication with an external power converter.

The MPQ5031 supports up to 100W PD power and PPS as well. It can flexibly configure the PDO list, select slave devices, configure charging protocols, and set the protection mode.

Two NTC pins can be used to monitor for abnormal temperature rise, such as on the Type-C receptacle and PCB board. Power sharing functionality supports smart power budget management between two USB PD ports. PDO capability is reduced when the car battery voltage is low. High-voltage I/O pins support short to battery and short to VBUS protection for the DC/DC converter.

The MPQ5031 is available in a QFN-20 (4mmx4mm) package with wettable flanks.

### FEATURES

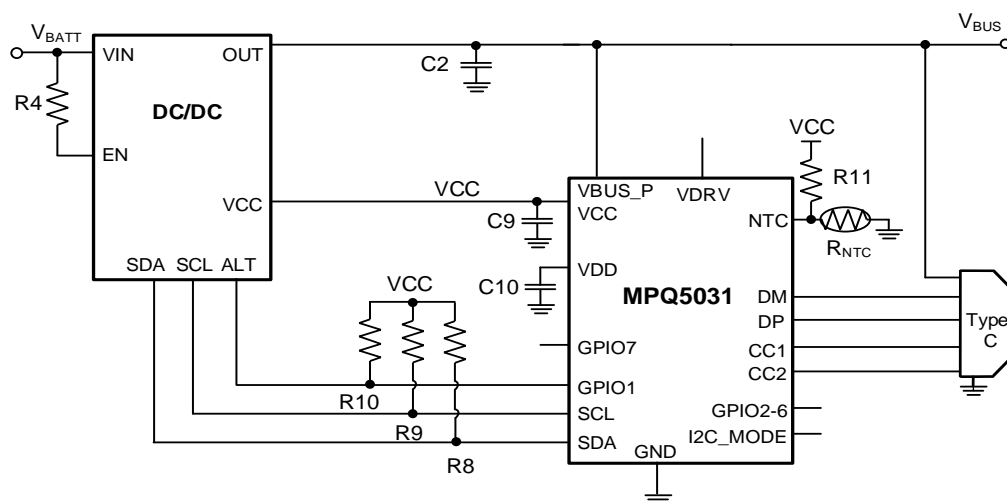
- Supports a 3.3V to 21V Bus Voltage Range
- 4.6V to 5.5V VCC Supply Voltage Range
- Integrated Physical Layer for BMC
- Integrated Protocol Layer
- Integrated Policy Engine
- Low Standby I<sub>Q</sub>: 100μA
- Supports One Type-C DFP Port with USB PD3.0 and PPS
- Supports DCP Schemes for BC1.2, 3A Divider, and 1.2V/1.2V Mode
- Supports QC3.0, Huawei FCP
- VBUS Isolation N-Channel MOSFET Driver
- EN Off Timer Up to 120 Minutes
- I<sup>2</sup>C Master/Slave Interface and Interrupt
- Load-Shedding with NTC or Battery Low Detection Function
- High-Voltage Pins for CC1, CC2, DP, and DM
- Integrated High-Voltage V<sub>CONN</sub> Supply Power Switch
- Passed 60W USB-IF PPS Certification with the MPQ4230 (TID: 2313)
- Passed 100W USB-IF PPS Certification with the MPQ4214 (TID: 2316)
- Available in a QFN-20 (4mmx4mm) Package with Wettable Flanks
- Available in Automotive AEC-Q100 Grade 1

### APPLICATIONS

- USB Power Delivery (Provider) Charging Ports
- USB PD Hubs

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## TYPICAL APPLICATION



## ORDERING INFORMATION

| Part Number*           | Package             | Top Marking | MSL |
|------------------------|---------------------|-------------|-----|
| MPQ5031GRE-0001-AEC1   | QFN-20<br>(4mmx4mm) | See Below   | 1   |
| MPQ5031GRE-0002-AEC1   |                     |             |     |
| MPQ5031GRE-0003-AEC1   |                     |             |     |
| MPQ5031GRE-0004-AEC1   |                     |             |     |
| MPQ5031GRE-0013-AEC1   |                     |             |     |
| MPQ5031GRE-0015-AEC1   |                     |             |     |
| MPQ5031GRE-xxxx-AEC1** |                     |             |     |
| EVKT-MPQ5031           | -                   | -           | -   |

\* For Tape & Reel, add suffix –Z (e.g. MPQ5031GRE-xxxx-AEC1–Z).

\*\* “xxxx” is the configuration code identifier for the register setting stored in the OTP. Each “x” can be a hexadecimal value between 0 and F.

## TOP MARKING

**MPSYWW**

**MP5031**

**LLLLLL**

**E**

MPS: MPS prefix  
Y: Year code  
WW: Week code  
MP5031: Part number  
LLLLLL: Lot number  
E: Wettable lead flank

## EVALUATION KIT EVKT-MPQ5031

EVKT-MPQ5031 kit contents (items listed below can be ordered separately):

| # | Part Number          | Item   | Quantity |
|---|----------------------|--|----------|
| 1 | EVQ5031-4230-RE-00A  | MPQ5031 + MPQ4230 evaluation board.  | 1        |
| 2 | EVKT-USB12C-02 bag   | Includes USB to I <sup>2</sup> C communication interface, one USB cable, and one ribbon cable. | 1        |
| 3 | MPQ5031GRE-0000-AEC1 | IC with default configuration. Can be used for OTP configurations.                             | 2        |

**Order directly from [MonolithicPower.com](http://MonolithicPower.com) or our distributors.**

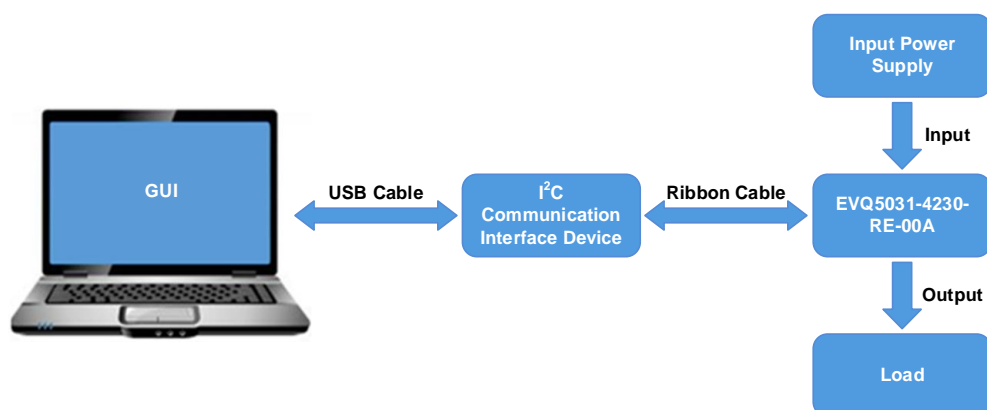
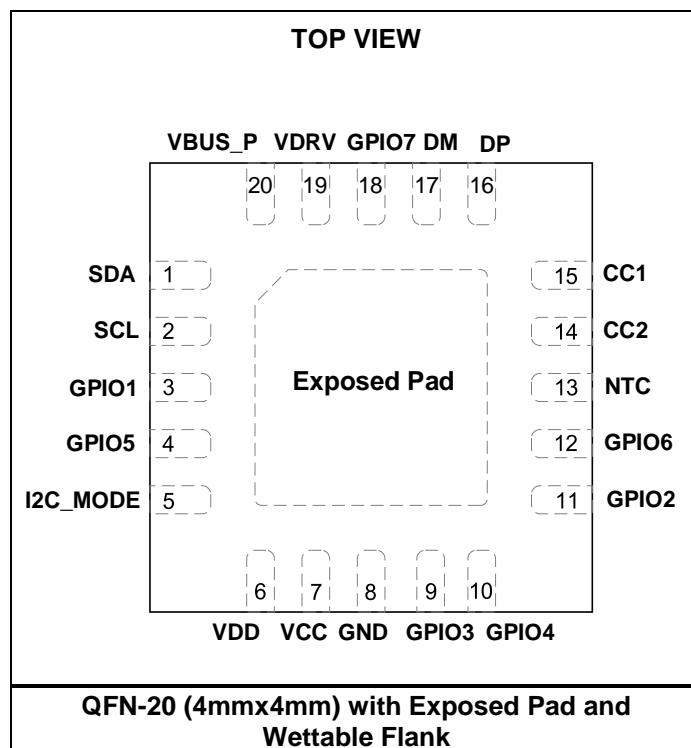


Figure 1: EVKT-MPQ5031 Evaluation Kit Set-Up

## PACKAGE REFERENCE



## PIN FUNCTIONS

| Pin #       | Name     | I/O           | Description   |
|-------------|----------|---------------|---|
| 1           | SDA      | Bidirectional | <b>I<sup>2</sup>C data line.</b>  |
| 2           | SCL      | Bidirectional | <b>I<sup>2</sup>C clock signal input.</b> When the MPQ5031 is selected as the master, SCL is an output pin.   |
| 3           | GPIO1    | Bidirectional | <b>General purpose I/O 1.</b> See the GPIO register section on page 34 for more details.  |
| 4           | GPIO5    | Bidirectional | <b>General purpose I/O 5.</b> See the GPIO register section on page 35 for more details.  |
| 5           | I2C_MODE | Input         | <b>I<sup>2</sup>C operation mode setting.</b> Float or pull the I2C_MODE pin low to set the MPQ5031 as the I <sup>2</sup> C master. Pull this pin high to set the MPQ5031 as an I <sup>2</sup> C slave. When the MPQ5031 is set to I <sup>2</sup> C slave mode, the slave functions on GPIO5 and GPIO6 are disabled. Only pin 1 and pin 2 (SDA and SCL) are the I <sup>2</sup> C slave entrance. This pin has an internal 1M $\Omega$ pull-down resistor. |
| 6           | VDD      | Output        | <b>Internal 1.8V LDO regulator output.</b> Decouple with 0.47 $\mu$ F capacitor.  |
| 7           | VCC      | Input         | <b>5V power supply for all internal circuitry.</b> The MPQ5031 operates from a 4.5V to 5.5V input voltage. A 4.7 $\mu$ F ceramic capacitor (C <sub>IN</sub> ) must be used to supply power to the internal circuitry, including VCONN.  |
| 8           | GND      | N/A           | <b>Ground.</b>  |
| 9           | GPIO3    | Bidirectional | <b>General purpose I/O 3.</b> See the GPIO register section on page 34 for more details.  |
| 10          | GPIO4    | Bidirectional | <b>General purpose I/O 4.</b> See the GPIO register section on page 33 for more details.  |
| 11          | GPIO2    | Bidirectional | <b>General purpose I/O 2.</b> See the GPIO register section on page 34 for more details.  |
| 12          | GPIO6    | Bidirectional | <b>General purpose I/O 6.</b> See the GPIO register section on page 35 for more details.  |
| 13          | NTC      | Input         | <b>External temperature-sense pin.</b> See the I <sup>2</sup> C register description on page 34 for the NTC trigger response.   |
| 14          | CC2      | Bidirectional | <b>Configuration channel (CC).</b> CC2 is used for the discovery, configuration, and management of connections across a USB Type-C cable.   |
| 15          | CC1      | Bidirectional | <b>Configuration channel (CC).</b> CC1 is used for the discovery, configuration, and management of connections across a USB Type-C cable.   |
| 16          | DP       | Bidirectional | <b>D+ data line to USB connector.</b> The DP and DM pins are the input/output used for handshaking with portable devices.   |
| 17          | DM       | Bidirectional | <b>D- data line to USB connector.</b> The DP and DM pins are the input/output used for handshaking with portable devices.   |
| 18          | GPIO7    | Bidirectional | <b>General purpose I/O 7.</b> See the GPIO register section on page 35 for more details.  |
| 19          | VDRV     | Output        | <b>External N-Channel MOSFET gate driver signal.</b> When the sink is attached, VDRV drives the external N-channel MOSFET to turn on. Then power flows from the DC/DC output to the sink. When the sink is detached, VDRV drives the external N-channel MOSFET to turn off to isolate the power path.   |
| 20          | VBUS_P   | Input         | <b>Bus voltage sensing and discharge pin.</b>   |
| Exposed pad | N/A      | N/A           | <b>Exposed pad.</b> Connect to ground when designing the PCB layout.  |

## ABSOLUTE MAXIMUM RATINGS <sup>(1)</sup>

|   |                               |
|---|-------------------------------|
| VBUS_P .....  | -0.3V (-5V for <10ns) to +24V |
| VDRV .....  | VBUS_P + 5V                   |
| VDD .....   | -0.3V to +3V                  |
| DM, DP, CC1, CC2 .....  | -0.3V (-5V for <10ns) to +24V |
| GPIO4, GPIO6, NTC .....   | -0.3V to +5.5V                |
| All other pins .....  | -0.3V to +6V                  |
| Continuous power dissipation (T <sub>A</sub> = 25°C) <sup>(2)</sup> |                               |
| QFN-20 (4mmx4mm) .....  | 2.1W                          |
| Junction temperature .....  | 150°C                         |
| Lead temperature .....  | 260°C                         |
| Storage temperature .....   | -65°C to +150°C               |

## ESD Ratings

|                                  |       |
|----------------------------------|-------|
| Human body model (HBM) .....     | ±2kV  |
| Charged device model (CDM) ..... | ±750V |

## Recommended Operating Conditions <sup>(3)</sup>

|  |                 |
|--|-----------------|
| Power supply to VCC .....                      | 5V/25mA         |
| Operating junction temp (T <sub>J</sub> ) .... | -40°C to +125°C |

## Thermal Resistance <sup>(4)</sup>      θ<sub>JA</sub>      θ<sub>JC</sub>

|                        |          |             |
|------------------------|----------|-------------|
| QFN-20 (4mmx4mm) ..... | 60 ..... | 12 ... °C/W |
|------------------------|----------|-------------|

### Notes:

- 1) Exceeding these ratings may damage the device.
- 2) The maximum allowable power dissipation is a function of the maximum junction temperature, T<sub>J</sub> (MAX), the junction-to-ambient thermal resistance, θ<sub>JA</sub>, and the ambient temperature, T<sub>A</sub>. The maximum allowable continuous power dissipation at any ambient temperature is calculated by P<sub>D</sub> (MAX) = (T<sub>J</sub> (MAX) - T<sub>A</sub>) / θ<sub>JA</sub>. Exceeding the maximum allowable power dissipation can cause excessive die temperature, and the device may go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.
- 3) The device is not guaranteed to function outside of its operating conditions.
- 4) Measured on JESD51-7, 4-layer PCB. The value of θ<sub>JA</sub> given in this table is only valid for comparison with other packages and cannot be used for design purposes. These values were calculated in accordance with JESD51-7 and simulated on a specified JEDEC board. They do not represent the performance obtained in an actual application.

## ELECTRICAL CHARACTERISTICS

$V_{CC} = 5V$ ,  $T_J = -40^{\circ}C$  to  $+125^{\circ}C$ , typical value is tested at  $T_J = 25^{\circ}C$ , unless otherwise noted.

| Parameter                              | Symbol                   | Condition  | Min  | Typ  | Max  | Units       |
|--|--------------------------|--|------|------|------|-------------|
| Standby supply current                 | $I_{STB}$                | VCC current, unattached  |      | 100  |      | $\mu A$     |
| Supply current (on)                    | $I_{ON}$                 | CC1 to GND with 5.1k $\Omega$ Rd (as defined by USB Type-C Cable and Connector Specification Revision 2.0, which can be downloaded from the official USB website at <a href="https://usb.org/">https://usb.org/</a> ). |      | 3.5  | 4.5  | mA          |
| Thermal shutdown <sup>(5)</sup>        | $T_{OTP\_R}$             |  |      | 150  |      | $^{\circ}C$ |
| Thermal hysteresis <sup>(5)</sup>      | $T_{OTP\_HYS}$           |  |      | 20   |      | $^{\circ}C$ |
| VDD regulator                          | $V_{DD}$                 |  | 1.7  | 1.8  | 1.9  | V           |
| VDD load regulation                    | $V_{DD\_REG}$            | $I_{DD} = 5mA$   |      | 3    |      | %           |
| VCC UVLO rising threshold              | $V_{CC\_RS}$             |  | 4    | 4.3  | 4.6  | V           |
| VCC UVLO threshold hysteresis          | $V_{CC\_HYS}$            |  |      | 350  |      | mV          |
| VBUS_P_UV falling threshold            | $V_{BUS\_P\_UV}$         | I <sup>2</sup> C set VBUS_UV_THD = 0b  | 2.79 | 2.97 | 3.15 | V           |
| <b>GPIO7</b>                           |                          |  |      |      |      |             |
| DISCHG output high                     | $V_{DIS\_HIGH}$          | Discharge turn-on, 50k $\Omega$ load   |      | 4.4  |      | V           |
| DISCHG output low                      | $R_{DIS\_LOW}$           |  |      | 3.3  |      | k $\Omega$  |
| ADJ sink current                       | $I_{ADJ}$                | GPIO3_ISENS+ = 1.5V  | 1    | 2    | 3    | $\mu A$     |
| EN_OUT_MID                             | $V_{EN\_OUT\_MID}$       | 100k $\Omega$ , pull-up resistor to 12V  | 0.8  | 1    | 1.2  | V           |
| EN_OUT high                            | $V_{EN\_OUT\_H}$         | Open drain, 100k $\Omega$ , pull-up resistor to VCC  | 4.5  |      |      | V           |
| EN_OUT low                             | $V_{EN\_OUT\_L}$         |  |      |      | 0.4  | V           |
| <b>GPIO5, GPIO6</b>                    |                          |  |      |      |      |             |
| VBUS_UV_FIXPDO falling threshold       | $V_{BUS\_UVFIX\_FALL}$   | VBUS = 5V  | 0.91 | 0.96 | 1.01 | V           |
| IPWM duty cycle                        | $IPWM_{DUTY}$            | 4.7k $\Omega$ , pull-up resistor to VCC, 3A PDO  |      | 50   |      | %           |
| SYNC_OUT1 frequency                    | $f_{SYNC1}$              | 4.7k $\Omega$ , pull-up resistor to VCC  |      | 450  |      | kHz         |
| SYNC_OUT2 frequency                    | $f_{SYNC2}$              | 4.7k $\Omega$ , pull-up resistor to VCC  |      | 450  |      | kHz         |
| I <sup>2</sup> C_SLV_SDA/SCL frequency | $f_{I2C\_SLV\_SDA\_SCL}$ | 4.7k $\Omega$ , pull-up resistor to VCC  |      | 400  |      | kHz         |
| VSEL2 output low                       | $V_{SEL\_LOW}$           | 100k $\Omega$ to VCC   |      |      | 0.4  | V           |
| <b>GPIO4, GPIO3</b>                    |                          |  |      |      |      |             |
| EN UVLO rising threshold               | $V_{EN\_H}$              |  | 1.33 | 1.43 | 1.53 | V           |
| EN UVLO falling hysteresis voltage     | $V_{EN\_L}$              |  |      | 220  |      | mV          |
| EN_OFF_DELAY                           | $t_{EN\_OFF\_DELAY}$     | EN_OFF_TIMER = 010b  |      | 22   |      | min         |
| VBATT low falling threshold            | $V_{BATT\_LOW\_F}$       | Set GPIO4 = 11b  | 1.07 | 1.12 | 1.17 | V           |
| VBATT low rising threshold             | $V_{BATT\_LOW\_R}$       | Set GPIO4 = 11b  | 1.12 | 1.18 | 1.24 | V           |

**ELECTRICAL CHARACTERISTICS (continued)**

$V_{CC} = 5V$ ,  $T_J = -40^{\circ}C$  to  $+125^{\circ}C$ , typical value is tested at  $T_J = 25^{\circ}C$ , unless otherwise noted.

| Parameter   | Symbol              | Condition   | Min | Typ  | Max  | Units      |
|---|---------------------|---|-----|------|------|------------|
| ATTACH output high  | $V_{ATTACH\_HIGH}$  |   | 4.5 |      |      | V          |
| ATTACH output low   | $V_{ATTACH\_LOW}$   | Sink is attached  |     |      | 0.4  | V          |
| IPWM duty cycle   | $IPWM_{DUTY}$       | 4.7k $\Omega$ , pull-up resistor to VCC,<br>3A PDO              |     | 50   |      | %          |
| Plug orientation (POL)<br>output low                      | $V_{POL\_L}$        | CC1 = 5.1k $\Omega$   |     |      | 0.4  | V          |
| POL output high   | $V_{POL\_H}$        | CC2 = 5.1k $\Omega$ , 10k $\Omega$ ,<br>pull-up resistor to VCC | 4.5 |      |      | V          |
| <b>GPIO2</b>  |                     |   |     |      |      |            |
| Power share input low                                     | $V_{PS\_LOW}$       | 10k $\Omega$ pull-up resistor to VCC                            |     |      | 0.4  | V          |
| Power share input high                                    | $V_{PS\_H}$         | 10k $\Omega$ pull-up resistor to VCC                            | 3   |      |      | V          |
| POL output low  | $V_{POL\_L}$        | CC1 = 5.1k $\Omega$   |     |      | 0.4  | V          |
| POL output high   | $V_{POL\_H}$        | CC2 = 5.1k $\Omega$ , 10k $\Omega$ ,<br>pull-up resistor to VCC | 4.5 |      |      | V          |
| QC_12 pull low resistance                                 | $R_{QC\_12}$        | DP/DM enter QC 12V  |     | 8    |      | $\Omega$   |
| <b>I2C_MODE</b>   |                     |   |     |      |      |            |
| Logic high threshold                                      | $V_{I2C\_H}$        | Slave mode  | 1   | 1.2  | 1.4  | V          |
| Hysteresis  | $V_{I2C\_H\_HYS}$   |   |     | 100  |      | mV         |
| Resistance  | $R_{I2C\_MODE}$     |   |     | 1    |      | M $\Omega$ |
| <b>GPIO1</b>  |                     |   |     |      |      |            |
| VSEL1 pull low resistance                                 | $R_{VSEL1}$         | 12V PDO is selected   |     | 100  |      | k $\Omega$ |
| VSEL1 output high   | $V_{SEL\_HIGH}$     | 100k $\Omega$ to VCC  | 4.5 |      |      | V          |
| INT logic high  | $V_{INT\_HIGH}$     |   | 4.5 |      |      | V          |
| INT logic low   | $V_{INT\_LOW}$      |   |     |      | 0.4  | V          |
| Leakage   | $I_{INT\_LKG}$      |   |     |      | 1    | $\mu A$    |
| <b>PDO_SEL_OUTPUT (Configure SLAVE_DEVICE_SEL = 101b)</b> |                     |   |     |      |      |            |
| PDO2 to PDO3 SEL_OUT<br>pull low resistance               | $R_{PDO2\_LOW}$     |   |     | 7    |      | $\Omega$   |
| PDO2-4 SEL OUT leakage                                    | $V_{PDO\_HIGH}$     | 5V PDO is selected  |     |      | 1    | $\mu A$    |
| <b>NTC, NTC2</b>  |                     |   |     |      |      |            |
| External thermal-sense<br>trip threshold                  | $V_{NTC\_R}$        | $R_P = 47k\Omega$ , $R_{NTC} = 4.72k\Omega$ (100 $^{\circ}C$ )  | 7.5 | 9.1  | 10.5 | %VCC       |
| External thermal-sense<br>recovery threshold              | $V_{NTC\_F}$        | $R_P = 47k\Omega$ , $R_{NTC} = 9.45k\Omega$ (80 $^{\circ}C$ )   |     | 16.7 |      | %VCC       |
| <b>Gate Drive (VDRV)</b>                                  |                     |   |     |      |      |            |
| Gate drive voltage  | $V_{DRV}$           | $V_{DRV} - V_{BUS\_P}$  |     | 4.85 |      | V          |
| Gate drive voltage at 15 $\mu A$                          | $V_{DRV\_1}$        | $I_{SOURCE} = 15\mu A$  |     | 4.4  |      | V          |
| Pull-down resistor  | $R_{PULL\_DOWN}$    |   |     | 5    |      | k $\Omega$ |
| <b>BC1.2 DCP Mode</b>                                     |                     |   |     |      |      |            |
| DP and DM short resistance                                | $R_{DP\_DM\_SHORT}$ | $V_{DP} = 0.8V$ , $I_{DM} = 1mA$ , $T_J = 25^{\circ}C$          |     | 25   | 40   | $\Omega$   |



## ELECTRICAL CHARACTERISTICS (continued)

$V_{CC} = 5V$ ,  $T_J = -40^{\circ}C$  to  $+125^{\circ}C$ , typical value is tested at  $T_J = 25^{\circ}C$ , unless otherwise noted.

| Parameter  | Symbol                  | Condition                               | Min  | Typ  | Max  | Units      |
|--|-------------------------|---|------|------|------|------------|
| <b>Divider Mode</b>  |                         |   |      |      |      |            |
| DP output voltage  | $V_{DIVIDER\_DP}$       | $V_{OUT} = 5V$                          | 2.55 | 2.75 | 2.95 | V          |
| DM output voltage  | $V_{DIVIDER\_DM}$       | $V_{OUT} = 5V$                          | 3.35 | 3.6  | 3.85 | V          |
| DP output impedance  | $R_{DIVIDER\_DP}$       |   |      | 22   |      | k $\Omega$ |
| DM output impedance  | $R_{DIVIDER\_DM}$       |   |      | 22   |      | k $\Omega$ |
| <b>1.2V/1.2V Mode</b>  |                         |   |      |      |      |            |
| DP/DM output voltage   | $V_{DP\_DM\_1.2V}$      | $V_{OUT} = 5V$                          | 1.05 | 1.20 | 1.35 | V          |
| DP/DM output impedance   | $R_{DP\_DM\_1.2V}$      |   |      | 300  |      | k $\Omega$ |
| <b>Quick Charge 3.0 Mode</b>                                   |                         |   |      |      |      |            |
| DP/DM low voltage  | $V_{QC\_LOW}$           |   | 0.2  | 0.3  | 0.4  | V          |
| DP/DM high voltage   | $V_{QC\_HIGH}$          |   | 1.8  | 2    | 2.2  | V          |
| DP output impedance  | $R_{DP\_QC}$            |   |      | 350  | 1500 | k $\Omega$ |
| DM output impedance  | $R_{DM\_QC}$            |   |      | 20   |      | k $\Omega$ |
| DM low glitch time <sup>(5)</sup>                              | $t_{GLITCH\_DM}$        |   |      | 10   |      | ms         |
| DP high glitch time  | $t_{GLITCH\_DP}$        |   | 1000 |      | 1500 | ms         |
| Output voltage change glitch time <sup>(5)</sup>               | $t_{GLITCH\_V\_CHANGE}$ |   | 20   | 40   | 60   | ms         |
| Bus voltage step <sup>(5)</sup>                                | $V_{BUS\_CONT\_STEP}$   |   | 150  | 200  | 250  | mV         |
| Time for VBUS to discharge to 5V when DP < 0.6V <sup>(5)</sup> | $t_{V\_UNPLUG}$         |   |      |      | 500  | ms         |
| <b>FCP Mode</b>  |                         |   |      |      |      |            |
| DM Tx high voltage   | $V_{FCPT\_H}$           | $R_{LOAD} = 15k\Omega$                  | 2.55 |      | 5    | V          |
| DM Tx low voltage  | $V_{FCPT\_L}$           | $R_{LOAD} = 15k\Omega$                  |      |      | 0.4  | V          |
| DM Rx high voltage   | $V_{FCPR\_H}$           |   | 1.5  |      | 5    | V          |
| DM Rx low voltage  | $V_{FCPR\_L}$           |   |      |      | 1    | V          |
| DM pull-low resistance <sup>(5)</sup>                          | $R_{LD\_D-}$            |   |      | 15   |      | k $\Omega$ |
| Unit interval of PHY <sup>(5)</sup>                            | UI                      | $f_{CLK} = 125kHz$                      | 144  | 160  | 176  | $\mu s$    |
| <b>CDP Mode (I<sup>2</sup>C set CDP_EN=1)</b>                  |                         |   |      |      |      |            |
| DM CDP output voltage  | $V_{DM\_SRC}$           | $V_{DP} = 0.6V$ , $DM\_SINK = 250\mu A$ | 0.5  | 0.6  | 0.7  | V          |
| DP rising lower window threshold for $V_{DM\_SRC}$             | $V_{DAT\_REF}$          |   | 0.25 | 0.35 | 0.45 | V          |
| DP rising lower window threshold hysteresis                    | $V_{DAT\_REF\_HYS}$     |   |      | 50   |      | mV         |
| DP rising upper window threshold for $V_{DM\_SRC}$             | $V_{LGC\_SRC}$          |   | 0.8  | 0.95 | 1.1  | V          |
| DP rising upper window threshold hysteresis                    | $V_{LGC\_SRC\_HYS}$     |   |      | 80   |      | mV         |
| <b>USB Type-C – CC1 and CC2 pins</b>                           |                         |   |      |      |      |            |
| CC pull-up current 1   | $I_{RP1}$               | $VBUS = 5V/3A$ , $T_J = 25^{\circ}C$    | 304  | 330  | 356  | $\mu A$    |
| CC pull-up current 2   | $I_{RP2}$               | $VBUS = 5V/1.5A$ , $T_J = 25^{\circ}C$  | 162  | 180  | 198  | $\mu A$    |
| CC voltage to enable $V_{CONN}$ for 3A Type-C mode             | $V_{RA1}$               | $T_J = 25^{\circ}C$                     |      |      | 0.75 | V          |

## ELECTRICAL CHARACTERISTICS (continued)

$V_{CC} = 5V$ ,  $T_J = -40^{\circ}C$  to  $+125^{\circ}C$ , typical value is tested at  $T_J = 25^{\circ}C$ , unless otherwise noted.

| Parameter   | Symbol                   | Condition               | Min  | Typ  | Max  | Units      |
|---|--------------------------|-------------------------|------|------|------|------------|
| CC voltage to enable $V_{BUS}$ for 3A Type-C mode             | $V_{RD1}$                | $T_J = 25^{\circ}C$     | 0.85 |      | 2.45 | V          |
| CC detach threshold for 3A Type-C mode                        | $V_{OPEN1}$              | $T_J = 25^{\circ}C$     | 2.75 |      |      | V          |
| CC voltage falling debounce timer                             | $t_{CC\_DEBOUNCE}$       | VBUS enable deglitch    | 100  | 150  | 200  | ms         |
| CC voltage rising debounce timer                              | $t_{PD\_DEBOUNCE}$       | VBUS disable deglitch   | 5    | 10   | 15   | ms         |
| $V_{CONN}$ output power                                       | $P_{V\_CONN}$            | VCC supplies $V_{CONN}$ | 0.1  |      |      | W          |
| <b>USB PD</b>   |                          |                         |      |      |      |            |
| Unit interval   | $t_{UI}$                 | $T_J = 25^{\circ}C$     | 3.0  | 3.35 | 3.7  | $\mu s$    |
| <b>Transmitter</b>  |                          |                         |      |      |      |            |
| End drive BMC <sup>(5)</sup>                                  | $t_{EDBMC}$              |                         |      |      | 23   | $\mu s$    |
| Fall time <sup>(5)</sup>                                      | $t_{FALL}$               |                         | 300  |      |      | ns         |
| Rise time <sup>(5)</sup>                                      | $t_{RISE}$               |                         | 300  |      |      | ns         |
| Hold low BMC <sup>(5)</sup>                                   | $t_{HLBMC}$              |                         | 1    |      |      | $\mu s$    |
| Logic high voltage  | $V_{LH}$                 |                         | 1    | 1.15 | 1.3  | V          |
| Logic low voltage   | $V_{LL}$                 |                         |      |      | 100  | mV         |
| Output impedance  | $R_{TX}$                 |                         |      | 50   |      | $\Omega$   |
| <b>Receiver <sup>(5)</sup></b>                                |                          |                         |      |      |      |            |
| CC receiver capacitance                                       | $C_{RECEIVER}$           |                         |      |      | 600  | pF         |
| Transitions for signal detection                              | $N_{TRANSITION}$         |                         | 3    |      |      | edges      |
| Rx bandwidth limiting filter                                  | $t_{RX\_FILTER}$         |                         | 100  |      |      | ns         |
| Time Window for Detecting Non-idle                            | $t_{TRANSITION\_WINDOW}$ |                         | 12   |      | 20   | $\mu s$    |
| Receiver input impedance                                      | $R_{BMC\_RX}$            |                         | 1    |      |      | M $\Omega$ |
| <b>I<sup>2</sup>C Interface Specifications <sup>(5)</sup></b> |                          |                         |      |      |      |            |
| Input logic high  | $V_{IL}$                 |                         | 1.4  |      |      | V          |
| Input logic low   | $V_{IH}$                 |                         |      |      | 0.6  | V          |
| Output voltage logic low                                      | $V_{OUT\_L}$             |                         |      |      | 0.4  | V          |
| SCL clock frequency   | $f_{SCL}$                |                         |      | 400  |      | kHz        |
| SCL high time   | $t_{HIGH}$               |                         | 60   |      |      | ns         |
| SCL low time  | $t_{LOW}$                |                         | 160  |      |      | ns         |
| Data set-up time  | $t_{SU\_DAT}$            |                         | 10   |      |      | ns         |
| Data hold time  | $t_{HD\_DAT}$            |                         |      | 70   |      | ns         |
| Set-up time for repeated start                                | $t_{SU\_STA}$            |                         | 160  |      |      | ns         |
| Hold time for a repeated start condition                      | $t_{HD\_STA}$            |                         | 160  |      |      | ns         |
| Bus free time between a start and a stop condition            | $t_{BUF}$                |                         | 160  |      |      | ns         |

## ELECTRICAL CHARACTERISTICS *(continued)*

$V_{CC} = 5V$ ,  $T_J = -40^{\circ}C$  to  $+125^{\circ}C$ , typical value is tested at  $T_J = 25^{\circ}C$ , unless otherwise noted.

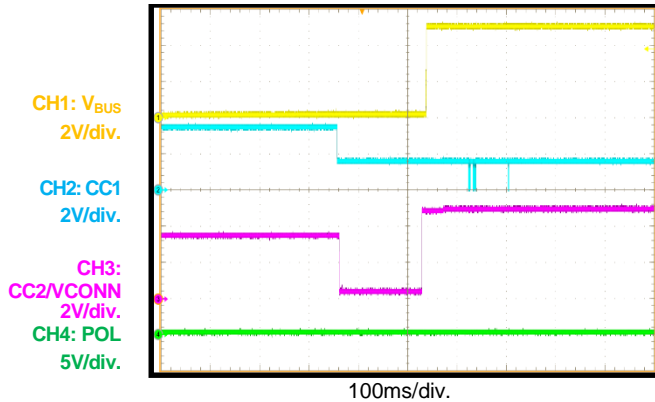
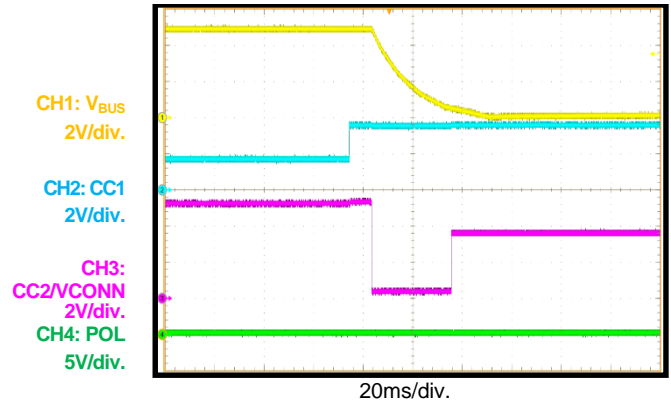
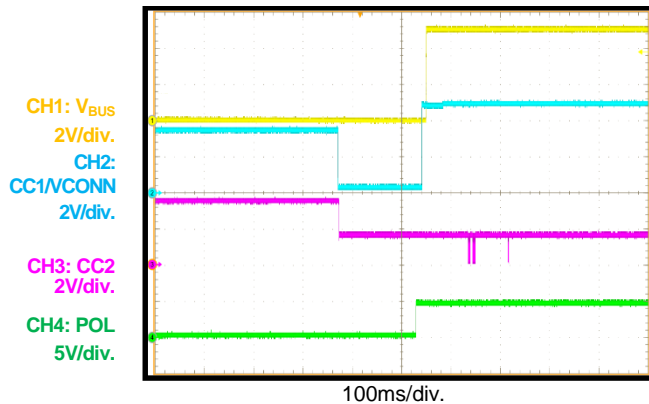
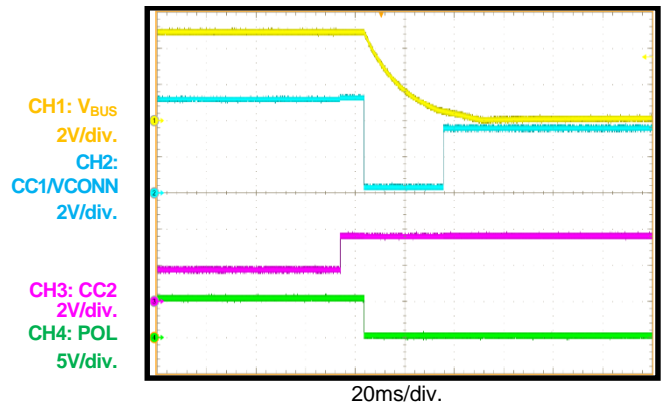
| Parameter                         | Symbol       | Condition | Min | Typ | Max | Units |
|-----------------------------------|--------------|-----------|-----|-----|-----|-------|
| Set-up time for a stop condition  | $t_{SU,STO}$ |           | 160 |     |     | ns    |
| SCL and SDA rise time             | $t_R$        |           | 10  |     | 300 | ns    |
| SCL and SDA fall time             | $t_F$        |           | 10  |     | 300 | ns    |
| Pulse width of suppressed spike   | $t_{SP}$     |           | 0   |     | 50  | ns    |
| Capacitance bus for each bus line | $C_B$        |           |     |     | 400 | pF    |

### Note:

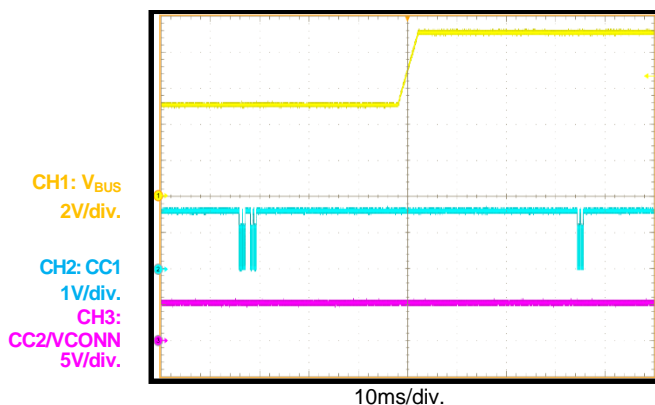
5) Guaranteed by characterization.

# TYPICAL PERFORMANCE CHARACTERISTICS

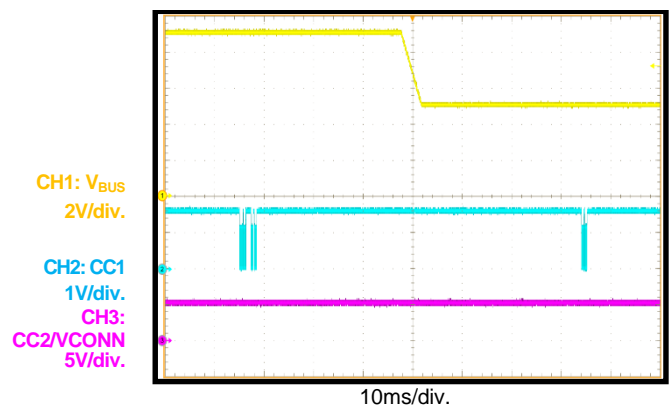
$V_{CC} = 5V$ ,  $V_{BUS} = 5V$  to  $20V$ ,  $T_A = 25^\circ C$ , unless otherwise noted. Connect the MPQ5031's  $V_{BUS\_P}$  pin to the MPQ4230's output.

**CC1 Attached Rd to Enable VBUS**
 $I_{OUT} = 0A$ 

**CC1 Detached Rd to Disable VBUS**
 $I_{OUT} = 0A$ 

**CC2 Attached Rd to Enable VBUS**
 $I_{OUT} = 0A$ 

**CC2 Detached Rd to Disable VBUS**
 $I_{OUT} = 0A$ 

**PDO Transition**

5V PDO to 9V PDO


**PDO Transition**

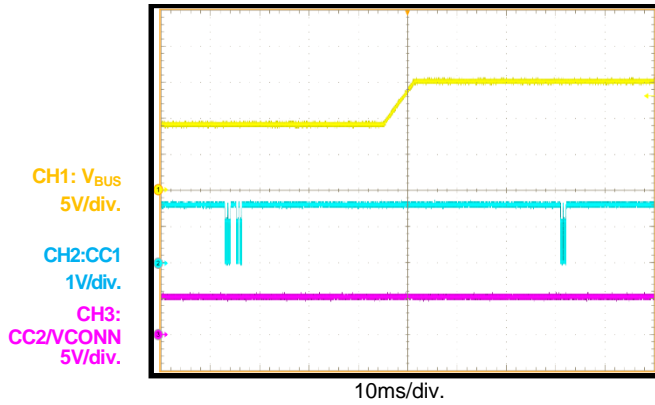
9V PDO to 5V PDO



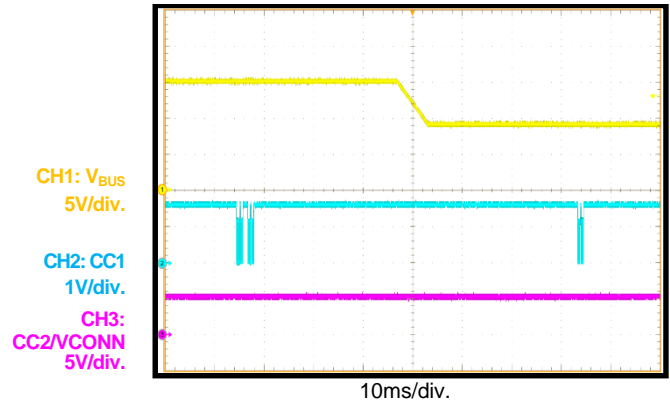
# TYPICAL PERFORMANCE CHARACTERISTICS (continued)

$V_{CC} = 5V$ ,  $V_{BUS} = 5V$  to  $20V$ ,  $T_A = 25^\circ C$ , unless otherwise noted. Connect the MPQ5031's VBUS\_P pin to the MPQ4230's output.

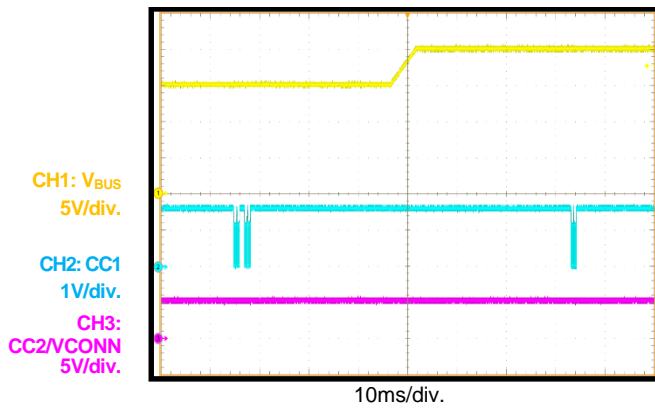
**PDO Transition**  
9V PDO to 15V PDO



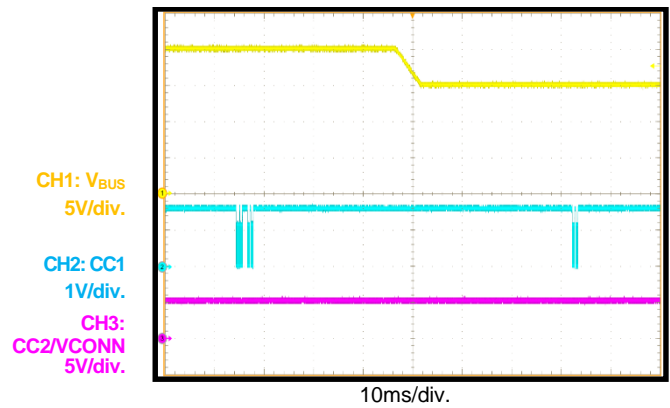
**PDO Transition**  
15V PDO to 9V PDO



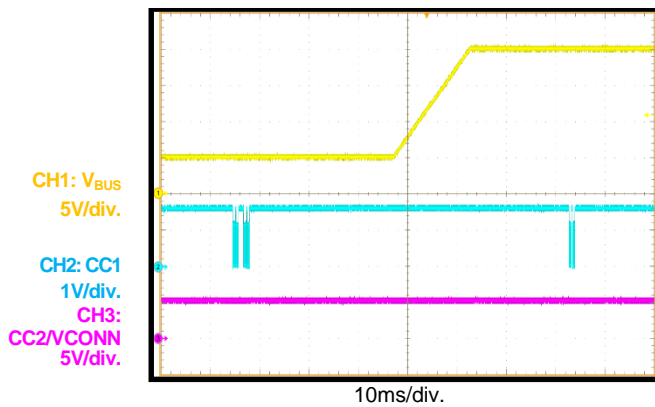
**PDO Transition**  
15V PDO to 20V PDO



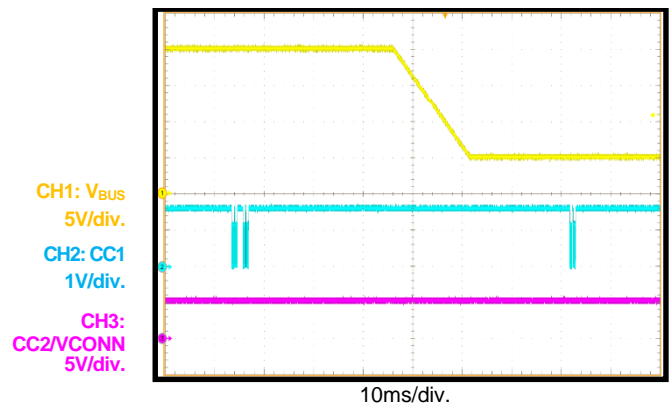
**PDO Transition**  
20V PDO to 15V PDO



**PDO Transition**  
5V PDO to 20V PDO



**PDO Transition**  
20V PDO to 5V PDO

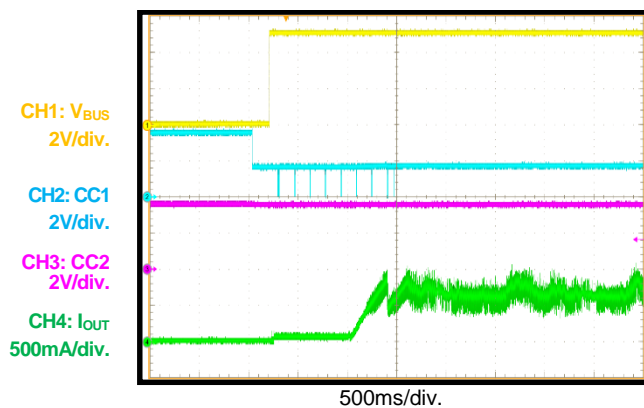


## TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

$V_{CC} = 5V$ ,  $V_{BUS} = 5V$  to  $20V$ ,  $T_A = 25^\circ C$ , unless otherwise noted. Connect the MPQ5031's VBUS\_P pin to the MPQ4230's output.

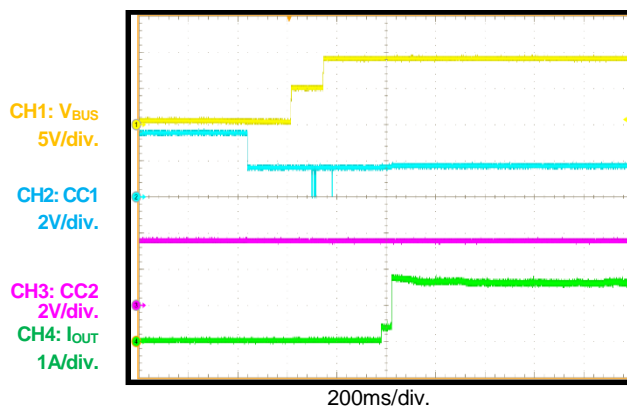
### Mobile Phone Charging Test

Phone requests 5V PDO



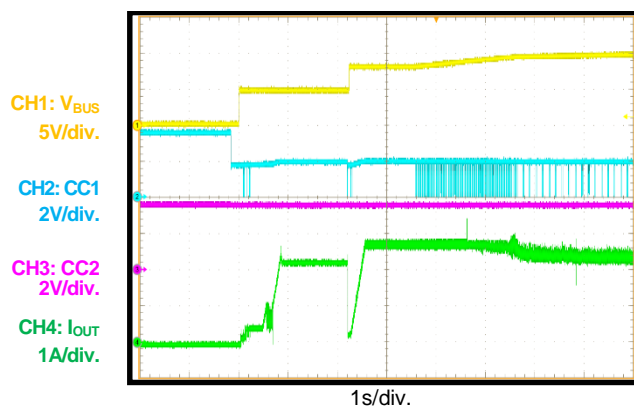
### Mobile Phone Charging Test

Phone requests 9V PDO



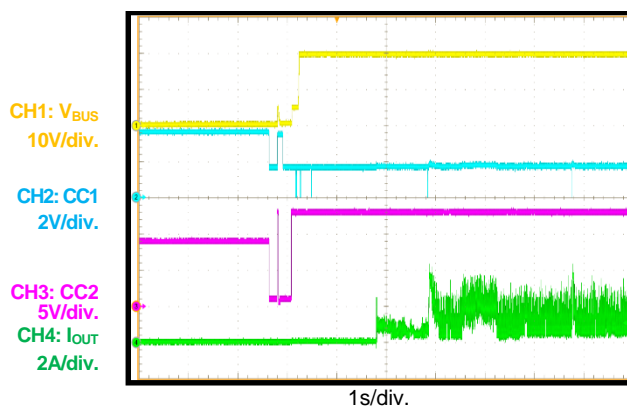
### Mobile Phone Charging Test

Phone requests 3.3V to 21V APDO



### Laptop Charging Test

Laptop requests 20V PDO



The block diagram illustrates the internal architecture of the USB-C PD controller IC. Key components and connections include:

- Power Input/Output:**
  - VBUS\_P:** Connected to the VCC pin of the Charge Pump and the VCC pin of the IC.
  - VCC:** Connected to the VCC pin of the IC and the VCC pin of the Charge Pump.
  - VDD:** Connected to the VDD pin of the IC and the VDD pin of the 1.8V VDD Regulator.
  - GND:** Connected to the GND pin of the IC and the GND pin of the 1.8V VDD Regulator.
- Control Logic:** The central component of the IC, receiving inputs from the 1.8V VDD Regulator, the NTC Comparator, the Thermal Sense, the Type-C Connection Detection and V<sub>CONN</sub> Control, and the I<sup>2</sup>C and OTP. It outputs to the VCONN, HV Switch and OCP, and the Charge Pump.
- Regulation and Protection:**
  - 1.8V VDD Regulator:** Provides a stable 1.8V supply to the IC.
  - NTC Comparator:** Monitors the temperature (NTC) and provides feedback to the Control Logic.
  - Thermal Sense:** Provides temperature feedback to the Control Logic.
  - Charge Pump:** Boosts the VCC supply to VDRV (V<sub>DRV</sub>) for the HV Switch and OCP.
  - UVLO (Undervoltage Lockout):** Monitors the VCC supply and provides feedback to the Control Logic.
- Communication and Configuration:**
  - I<sup>2</sup>C and OTP:** Provides I<sup>2</sup>C communication and OTP (One-Time Programmable) memory to the Control Logic.
  - GPIOs (GPIO2 to GPIO7):** General Purpose Input/Output pins for external control.
  - GPIO1:** Connected to the Ref pin of the Charge Pump.
- External Components:**
  - CC1 and CC2:** Connected to the CC1 and CC2 pins of the IC, which are used for Type-C connection detection and V<sub>CONN</sub> control.
  - DM and DP:** Differential Mode and Differential Pair pins for USB-C data communication.
  - BC1.2:** A BC1.2 (Battery Charge Controller) component connected to the DCP Auto-Detection CDP, QC3.0, FCP pins.

### Figure 2: Functional Block Diagram

## OPERATION

### Under-Voltage Lockout (UVLO)

Under-voltage lockout (UVLO) protects the chip from operating at an insufficient supply voltage. The MPQ5031's UVLO comparator monitors the VCC input voltage.

### VCC and VDD Regulator

The VCC pin is biased by an external 5V supply (e.g. the DC/DC converter's VCC pin). The VCC pin must have a decoupling capacitor between 1 $\mu$ F and 10 $\mu$ F.

The 1.8V internal VDD regulator uses VCC as the input. The VDD pin powers most of the digital circuitries, and requires a 0.47 $\mu$ F decoupling capacitor.

### Charging Mode Auto-Detection

#### Legacy USB 2.0 Mode

The MPQ5031 integrates a USB dedicated charging port auto-detection function that can recognize most mainstream portable devices. It supports the following charging schemes:

- USB Battery Charging Specification BC1.2/ Chinese Telecommunications Industry Standard YD/T 1591-2009
- Apple 3A divider mode
- 1.2V/1.2V mode
- QC3.0 Class A (3.3V to 12V)
- Huawei FCP Class A

The auto-detection function is a state machine that supports all of the above DCP charging schemes, starting in divider mode. If a device compliant with divider mode is attached, the MPQ5031 remains in divider mode. Then 3.6V is applied to the DM pin, and 2.7V is applied to the DP pin.

If a device compliant with BC1.2 or YD/T 1591-2009 is attached, the MPQ5031 operates in 1.2V/1.2V and BC1.2 DCP mode. DM and DP are shorted together with a resistance below 40 $\Omega$ . The MPQ5031 remains in that mode until the device releases the data line. Then the device returns to divider mode.

When a QC3.0 or FCP device (without PD protocol) is attached, the MPQ5031 automatically enters high-voltage quick charge mode.

The MPQ5031 supports BC1.2 charging data

port (CDP) handshaking as well, which can be enabled by the I<sup>2</sup>C. DCP mode should be disabled (LEGACY\_CHARGING\_MODE\_SEL = 11b) when the CDP function is selected.

If a USB PD contract is established once the sink is attached, QC3.0 functionality is disabled, but BC1.2 short mode is still enabled.

### USB Type-C Port

The USB Type-C receptacle, plug, and cable solution incorporates a configuration process to detect a downstream-facing port (DFP) to upstream-facing port (UFP) connection for V<sub>BUS</sub> management, and to determine the host-to-device relationship.

Initially, DFP-to-UFP attachment is detected by a host (DFP) when one of the CC pins at its USB Type-C receptacle senses a specified resistance to GND. Subsequently, UFP-to-DFP detachment is detected when the CC pin that was terminated at its USB Type-C receptacle is no longer connected to GND.

Power is not applied to the USB Type-C host or hub receptacle (V<sub>BUS</sub> or V<sub>CONN</sub>) until the DFP detects the presence of an attached device (UFP) port. When a DFP-to-UFP attachment is detected, the DFP enables power to the receptacle and begins normal USB operation with the attached device. When a DFP-to-UFP detachment is detected, the port sourcing V<sub>BUS</sub> removes power.

The MPQ5031 is a DFP (provider only), and its power supply capability is rated at 5V/3.0A by default. V<sub>CONN</sub> is provided by the DFP to power the cables and electronics in the plug. V<sub>CONN</sub> is provided instead of the CC pin if the CC pin is not connected to the cable's configuration channel (CC) wire. V<sub>CONN</sub> has a maximum power output of 100mW.

V<sub>CONN</sub> is disabled until R<sub>A</sub> is detected. R<sub>A</sub> is a pull-down resistor connected from the CC pin to GND, and its resistance should be below 1.2k $\Omega$ .

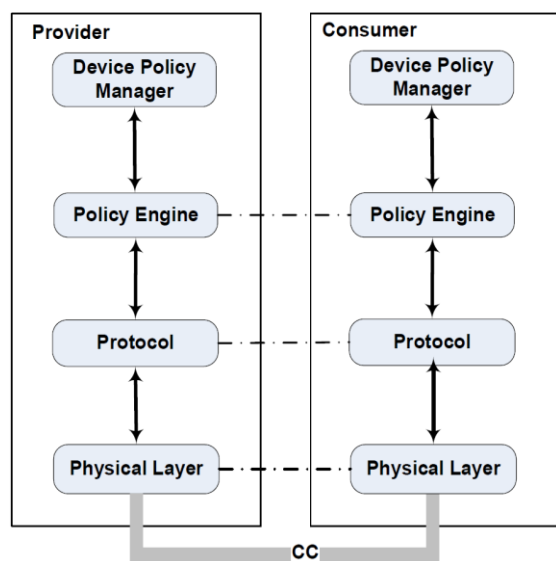
### USB Power Delivery

In USB power delivery (PD), pairs of directly attached ports negotiate voltage, current, and/or direction of power flow over the USB cable by



using the CC wire as the communication channel. The mechanisms that are implemented operate independently of other USB methods that are used to negotiate power.

Type-C connectors can support the CC wire as the communication channel. The USB PD engine is disabled until a valid Type-C connection is established. Figure 3 shows a USB PD communication stack.



**Figure 3: USB PD Communication Stack**

### DFP Commands

Table 1, Table 2, and Table 3 list the MPQ5031's supported commands. Table 1 lists the control messages.

**Table 1: Control Message**

| Transmitted Message   | Received Message        |
|-----------------------|-------------------------|
| Accept                | Get_PPS_Status          |
| Get_Sink_Cap          | Get_Source_Cap          |
| Get_Sink_Cap_Extended | Get_Source_Cap_Extended |
| Get_Status            | Get_Status              |
| GoodCRC               | GoodCRC                 |
| GotoMin               | Not_Supported           |
| Not_Supported         | Reject                  |
| PS_RDY                | Soft_Reset              |
| Reject                | VCONN_Swap              |
| Soft_Reset            |                         |

Table 2 lists the different data messages.

**Table 2: Data Messages**

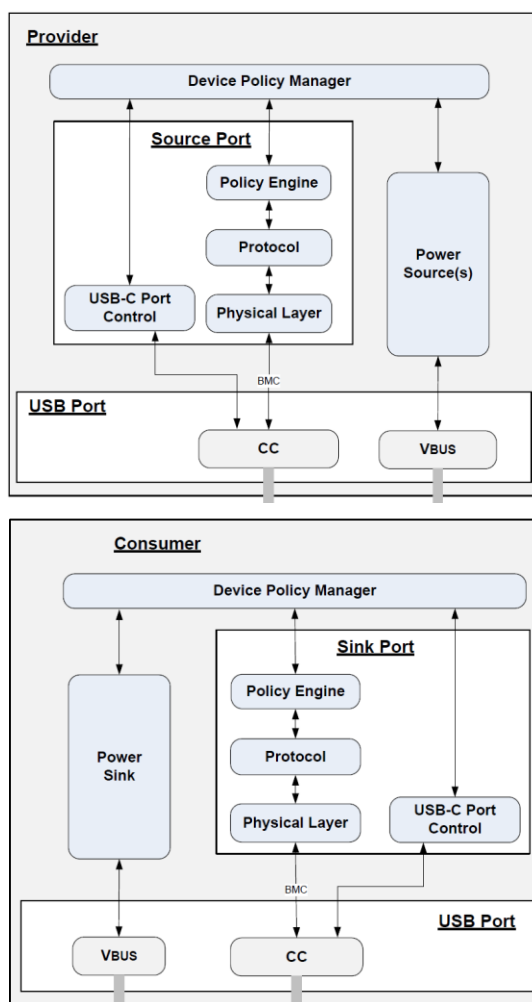
| Transmitted Message | Received Message  |
|---------------------|-------------------|
| Source_Capabilities | Sink_Capabilities |
| BIST                | Request           |
| Alert               | BIST              |
|                     | Alert             |

Table 3 lists the extended messages.

**Table 3: Extended Messages**

| Transmitted Message          | Received Message |
|------------------------------|------------------|
| Status                       |                  |
| PPS_Status                   |                  |
| Source_Capabilities_Extended |                  |

The MPQ5031 also supports soft reset, hard reset, and cable discovery for VDM signals. Figure 4 shows the device policy manager.



**Figure 4: Device Policy Manager**

## PD Contract Handshake

Figure 5 shows the MPQ5031's PD contract handshake sequence.

| #  | CH  | OS   | Power  | Data | Cable Plug | Type                |
|----|-----|------|--------|------|------------|---------------------|
| 0  | CC2 | SOP' |        |      | UFP or DFP | Vendor_Defined      |
| 1  | CC2 | SOP' |        |      | Cable Plug | GoodCRC             |
| 2  | CC2 | SOP' |        |      | Cable Plug | Vendor_Defined      |
| 3  | CC2 | SOP' |        |      | UFP or DFP | GoodCRC             |
| 4  | CC2 | SOP  | Source | DFP  |            | Source_Capabilities |
| 5  | CC2 | SOP  | Sink   | UFP  |            | GoodCRC             |
| 6  | CC2 | SOP  | Sink   | UFP  |            | Request             |
| 7  | CC2 | SOP  | Source | DFP  |            | GoodCRC             |
| 8  | CC2 | SOP  | Source | DFP  |            | Accept              |
| 9  | CC2 | SOP  | Sink   | UFP  |            | GoodCRC             |
| 10 | CC2 | SOP  | Source | DFP  |            | PS_RDY              |
| 11 | CC2 | SOP  | Sink   | UFP  |            | GoodCRC             |

**Figure 5: PD Contract Handshake**

## VBUS and VCONN Discharge

When the sink is detached or a hard reset occurs, the MPQ5031 sends a command to turn off the DC/DC regulator's output voltage, and VBUS\_P's 200Ω discharge resistor turns on for 200ms. The GPIO7 pin can also be used to control an external MOSFET to discharge the output voltage for 200ms. Meanwhile, the VCONN voltage is discharged with a 1kΩ resistor for 30ms.

## VBUS Under-Voltage (UV) Detection

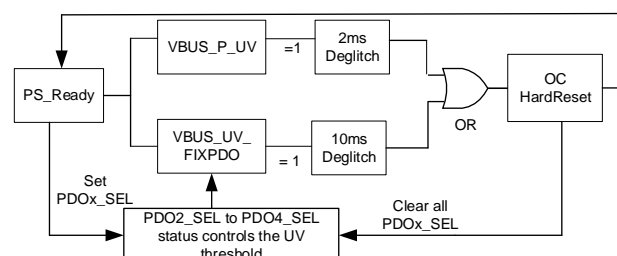
When a DC/DC converter with an I<sup>2</sup>C interface is selected, the VBUS under-voltage (UV) detection function is enabled by monitoring PG\_STATUS. If the VBUS\_P voltage is <2.97V (or <4.5V) during PPS operation, the VBUS\_UV bit is set to 1 internally, and a hard reset is triggered.

When a DC/DC converter without an I<sup>2</sup>C interface is selected, PPS functionality is disabled. In fixed PDO operation, GPIO5 can be configured to VBUS\_UV\_FIXPDO. For this function, connect GPIO5 to VBUS with a 1/5 resistor divider to detect the VBUS voltage. Table 4 lists how to set the VBUS UV threshold in a fixed PDO state. When the VBUS voltage is below the threshold, VBUS\_UV\_FIXPDO is set to 1 internally, and a hard reset is triggered.

**Table 4: VBUS UV Threshold (Only Valid for DC/DC Converters without I<sup>2</sup>C )**

| Sink Requested                 | VBUS_UV_FIXPDO Threshold (V) | VBUS UV threshold (V) |
|--------------------------------|------------------------------|-----------------------|
| Default, V <sub>OUT</sub> = 5V | 0.96                         | 4.8                   |
| V <sub>OUT</sub> = 9V          | 1.743                        | 8.715                 |
| V <sub>OUT</sub> = 15V         | 2.938                        | 14.69                 |
| V <sub>OUT</sub> = 20V         | 3.88                         | 19.4                  |

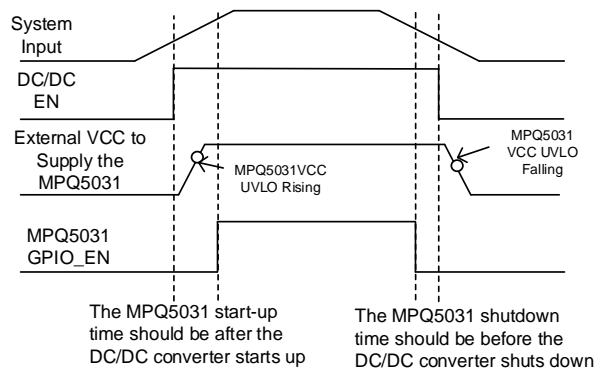
Figure 6 shows a VBUS UV example.



**Figure 6: VBUS UV Detection for Non-I<sup>2</sup>C DC/DC Applications Start-Up and Shutdown Timing**

The GPIO3, GPIO4, and GPIO6 pins can be configured to be the EN input function that controls when the MPQ5031 is on or off.

If the MPQ5031's VCC exceeds 4.3V and the GPIOx\_EN pin is pulled high, the PD engine can be enabled. The MPQ5031's start-up time should begin after the DC/DC converter start-up time, and its shutdown time should be before the converter's shutdown time (see Figure 7).



**Figure 7: MPQ5031 Start-Up and Shutdown Timing**

When the MPQ421x, MPQ423x, MPQ426x or MPQ4272 is used as the DC/DC converter, the converter's 5V LDO output can power the MPQ5031's VCC. If the MP28167-A is selected as the DC/DC converter, an external 5V LDO should be added to power the MPQ5031. The

external 5V LDO's start-up timing should be later than the MP281671-A's timing.

In the MPQ421x, MPQ4272, or MP28167-A PD solution, the MPQ5031's GPIOx\_EN pin should be added to control the PD engine's start-up/shutdown time.

If connecting the MPQ5031 GPIOx\_EN pin to VIN, the input voltage (VIN) of the PD's start-up and shutdown sequence can be calculated with Equation (1) and Equation (2), respectively:

$$V_{IN\_ON} (V) = 1.43V \times (R_{DN2} + R_{UP2}) / R_{DN2} \quad (1)$$

$$V_{IN\_OFF} (V) = 1.21V \times (R_{DN2} + R_{UP2}) / R_{DN2} \quad (2)$$

Figure 8 shows the MPQ5031's start-up time schematic.

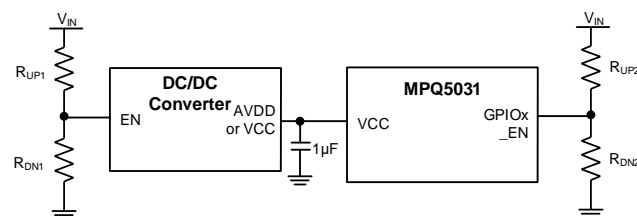


Figure 8: MPQ5031 Start-Up Time Schematic

Table 5 lists the VIN start-up and shutdown thresholds.

Table 5: VIN Start-Up/Shutdown Threshold

|                   | DC/DC EN Divider (kΩ) | MPQ5031 EN Divider (kΩ) | DC/DC Start-Up/Shutdown (V) | MPQ5031 Start-Up/Shutdown (V) |
|-------------------|-----------------------|-------------------------|-----------------------------|-------------------------------|
| MPQ5031 + MPQ4214 | 100/30                | 100/28.4                | 5.85/5.07                   | 6.47/5.47                     |
| MPQ5031 + MPQ4272 | 100/39                | 100/28.4                | 5.7/4.9                     | 6.47/5.47                     |

## EN Off Delay Timer

The GPIO3 pin can be configured for EN\_OFF\_DELAY\_OUT functionality. When EN is high, the IC is enabled immediately. When the external EN off signal is received, EN\_OFF\_DELAY\_OUT (GPIO3) remains high for 22min (EN\_OFF\_TIMER = 010b) to enable the upstream DC/DC converter. Once the 22min delay time completes, the USB PD engine is disabled immediately and CLK is disabled after a 200ms delay (see Figure 9). Figure 10 on page 20 shows the timing sequence.

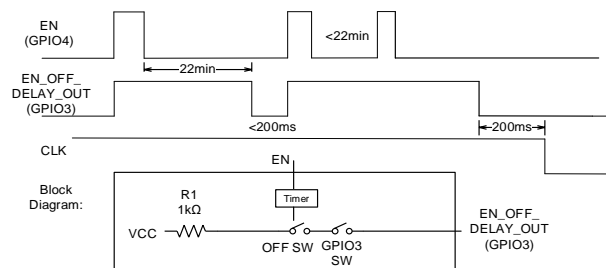
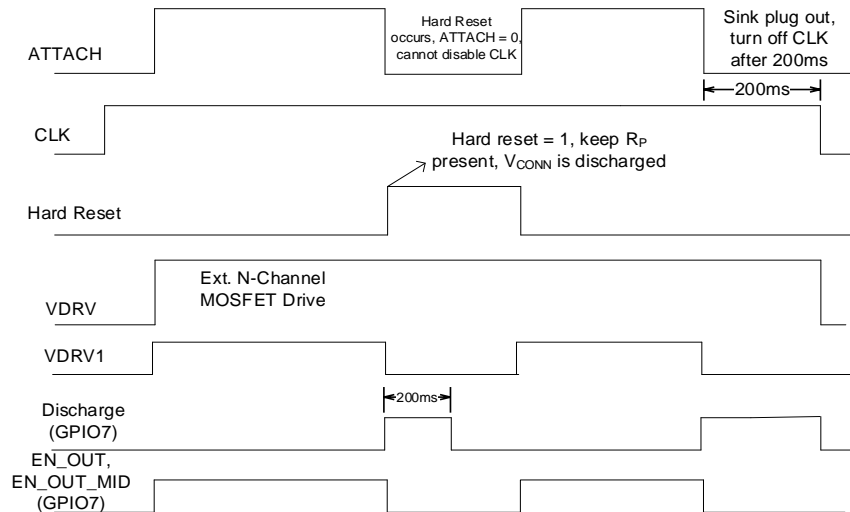
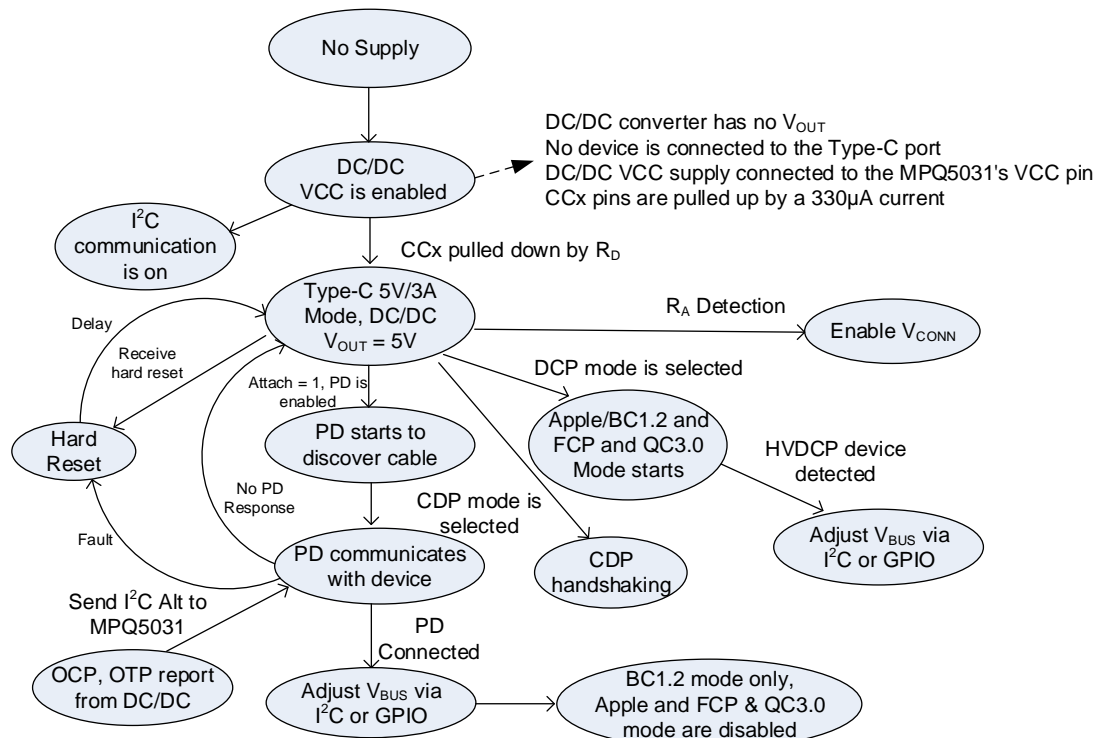


Figure 9: EN Off Timer

If EN\_OFF\_DELAY functionality is not required, configure the GPIO3 for a function that is not EN\_OFF\_DELAY\_OUT.

## State Machine and Timing Sequence



**Figure 10: State Machine and Attached Timing Sequence**

### V<sub>CONN</sub> Over-Current Protection (OCP)

The VCC to V<sub>CONN</sub> switch has a 20Ω resistance and a 50mA over-current protection (OCP) threshold. When V<sub>CONN</sub> OCP is triggered, the V<sub>CONN</sub> output latches off. The following actions can re-enable V<sub>CONN</sub> :

- Cycling power on VIN and EN
- A hard reset
- Detaching and reattaching the USB Type-C device

### Bidirectional I<sup>2</sup>C Interface

The MPQ5031's SDA and SCL pins support both I<sup>2</sup>C master and I<sup>2</sup>C slave functions. When cooperating with an external buck-boost converter (e.g. the MPQ4230), the MPQ5031 should operate in I<sup>2</sup>C master mode. When a user

wants to configure the MPQ5031's I<sup>2</sup>C register, I<sup>2</sup>C slave mode should be selected.

Float I2C\_MODE or pull it to GND to set the MPQ5031 to I<sup>2</sup>C master mode. Pull I2C\_MODE to VCC to set the MPQ5031 to I<sup>2</sup>C slave mode. In I<sup>2</sup>C slave mode (I2C\_MODE = VCC), the digital CLK is always on. The I<sup>2</sup>C register and I<sup>2</sup>C functionality are active once VCC is ready. The user does not need to wait for a Type-C sink to be attached.

The GPIO5 and GPIO6 pins can be configured as a second I<sup>2</sup>C slave entrance, but an internal clock must be turned on to access full I<sup>2</sup>C functionality. SDA, SCL, GPIO5, and GPIO6 cannot simultaneously work in I<sup>2</sup>C slave mode (see Table 6).

**Table 6: I<sup>2</sup>C Function on Pin 1, Pin 2 and GPIO5, GPIO6**

| I2C_MODE Input | Pin 1, Pin 2 (SDA, SCL) Function | GPIO5, GPIO6 I <sup>2</sup> C Function   | Internal Clock  |
|----------------|----------------------------------|--|---|
| VCC            | In I <sup>2</sup> C slave mode   | I <sup>2</sup> C functionality is disabled   | Always on   |
| GND            | In I <sup>2</sup> C master mode  | In I <sup>2</sup> C slave mode. Must turn on internal clock to access full I <sup>2</sup> C function | Either USB Type-C attachment or writing 0x55AA to register 0x14 can enable the internal clock |

### Battery Low Detection

The GPIO4 and GPIO2 pins can be configured as an input battery voltage sense pin. If the battery voltage drops below a certain level (this level is configurable), then the USB PD engine updates the source capability based on the I<sup>2</sup>C control bits VBATT\_LOW\_PULL\_PS\_EN and VBATT\_LOW\_PULL\_NTC\_EN (see Table 7). When the battery voltage recovers, the USB PD engine changes the source capabilities to normal. If VBATT\_LOW\_PULL\_NTC\_EN = 1, the source

capability returns to normal after a 16-second delay.

This function can also be disabled via I<sup>2</sup>C control bits VBATT\_LOW\_PULL\_PS\_EN and VBATT\_LOW\_PULL\_NTC\_EN.

The recommended resistor divider ratio on VBATT\_SENSE pin is 1/10. The internal comparator falling threshold is 1.12V, and the rising threshold is 1.18V with a 20μs deglitch time.

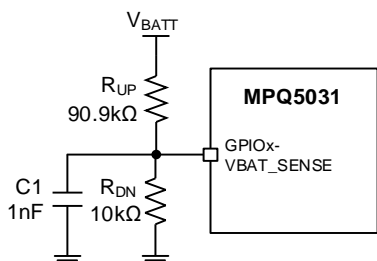
**Table 7: Battery Low Update Source Capability**

|                       |  |   |  |
|-----------------------|--|---|--|
| VBATT_LOW_PULL_PS_EN  | 0  | 0   | 1  |
| VBATT_LOW_PULL_NTC_EN | 0  | 1   | 0  |
| Battery Voltage Low   | PDO list is based on the PDO_TYPE register setting | Update PDO1 to 5V/2A, other PDOs are disabled | Disable the PDO with a power rating ≥ PWR_SHARE_TO_PDP |

The battery voltage can be calculated with Equation (3):

$$V_{BATT\_LOW} (V) = 1.12V \times (R_{DN} + R_{UP}) / R_{DN} \quad (3)$$

Figure 11 shows the resistor divider.



**Figure 11: VBATT\_SENSE Divider Resistor**

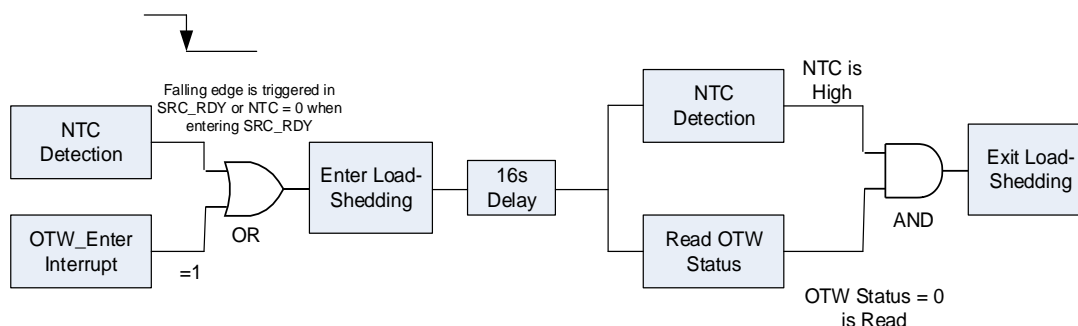
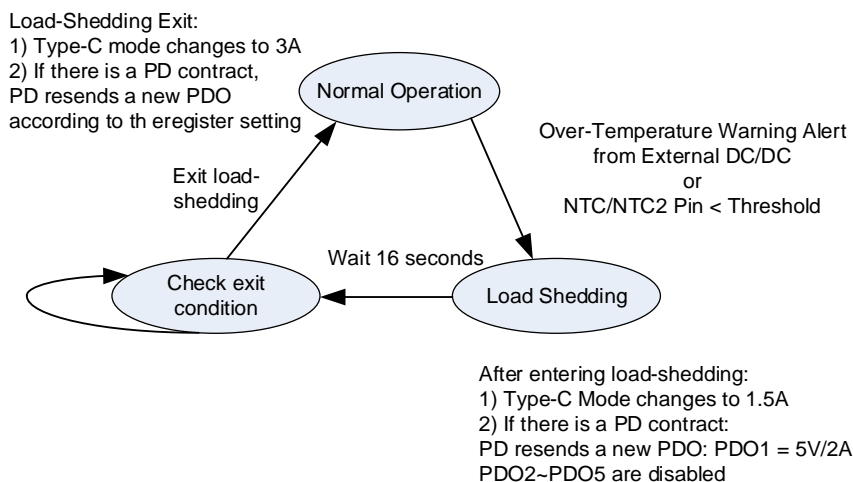
### Load-Shedding Entry and Recovery

When the NTC or NTC2 (NTC2\_PS\_EN = 0) falling threshold is triggered (NTC\_MODE = 0), the Type-C resistor ( $R_P$ ) pull-up current changes

from 330μA to 180μA, regardless of whether there is a PD contract.

When MPQ423x or MPQ426x device is selected (SLAVE\_DEVICE\_SEL = 001b), and it sends an OT\_WARNING signal and a PD contract exists, the Type-C pull-up current ( $R_P$ ) changes from 330μA to 180μA. The Type-C detection threshold then changes accordingly. If a PD contract exists, the USB PD PDO is updated to 5V/2A, and all other PDOs are disabled.

If the NTC or NTC2 voltage recovers to a normal value, and the external DC/DC converter OT\_WARNING = 0 (after a 16-second delay),  $R_P$  changes back to 330μA. If there was originally a PD contract, the MPQ5031 USB PD engine sends the default PDOs again. When NTC2\_PS\_EN = 1 and the NTC2 falling threshold is triggered, the MPQ5031 updates the PDO list based on the PWR\_SHARE\_TO\_PDP setting.



**Figure 12: Load-Shedding Logic and State Machine (NTC2\_PS\_EN = 0)**



## Thermal Shutdown

Thermal shutdown prevents the chip from operating at exceedingly high temperatures. When the silicon die temperature exceeds 150°C or the NTC/NTC2 falling threshold is triggered (NTC\_MODE = 1), the MPQ5031 resets the USB PD engine and stops the DC/DC converter from switching via I<sup>2</sup>C communication, or by pulling the converter's EN pin low. When the temperature falls below its lower threshold (about 130°C), the chip is enabled for CCx detection. If the sink is attached, the MPQ5031 starts to enable the USB PD engine again.

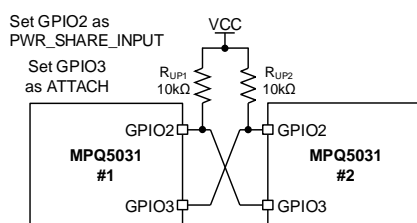
The I<sup>2</sup>C slave is still operational during thermal shutdown.

## Power Sharing Function

The GPIO2 pin can be configured for power share input functions. When GPIO2 (POWER\_SHARE) is pulled low, the USB PD engine disables the PDO if the power rating meets or exceeds PWR\_SHARE\_TO\_PDP, and all PPS APDOs are disabled.

The GPIO3, GPIO5, or GPIO7 pins can be configured for ATTACH indication. If using multiple devices, and the first MPQ5031 (MPQ5031 #1) detects that a sink is attached, it pulls GPIO3 low. Then the second MPQ5031's (MPQ5031 #2) GPIO2 is pulled low at the same time. MPQ5031 #2 disables the PDO with a power rating that is  $\geq$  PWR\_SHARE\_TO\_PDP, and all PPS APDOs are disabled.

The GPIO2 pin can also be used for power share output functions. When the MPQ5031's sink-requested PDO power rating is  $\geq$  PWR\_SHARE\_OUTPUT\_THLD, GPIO2 is pulled low.

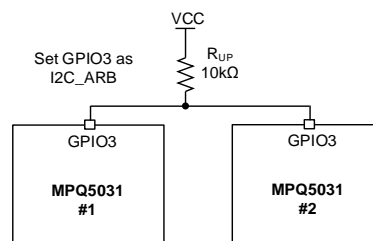


**Figure 13: Power-Share Connection between Two MPQ5031s (Cut Total Power to 50%/50%)**

## I<sup>2</sup>C Arbitration

The GPIO3 pin can be configured for I<sup>2</sup>C arbitration (I2C\_ARB) functions. When

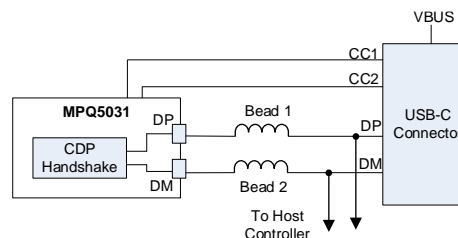
MPQ5031 #1 sends an I<sup>2</sup>C command, it pulls down GPIO3 first. GPIO3 is pulled high again after MPQ5031 #1's I<sup>2</sup>C command is finished. MPQ5031 #2 always checks the GPIO3 status, and starts to send an I<sup>2</sup>C command until GPIO3 is released to high (see Figure 14). It can be used in MPQ4272 reference design.



**Figure 14: I<sup>2</sup>C Arbitration Connection**

## CDP Mode

The MPQ5031 integrates CDP mode handshaking. Set CDP\_EN = 1 to enable CDP mode handshaking, and disable Apple divider mode, FCP, 1.2V/1.2V mode and other DCP schemes on DP and DM (LEGACY\_CHARGING\_MODE\_SEL = 11b) (see Figure 15).



**Figure 15: CDP Mode Set-Up**

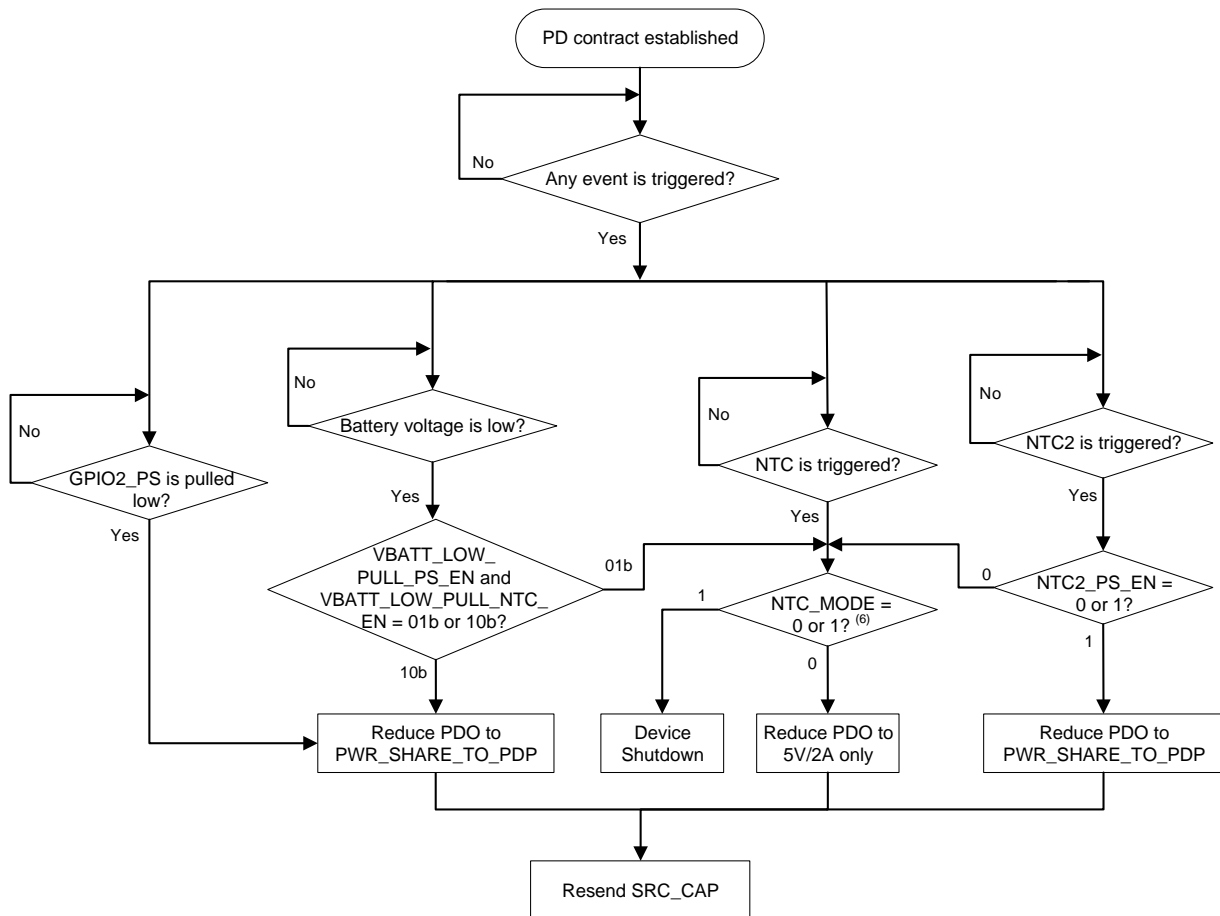
## Smart Line Drop Compensation

The MPQ5031 has smart line drop compensation when the MPQ423x, MPQ426x or MPQ421x DC/DC converter is attached. Line drop compensation is active in fixed PDO or non-PD conditions. After entering a PPS condition, line drop compensation is disabled. If the other DC/DC converter is selected, the line drop compensation value is determined by the converter's set-up. The MPQ5031 does not disable line drop compensation in a PPS state.

When an MPQ423x or MPQ426x device is selected (SLAVE\_DEVICE\_SEL = 001b), the line drop compensation value is determined by the MPQ423x or MPQ426x's set-up. The MPQ5031 disables MPQ423x or MPQ426x line drop compensation after entering PPS.

When an MPQ421x device is selected (SLAVE\_DEVICE\_SEL = 000b), the MPQ5031 GPIO3 can be configured for ISENS+ functions to sense the MPQ421x's COMP pin voltage.

GPIO7 can be configured for ADJ functions to sink the 2μA current on the MPQ421x's FB pin when the COMP voltage exceeds a certain voltage.



**Figure 16: PDO Reduce Logic and State Machine**

**Note:**

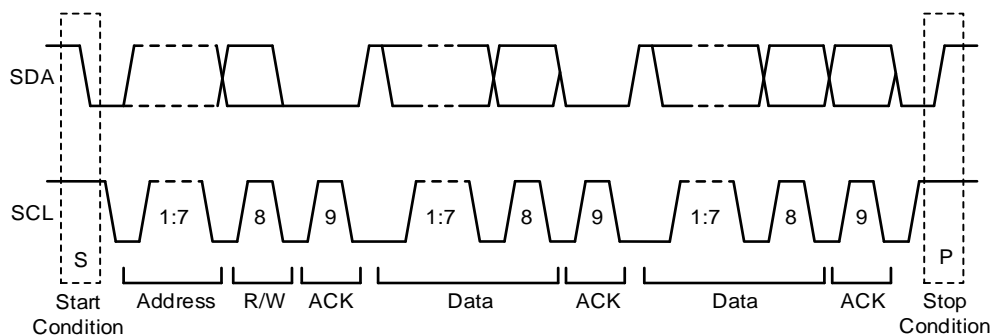
- 6) When NTC and PWR\_SHARE\_TO\_PDP events (GPIO2\_PS pulls low, battery voltage low or NTC2) are triggered at the same time, the PDO lists are updated based on the NTC set-up. If NTC\_MODE = 1, the device shuts down; if NTC\_MODE = 0, the PDO list is updated to 5V/2A.



## I<sup>2</sup>C Transfer Data

Every byte put on the SDA line must be 8 bits long. Each byte must be followed by an acknowledge (ACK) bit. The master generates the acknowledge-related clock pulse. The transmitter releases the SDA line (high) during the acknowledge clock pulse. The receiver must pull down the SDA line during the acknowledge clock pulse so that it remains stable (low) during the high period of this clock pulse.

Figure 17 shows the data transfer format. After the start condition (S), a slave address is sent. This address is 7 bits long followed by an 8th data direction bit (R/W). A 0 indicates a transmission (write), while a 1 indicates a request for data (read). A data transfer is always terminated by a stop condition (P) generated by the master. For a master to continue communicating on a bus, it can generate a repeated start condition (Sr) and address another slave without first generating a stop condition.



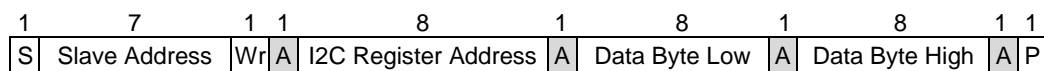
**Figure 17: Complete Data Transfer**

The MPQ5031 includes a full I<sup>2</sup>C slave controller. The I<sup>2</sup>C slave fully complies with the I<sup>2</sup>C specification requirements. It requires a start condition, valid I<sup>2</sup>C address, register address byte, and data byte for a single data update. After receiving each byte, the MPQ5031 acknowledges the byte by pulling the SDA line

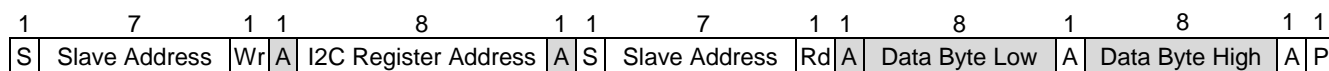
low during the high period of a single clock pulse. A valid I<sup>2</sup>C address then selects the MPQ5031, and the MPQ5031 performs an update on the falling edge of the LSB byte.

Figure 18 shows an example of an I<sup>2</sup>C read and write command.

### a) I<sup>2</sup>C Write Word



### b) I<sup>2</sup>C Read Word



**Figure 18: I<sup>2</sup>C Read and Write**

## I<sup>2</sup>C REGISTER MAP

I<sup>2</sup>C Slave, I2C\_MODE = VCC

| Add (Hex) | Name     | R/W | D15  | D14                                       | D13                         | D12                             | D11                                       | D10                  | D9       | D8   | D7                               | D6                                     | D5                        | D4                     | D3                           | D2                              | D1                       | D0                       |                          |  |
|-----------|----------|-----|--|---|-----------------------------|---------------------------------|---|----------------------|----------|--|----------------------------------|--|---------------------------|------------------------|------------------------------|---------------------------------|--------------------------|--------------------------|--------------------------|--|
| 00        | PDO_TYPE | R/W | OTP_SOFTWARE_REVISION_NO <sup>(7)</sup>  |   |                             |                                 |   |                      |          | RESERVED   |                                  | PDO5_EN <sup>(7)</sup>                 | PDO4_EN <sup>(7)</sup>    | PDO3_EN <sup>(7)</sup> | PDO2_EN <sup>(7)</sup>       | PDO5_TYPE <sup>(7)</sup>        | PDO4_TYPE <sup>(7)</sup> | PDO3_TYPE <sup>(7)</sup> | PDO2_TYPE <sup>(7)</sup> |  |
| 01        | PDO_V1   | R   | RESERVED   |   |                             |                                 |   |                      |          | PDO1_VOLTAGE_SETTING (5V)                        |                                  |  |                           |                        |                              |                                 |                          |                          |                          |  |
| 02        | PDO_I1   | R/W | OTP_SUFFIX_CODE <sup>(7)</sup>   |   |                             |                                 |   |                      |          | PDO1_CURRENT_SETTING <sup>(7)</sup> (3A default) |                                  |  |                           |                        |                              |                                 |                          |                          |                          |  |
| 03        | PDO_V2   | R/W | PDO2_VOLTAGE_SETTING <sup>(7)</sup> (9V default)   |   |                             |                                 |   |                      |          |  |                                  |  |                           |                        |                              |                                 |                          |                          |                          |  |
| 04        | PDO_I2   | R/W | RESERVED   |   |                             |                                 |   |                      |          | PDO2_CURRENT_SETTING <sup>(7)</sup> (3A default) |                                  |  |                           |                        |                              |                                 |                          |                          |                          |  |
| 05        | PDO_V3   | R/W | PDO3_VOLTAGE_SETTING <sup>(7)</sup> (15V default)  |   |                             |                                 |   |                      |          |  |                                  |  |                           |                        |                              |                                 |                          |                          |                          |  |
| 06        | PDO_I3   | R/W | RESERVED   |   |                             |                                 |   |                      |          | PDO3_CURRENT_SETTING <sup>(7)</sup> (3A default) |                                  |  |                           |                        |                              |                                 |                          |                          |                          |  |
| 07        | PDO_V4   | R/W | PDO4_VOLTAGE_SETTING <sup>(7)</sup> (20V default)  |   |                             |                                 |   |                      |          |  |                                  |  |                           |                        |                              |                                 |                          |                          |                          |  |
| 08        | PDO_I4   | R/W | RESERVED   |   |                             |                                 |   |                      |          | PDO4_CURRENT_SETTING <sup>(7)</sup> (3A default) |                                  |  |                           |                        |                              |                                 |                          |                          |                          |  |
| 09        | PDO_V5   | R/W | PDO5_VOLTAGE_SETTING <sup>(7)</sup> (3.3V to 21V default)  |   |                             |                                 |   |                      |          |  |                                  |  |                           |                        |                              |                                 |                          |                          |                          |  |
| 0A        | PDO_I5   | R/W | RESERVED   |   |                             |                                 |   |                      |          | PDO5_CURRENT_SETTING <sup>(7)</sup> (3A default) |                                  |  |                           |                        |                              |                                 |                          |                          |                          |  |
| 0B        | CTL1     | R/W | VBATT_LOW_PULL_PS_EN <sup>(7)</sup>  | LEGACY_CHARGING_MODE_SEL_1 <sup>(7)</sup> | NTC2_PS_EN <sup>(7)</sup>   | CDP_EN <sup>(7)</sup>           | LEGACY_CHARGING_MODE_SEL_0 <sup>(7)</sup> | RESERVED             |          | VBATT_LOW_PULL_NTC_EN <sup>(7)</sup>             | I2C_SLAVE_ADDRESS <sup>(7)</sup> |  |                           |                        | TYPE-C_MODE <sup>(7)</sup>   | SLAVE_DEVICE_SEL <sup>(7)</sup> |                          |                          |                          |  |
| 0C        | CTL2     | R/W | HD_RST   | SEND_SRC_CAP                              | USB_SUSPEND <sup>(7)</sup>  | USB_COMM_UNICATE <sup>(7)</sup> | LPS <sup>(7)</sup>                        |                      |          | TOUCH_CURRENT <sup>(7)</sup>                     |                                  |  | TOUCH_TEMP <sup>(7)</sup> |                        | UNCU_KEXT_MSG <sup>(7)</sup> | RESE_RVED                       | SRC_CAP <sup>(7)</sup>   | VDRV_EN <sup>(7)</sup>   |                          |  |
| 0D        | CTL3     | R/W | PFM_PWM <sup>(7)</sup>   | FREQ_DITHER <sup>(7)</sup>                | EN_OFF_TIMER <sup>(7)</sup> |                                 |   | GPIO4 <sup>(7)</sup> |          | GPIO3 <sup>(7)</sup>                             |                                  |  | GPIO2 <sup>(7)</sup>      |                        |                              | GPIO1 <sup>(7)</sup>            |                          |                          |                          |  |
| 0E        | CTL4     | R/W | NTC_MODE <sup>(7)</sup>  | VBUS_UV_THD <sup>(7)</sup>                | RESERVED                    |                                 |   | VDRV <sup>(7)</sup>  |          | GPIO7 <sup>(7)</sup>                             |                                  |  | GPIO6 <sup>(7)</sup>      |                        |                              | GPO5 <sup>(7)</sup>             |                          |                          |                          |  |
| 0F        | PWR_SHA  | R/W | PWR_SHARE_OUTPUT_THLD <sup>(7)</sup>   |   |                             |                                 |   |                      |          |  |                                  | POWER_SHARE_TO_PDP_THLD <sup>(7)</sup> |                           |                        |                              |                                 |                          |                          |                          |  |
| 10        | STATUS_1 | R   | PPS_OUTPUT_VOLTAGE   |   |                             |                                 |   |                      |          |  |                                  |  |                           |                        | BATTERY_SHORT                | ANALOG_DETECTED_TYPE_C          | ANA_OTP                  | PREVIOUS_PD_CONNECTED    | LOAD_SHED_DINDING        |  |
| 11        | STATUS_2 | R   | RESERVED   | CABLE_CAP                                 | CAPABILITY_MISMATCH         | OBJECT_POSITION                 |   |                      |          | SINK_REQUEST_CURRENT_APDO                        |                                  |  |                           |                        |                              |                                 | RESERVED                 |                          |                          |  |
| 12        | ID       | R   | VENDER ID:1000   |   |                             |                                 |   |                      | RESERVED |  |                                  |  |                           |                        |                              |                                 |                          |                          |                          |  |
| 14        | CLK_ON   | R/W | Enable control of the digital CLK: 0x55AA to enable the digital clock, 0x0000 to disable the clock |   |                             |                                 |   |                      |          |  |                                  |  |                           |                        |                              |                                 |                          |                          |                          |  |

### Note:

- 7) These registers are OTP-configurable. When the MPQ5031 VCC voltage rises above the UVLO rising threshold, the OTP contents are loaded to the I<sup>2</sup>C register.

## REGISTER DESCRIPTION

### PDO\_TYPE

PDO1 is always enabled, and is fixed as a 5V fixed-power data object (PDO).

Address: 0x00

Type: Read/Write

| Bits     | Name                     | Description  |
|----------|--------------------------|--|
| D[15:10] | OTP_SOFTWARE_REVISION_NO | Determined by MPS.   |
| D[7]     | PDO5_EN                  | Enables PDO5's power object. The bit is set to 1b by default.<br>0b: Disabled<br>1b: Enabled |
| D[6]     | PDO4_EN                  | Enables PDO4's power object. The bit is set to 1b by default.<br>0b: Disabled<br>1b: Enabled |
| D[5]     | PDO3_EN                  | Enables PDO3's power object. The bit is set to 1b by default.<br>0b: Disabled<br>1b: Enabled |
| D[4]     | PDO2_EN                  | Enables PDO2's power object. The bit is set to 1b by default.<br>0b: Disabled<br>1b: Enabled |
| D[3]     | PDO5_TYPE                | Sets PDO5's power object. The bit is set to 1b by default.<br>0b: Fixed PDO<br>1b: APDO      |
| D[2]     | PDO4_TYPE                | Sets PDO4's power object. The bit is set to 0b by default.<br>0b: Fixed PDO<br>1b: APDO      |
| D[1]     | PDO3_TYPE                | Sets PDO3's power object. The bit is set to 0b by default.<br>0b: Fixed PDO<br>1b: APDO      |
| D[0]     | PDO2_TYPE                | Sets PDO2's power object. The bit is set to 0b by default.<br>0b: Fixed PDO<br>1b: APDO      |

### PDO\_V1

Address: 0x01

Type: Read-Only

| Bits   | Name                 | Description   |
|--------|----------------------|---|
| D[9:0] | PDO1_VOLTAGE_SETTING | This bit sets PDO1's output voltage in 50mV units. Fixed to 0001 1001 00b (5V). |

**PDO\_I1**

Address: 0x02

Type: Read/Write

| Bits     | Name                 | Description  |
|----------|----------------------|--|
| D[15:10] | OTP_SUFFIX_CODE      | Determined by MPS.   |
| D[9:0]   | PDO1_CURRENT_SETTING | Sets PDO1's maximum output current in 10mA units. The default is 3A. When these bits are set >3A, the MPQ5031 first checks the cable current rating. If set to 5A, send a >3A setting. If the cable capability is 3A, only send a 3A maximum current capability. |

**PDO\_V2**

Address: 0x03

Type: Read/Write

Default PDO TYPE: Fixed PDO

If PDO2\_TYPE is set to 0b (fixed PDO):

| Bits     | Name                 | Description  |
|----------|----------------------|--|
| D[15:10] | RESERVED             | Reserved. Set to 0b.   |
| D[9:0]   | PDO2_VOLTAGE_SETTING | Sets PDO2's output voltage in 50mV units. The default is 9V. |

If PDO2\_TYPE is set to 1b (APDO):

| Bits    | Name                 | Description   |
|---------|----------------------|---|
| D[15:8] | PDO2_MAXIMUM_VOLTAGE | Sets PDO2's maximum voltage in 100mV increments. The absolute maximum value is 21V. |
| D[7:0]  | PDO2_MINIMUM_VOLTAGE | Sets PDO2's minimum voltage in 100mV increments.                                    |

**PDO\_I2**

Address: 0x04

Type: Read/Write

Default PDO TYPE: Fixed PDO

If PDO2\_TYPE is set to 0b (fixed PDO):

| Bits     | Name                 | Description  |
|----------|----------------------|--|
| D[15:10] | RESERVED             | Reserved. Set to 0b.   |
| D[9:0]   | PDO2_CURRENT_SETTING | Sets PDO2's maximum output current setting in 10mA units. The default is 3A. When these bits are set >3A, the MPQ5031 first checks the cable current rating. If set to 5A, send a >3A setting. If the cable capability is 3A, only send a 3A maximum current capability. |

If PDO2\_TYPE is set to 1b (APDO):

| Bits    | Name                 | Description   |
|---------|----------------------|---|
| D[15:7] | RESERVED             | Reserved. Set to 0b.  |
| D[6:0]  | PDO2_CURRENT_SETTING | Sets PDO2's maximum current in 50mA increments. When these bits are set >3A, the MPQ5031 first checks the cable current rating. If set to 5A, send a >3A setting. If the cable capability is 3A, only send a 3A maximum current capability. |

**PDO\_V3**

Address: 0x05

Type: Read/Write

Default PDO TYPE: Fixed PDO

If PDO3\_TYPE is set to 0b (fixed PDO):

| Bits     | Name                 | Description   |
|----------|----------------------|---|
| D[15:10] | RESERVED             | Reserved. Set to 0b.  |
| D[9:0]   | PDO3_VOLTAGE_SETTING | Sets PDO3's output voltage in 50mV units. The default is 15V. |

If PDO3\_TYPE is set to 1b (APDO):

| Bits    | Name                 | Description   |
|---------|----------------------|---|
| D[15:8] | PDO3_MAXIMUM_VOLTAGE | Sets PDO3's maximum voltage in 100mV increments. The absolute maximum value is 21V. |
| D[7:0]  | PDO3_MINIMUM_VOLTAGE | Sets PDO3's minimum voltage in 100mV increments.                                    |

**PDO\_I3**

Address: 0x06

Type: Read/Write

Default PDO TYPE: Fixed PDO

If PDO3\_TYPE is set to 0b (fixed PDO):

| Bits     | Name                 | Description  |
|----------|----------------------|--|
| D[15:10] | RESERVED             | Reserved. Set to 0b.   |
| D[9:0]   | PDO3_CURRENT_SETTING | Sets PDO3's maximum output current in 10mA units. The default is 3A. When these bits are set >3A, the MPQ5031 first checks the cable current rating. If set to 5A, send a >3A setting. If the cable capability is 3A, only send a 3A maximum current capability. |

If PDO3\_TYPE is set to 1b (APDO):

| Bits    | Name                 | Description   |
|---------|----------------------|---|
| D[15:7] | RESERVED             | Reserved. Set to 0b.  |
| D[6:0]  | PDO3_CURRENT_SETTING | Sets PDO3's maximum current in 50mA increments. When these bits are set >3A, the MPQ5031 first checks the cable current rating. If it is set to 5A, send a >3A setting. If the cable capability is 3A, only send a 3A maximum current capability. |

**PDO\_V4**

Address: 0x07

Type: Read/Write

Default PDO TYPE: Fixed PDO

If PDO4\_TYPE is set to 0b (fixed PDO):

| Bits     | Name                 | Description   |
|----------|----------------------|---|
| D[15:10] | RESERVED             | Reserved. Set to 0b.  |
| D[9:0]   | PDO4_VOLTAGE_SETTING | Sets PDO4's output voltage in 50mV units. The default is 20V. |

If PDO4\_TYPE is set to 1b (APDO):

| Bits    | Name                 | Description   |
|---------|----------------------|---|
| D[15:8] | PDO4_MAXIMUM_VOLTAGE | Sets PDO4's maximum voltage in 100mV increments. The absolute maximum value is 21V. |
| D[7:0]  | PDO4_MINIMUM_VOLTAGE | Sets PDO4's minimum voltage in 100mV increments.                                    |

#### **PDO\_I4**

Address: 0x08

Type: Read/Write

Default PDO TYPE: Fixed PDO

If PDO4\_TYPE is set to 0b (fixed PDO):

| Bits     | Name                 | Description  |
|----------|----------------------|--|
| D[15:10] | RESERVED             | Reserved. Set to 0b.   |
| D[9:0]   | PDO4_CURRENT_SETTING | Sets PDO4's maximum output current in 10mA units. The default is 3A. When these bits are set >3A, the MPQ5031 first checks the cable current rating. If set to 5A, send a >3A setting. If the cable capability is 3A, only send a 3A maximum current capability. |

If PDO4\_TYPE is set to 1b (APDO):

| Bits    | Name                 | Description   |
|---------|----------------------|---|
| D[15:7] | RESERVED             | Reserved. Set to 0b.  |
| D[6:0]  | PDO4_CURRENT_SETTING | Sets PDO4's maximum current in 50mA increments. When these bits are set >3A, the MPQ5031 first checks the cable current rating. If set to 5A, send a >3A setting. If the cable capability is 3A, only send a 3A maximum current capability. |

#### **PDO\_V5**

Address: 0x09

Type: Read/Write

Default PDO TYPE: APDO

If PDO5\_TYPE is set to 0b (fixed PDO):

| Bits     | Name                 | Description                               |
|----------|----------------------|---|
| D[15:10] | RESERVED             | Reserved. Set to 0b.                      |
| D[9:0]   | PDO5_VOLTAGE_SETTING | Sets PDO5's output voltage in 50mV units. |

If PDO5\_TYPE is set to 1b (APDO):

| Bits    | Name                 | Description   |
|---------|----------------------|---|
| D[15:8] | PDO5_MAXIMUM_VOLTAGE | Sets PDO5's maximum voltage in 100mV increments. The default is 21V.  |
| D[7:0]  | PDO5_MINIMUM_VOLTAGE | Sets PDO5's minimum voltage in 100mV increments. The default is 3.3V. |

#### **PDO\_I5**

Address: 0x0A

Type: Read/Write

Default PDO TYPE: APDO

If PDO5\_TYPE is set to 0b (fixed PDO):

| Bits     | Name                 | Description   |
|----------|----------------------|---|
| D[15:10] | RESERVED             | Reserved. Set to 0b.  |
| D[9:0]   | PDO5_CURRENT_SETTING | Sets PDO5's maximum output current in 10mA units. When these bits are set >3A, the MPQ5031 first checks the cable current rating. If set to 5A, send a >3A setting. If the cable capability is 3A, only send a 3A maximum current capability. |

If PDO5\_TYPE is set to 1b (APDO) (default):

| Bits    | Name                 | Description  |
|---------|----------------------|--|
| D[15:7] | RESERVED             | Reserved. Set to 0b.   |
| D[6:0]  | PDO5_CURRENT_SETTING | Sets PDO5's maximum current in 50mA increments. The default is 3A. When these bits are set >3A, the MPQ5031 first checks the cable current rating. If set to 5A, send a >3A setting. If the cable capability is 3A, only send a 3A maximum current capability. |

### CTL1

Address: 0x0B

Type: Read/Write

| Bits   | Name   | Description  |  |   |   |   |                             |                                   |   |   |  |   |  |  |   |  |   |
|--|--|--|--|---|---|---|-----------------------------|-----------------------------------|---|---|--|---|--|--|---|--|---|
| D[15]<br>D[8]                                      | VBATT_LOW_PULL_PS_EN<br>VBATT_LOW_PULL_NTC_EN          | <div>Controls battery voltage low detection if GPIO2 or GPIO4 is set to VBATT_SENSE. These bits are set to 01b by default. These bits cannot be set to 11b. The table below lists the configurations.</div> <table><tr><td>D[15]: VBATT_LOW_PULL_PS_EN</td><td>0</td><td>0</td><td>1</td></tr><tr><td>D[8]: VBATT_LOW_PULL_NTC_EN</td><td>0</td><td>1</td><td>0</td></tr><tr><td>PDO List when Battery Voltage Low Condition Occurs</td><td>PDO list is based on register PDO_TYPE setting.</td><td>Update PDO1 to 5V/2A, other PDOs are disabled.</td><td>Disable the PDO with a power rating equal to or exceeding PWR_SHARE_TO_PDP</td></tr></table>  | D[15]: VBATT_LOW_PULL_PS_EN  | 0   | 0 | 1 | D[8]: VBATT_LOW_PULL_NTC_EN | 0                                 | 1 | 0 | PDO List when Battery Voltage Low Condition Occurs | PDO list is based on register PDO_TYPE setting. | Update PDO1 to 5V/2A, other PDOs are disabled. | Disable the PDO with a power rating equal to or exceeding PWR_SHARE_TO_PDP |   |  |   |
| D[15]: VBATT_LOW_PULL_PS_EN                        | 0  | 0  | 1  |   |   |   |                             |                                   |   |   |  |   |  |  |   |  |   |
| D[8]: VBATT_LOW_PULL_NTC_EN                        | 0  | 1  | 0  |   |   |   |                             |                                   |   |   |  |   |  |  |   |  |   |
| PDO List when Battery Voltage Low Condition Occurs | PDO list is based on register PDO_TYPE setting.        | Update PDO1 to 5V/2A, other PDOs are disabled.   | Disable the PDO with a power rating equal to or exceeding PWR_SHARE_TO_PDP |   |   |   |                             |                                   |   |   |  |   |  |  |   |  |   |
| D[14]<br>D[11]                                     | LEGACY_CHARGING_MODE_SEL1<br>LEGACY_CHARGING_MODE_SEL0 | <div>The MPQ5031 supports different legacy charging modes, such as QC3.0, HUAWEI FCP, BC1.2 DCP and Apple divider mode. The table below lists different charging mode selections. These bits are set to 01b by default.</div> <table><tr><td>D[14]: LEGACY_CHARGING_MODE_SEL_1</td><td>0</td><td>0</td><td>1</td><td>1</td></tr><tr><td>D[11]: LEGACY_CHARGING_MODE_SEL_0</td><td>0</td><td>1</td><td>0</td><td>1</td></tr><tr><td>DP/DM Charging Mode</td><td>All modes are active</td><td>Only DCP is active. No Apple divider mode or QC mode. Short the DP and DM pins.</td><td>Apple divider mode/DCP mode is active.</td><td>Only DCP is active. No Apple divider mode or QC mode. Short the DP and DM pins.</td></tr></table> | D[14]: LEGACY_CHARGING_MODE_SEL_1  | 0   | 0 | 1 | 1                           | D[11]: LEGACY_CHARGING_MODE_SEL_0 | 0 | 1 | 0  | 1   | DP/DM Charging Mode                            | All modes are active   | Only DCP is active. No Apple divider mode or QC mode. Short the DP and DM pins. | Apple divider mode/DCP mode is active. | Only DCP is active. No Apple divider mode or QC mode. Short the DP and DM pins. |
| D[14]: LEGACY_CHARGING_MODE_SEL_1                  | 0  | 0  | 1  | 1   |   |   |                             |                                   |   |   |  |   |  |  |   |  |   |
| D[11]: LEGACY_CHARGING_MODE_SEL_0                  | 0  | 1  | 0  | 1   |   |   |                             |                                   |   |   |  |   |  |  |   |  |   |
| DP/DM Charging Mode                                | All modes are active                                   | Only DCP is active. No Apple divider mode or QC mode. Short the DP and DM pins.  | Apple divider mode/DCP mode is active.                                     | Only DCP is active. No Apple divider mode or QC mode. Short the DP and DM pins. |   |   |                             |                                   |   |   |  |   |  |  |   |  |   |
| D[13]  | NTC2_PS_EN   | <div>Enables the NTC2 power share function. This bit is set to 0b by default.</div> <div>0: Disabled<br/>1: Enabled</div>  |  |   |   |   |                             |                                   |   |   |  |   |  |  |   |  |   |
| D[12]  | CDP_EN   | <div>Enables CDP mode. This bit is set to 0b by default.</div> <div>0b: Non-CDP mode, charging-only protocol on DP and DM pins<br/>1b: CDP mode enabled. The CDP protocol is enabled on the DP and DM pins. QC, Apple divider, and DCP modes are disabled (set LEGACY_CHARGING_MODE_SEL = 11b)</div>   |  |   |   |   |                             |                                   |   |   |  |   |  |  |   |  |   |
| D[10:9]  | RESERVED   | Reserved. Always write 00b to these bits.  |  |   |   |   |                             |                                   |   |   |  |   |  |  |   |  |   |
| D[7:4]   | I2C_SLAVE_ADDRESS                                      | Sets the slave I <sup>2</sup> C address. This bit is set to 1000b by default.  |  |   |   |   |                             |                                   |   |   |  |   |  |  |   |  |   |

|        |                  |   |
|--------|------------------|---|
| D[3]   | TYPE-C_MODE      | <p>Selection bit for 3A or 1.5A Type-C mode. This bit is set to 0b by default. In 5V/3A Type-C mode, the pull-up current (<math>R_P</math>) is 330<math>\mu</math>A, and the detection range (<math>R_d</math>) is between 0.8V and 2.6V.</p> <p>0: 3A Type-C mode<br/>1: 1.5A Type-C mode</p>  |
| D[2:0] | SLAVE_DEVICE_SEL | <p>Selects the power device that is incorporated with the MPQ5031. These bits are set to 001b by default.</p> <p>000b: MPQ421x<br/>001b: MPQ423x, MPQ426x<br/>010b: MP28167-A<br/>011b: MPQ4272-Page 0<br/>100b: MPQ4272-Page 1<br/>101b: For Non-I<sup>2</sup>C DC/DC converters. PDO2_SEL is pulled low when PDO2 is selected. PDO2_SEL and PDO3_SEL both pull low when PDO3 is selected. PDO2_SEL, PDO3_SEL, and PDO4_SEL all pull low when PDO4 is selected. EN_OUT = low, EN_OUT_MID = low during hard reset and detach events. For more details, see Figure 10 on page 20.</p> <p>Others values are reserved.</p> |

## CTL2

The message bits/bytes referenced in bits D[13:3] are defined in the USB Power Delivery Specification Revision 3.0, Version 2.0, which can be downloaded from the official USB website at <https://usb.org/>.

Address: 0x0C

Type: Read/Write

| Bits    | Name           | Description  |
|---------|----------------|--|
| D[15]   | HDRST          | <p>Sends the hard reset command. This bit is set to 0b by default.</p> <p>0b: Normal state<br/>1b: Send a hard reset command to the sink. After the HDRST message is sent, this bit auto-resets to 0b</p>  |
| D[14]   | SEND_SRC_CAP   | <p>Sends the source capability command. The PD engine only sends a SOURCE_CAP message while in the ready state. This bit is set to 0b by default.</p> <p>0b: Normal state<br/>1b: Send source capability. After SOURCE_CAP is sent, this bit auto-resets to 0b</p> <p>When there is a PDO configuration change in I<sup>2</sup>C registers 0x01~0x09, SEND_SRC_CAP should be set to make the new PDO take effect. After sending a new source capability, the MPQ5031 clears this bit. Change the 0x00 register for the new PDO to take effect immediately.</p> |
| D[13]   | USB SUSPEND    | <p>Sets whether USB suspend functions are supported. This bit is set to 0b by default. This bit is defined in Fixed Supply PDO message bit[28].</p> <p>0b: USB suspend is not supported<br/>1b: USB suspend is supported</p>   |
| D[12]   | USBCOMMUNICATE | <p>Sets whether USB communication capabilities are supported. This bit is set to 0b by default. This bit is defined in Fixed Supply PDO message bit[26].</p> <p>0b: USB communication capabilities are not supported<br/>1b: USB communication capabilities are supported</p>  |
| D[11:9] | LPS            | <p>LPS compliant when set. These bits are defined in SOURCE_CAPABILITIES_EXTENDED Message byte 12, bits[2:0]. These bits are set to 101b by default.</p> <p>D[11] = LPS bit<br/>D[10] = PS1 bit<br/>D[9] = PS2 bit</p>   |



|        |               |   |
|--------|---------------|---|
| D[8:6] | TOUCH_CURRENT | Sets the touch current, bits[2:0]. These bits are defined in SOURCE_CAPABILITIES_EXTENDED Message byte 13, bits[2:0]. These bits are set to 000b by default. D[8] indicates touch current bit[2]. |
| D[5:4] | TOUCH_TEMP    | Sets the touch temperature default value to 0, 1, or 2. These bits are defined in SOURCE_CAPABILITIES_EXTENDED Message byte 20, bits[1:0]. These bits are set to 00b by default.                  |
| D[3]   | UNCUKEXTMSG   | Sets the unchunked extend message bit. This bit is defined in Fixed Supply PDO message bit[24]. This bit is set to 1b by default.   |
| D[2]   | RESERVED      | Reserved. Always write 0b to this bit.  |
| D[1]   | SRC_CAP       | Send source capability twice control bit when a PD2.0 device is attached. This bit is set to 0b by default.<br>0: Send source capability twice<br>1: Send source capability once                  |
| D[0]   | VDRV_EN       | Enables VDRV functions. This bit is set to 0b by default.<br>0b: Disable the VDRV output. VDRV has 5.1kΩ pull-down resistor when it is disabled<br>1b: Enable VDRV functions                      |

### CTL3

Address: 0x0D

Type: Read/Write

| Bits     | Name         | Description   |
|----------|--------------|---|
| D[15]    | PFM_PWM      | Sets the MP28167-A and MPQ421x operation modes. This bit is set to 1b by default.<br>0b: PFM mode. If the MP28167-A is selected as the I <sup>2</sup> C slave, the MP28167-A's 0x04 register D[4] = 0. If the MPQ421x is selected as the I <sup>2</sup> C slave, the MPQ421x's 0x02 register D[2] = 0.<br>1b: PWM mode. If the MP28167-A is selected as the I <sup>2</sup> C slave, then 0x04 register D[4] = 1. If the MPQ421x is selected as the I <sup>2</sup> C slave, then the its 0x02 register D[2] = 1  |
| D[14]    | FREQ_DITHER  | Enables frequency dithering for the MPQ421x. This bit is set to 0b by default.<br>0b: Disabled (fixed-frequency mode). If the MPQ421x is selected as the I <sup>2</sup> C slave, the MPQ421x's 0x02 register D[4] = 0<br>1b: Enabled. If the MPQ421x is selected as the I <sup>2</sup> C slave, the MPQ421x's 0x02 register D[4] = 1. For other devices like the MPQ4230, ignore this bit   |
| D[13:11] | EN_OFF_TIMER | Sets the EN off time delay. Only valid when GPIO4 is set for EN functions. These bits are set to 010b by default.<br>000b: No delay<br>001b: 10 minutes<br>010b: 22 minutes<br>011b: 40 minutes<br>100b: 80 minutes<br>101b: 120 minutes  |
| D[10:9]  | GPIO4        | Configures the function of the GPIO4 pin. These bits are set to 00b by default.<br>00b: Reserved. This pin can be floated or tied to ground<br>01b: EN function. When the external input is >1.4V, the MPQ5031 is enabled. When the external input is <1.2V, the MPQ5031 is disabled in a low I <sub>Q</sub> state. EN_OFF_TIMER can configure the off delay<br>10b: NTC2 function. Refer to the NTC2 description on page 22.<br>11b: The GPIO4 pin functions as the VBATT_SENSE pin, and monitors the battery voltage. If the battery voltage is low (resistor divider ratio is 1/10), then the PD updates the source capability. The internal comparator falling threshold is 1.1V, and the rising threshold is 1.15V with a 20μs deglitch time. This comparator operates when VCC exceeds the under-voltage lockout (UVLO) threshold after a 5s delay time |

|        |       |   |
|--------|-------|---|
| D[8:6] | GPIO3 | <p>Configures the function of GPIO3 pin. This low-voltage pin supports 5.5V operation and has an internal ESD Zener diode. These bits are set to 000b by default.</p> <p>000b: I2C_ARB function. Tri-state input or output to avoid having two I<sup>2</sup>C masters. This function has a similar structure to GPIO2 when it is set to PWE_SHARE. See the I<sup>2</sup>C Arbitration section on page 23 for more details</p> <p>001b: EN function. When the external input is &gt;1.4V, the MPQ5031 is enabled. When the external input is &lt;1.2V, the MPQ5031 is disabled in a low I<sub>Q</sub> state</p> <p>010b: ATTACH function. GPIO3 is pulled low once a Type-C port is attached. Open-drain structure</p> <p>011b: EN_OFF_DELAY_OUT function. When EN goes low, this pin still outputs high. It changes to a floating state after 22 minutes. This signal can be used to control the upstream DC/DC converter's enable pin</p> <p>100b: POL output</p> <p>101b: PDO3_SEL_OUT. This is an open-drain output. When PDO3 is selected, this pin pulls low. The pull-down speed is very slow (typically 1ms to drop from 100kΩ to 2Ω)</p> <p>110b: ISENS+ function. This pin is used for line drop compensation when the MPQ4214 is selected. Connect ISENS+ to the MPQ4214's COMP pin to sense current information</p> <p>111b: IPWM function. The PWM output sets the external buck-boost's PPS CC current limit. This pin must be pulled up externally. The PWM signal frequency is 10kHz</p> |
| D[5:3] | GPIO2 | <p>Configures the function of the GPIO2 pin. This is a low-voltage pin. These bits are set to 110b by default.</p> <p>000b: QC_12 function. For QC2.0 mode, this pin is used to enable QC 12V<sub>OUT</sub></p> <p>001b: POL output. This is an open-drain output to indicate the plug orientation. When CC1 is selected as the CC line, the POL is pulled low. When CC2 is selected as the CC line, the POL is an open drain</p> <p>010b: GPIO2 is pulled low</p> <p>110b: PWR_SHARE function. See the Power Sharing Function section on page 23 for more details</p> <p>111b: VBATT_SENSE pin</p>   |
| D[2:0] | GPIO1 | <p>Configures the function of the GPIO1 pin. It is a low-voltage pin that supports 5.5V operation. These bits are set to 001b by default.</p> <p>000b: PDO2_SEL_OUT. This pin is an open-drain output. When PDO2 is selected, this pin is pulled low. The pull-down speed is very slow (typically 1ms to drop from 100kΩ to 2Ω). For QC2.0 mode, this pin is used to enable 9V<sub>OUT</sub> (QC logic adds this output signal as well)</p> <p>001b: Interrupt input pin. This is a high-impedance pin that monitors the input signal. In real applications, it should be connected to the external DC/DC converter's ALT pin to get interruption information from the I<sup>2</sup>C slave</p> <p>010b: GPIO1 is pulled low</p> <p>011b: GPIO1 is an open drain</p> <p>100b: VSEL1. Output voltage selection pin. See the GPIO Summary section on page 38 for more details</p> <p>100b~111b: Reserved</p>  |

#### CTL4

Address: 0x0E

Type: Read/Write

| Bits  | Name     | Description   |
|-------|----------|---|
| D[15] | NTC_MODE | <p>Sets the NTC behavior. This bit is set to 0b by default.</p> <p>0b: If NTC is triggered, the MPQ5031 initiates load-shedding</p> <p>1b: If NTC is triggered, the MPQ5031 shuts down. This process is similar to internal thermal shutdown, and the ENO_MID output is set</p> |

|         |             |  |
|---------|-------------|--|
| D[14]   | VBUS_UV_THD | <p>Sets the VBUS_P under-voltage (UV) threshold. Set the threshold to 2.97V when the minimum APDO voltage is 3.3V, and to 4.5V when the minimum APDO voltage is 5V. This bit is set to 0b by default.</p> <p>0b: The VBUS_P falling threshold is 2.97V<br/>1b: The VBUS_P falling threshold is 4.5V</p>  |
| D[10:9] | VDRV        | <p>Sets the VDRV pin function. These bits are set to 00b by default.</p> <p>00b: VDRV function. This pin is the external N-channel MOSFET gate driver signal. When the sink is attached, VDRV drives the external N-channel MOSFET to turn on. Then power will flow from the DC/DC output to the sink. When the sink is detached, VDRV drives the external N-channel MOSFET to turn off to isolate the power path<br/>01b: VDRV1 function. See Figure 10 on page 20 for the timing sequence</p>  |
| D[8:6]  | GPIO7       | <p>Configures the GPIO7 pin. It is a low-voltage pin. These bits are set to 011b by default.</p> <p>000b: DISCHG pin. Output discharge function. The discharge function only turns on for 200ms, then turns off. DISCHG only outputs a control signal. An external N-channel MOSFET should be added between VBUS and GND for this function<br/>001b: ATTACH function. This pin is pulled low once a Type-C port is attached. Open-drain structure<br/>011b: EN_OUT_MID function. If there is a hard reset or a detach event, this pin clamps the voltage to 1V<br/>100b: EN_OUT. This output controls the upstream DC/DC output. If a hard reset occurs, the PD engine pulls this pin to GND. In normal operation, this pin is an open drain output<br/>101b: ADJ function. This function is used for MPQ421x line drop compensation. It sinks a 2μA current when the COMP voltage &gt;1.2V</p>  |
| D[5:3]  | GPIO6       | <p>Configures the GPIO6 pin. These bits are set to 110b by default.</p> <p>000b: PDO4_SEL_OUT. When PDO4 is selected, this bit is an open drain output<br/>001b: VSEL2. Output voltage selection pin<br/>010b: POL output. Open-drain output to indicate the plug orientation. If CC1 is selected as the CC line, then the POL is pulled low. If CC2 is selected as the CC line, then the POL is an open drain<br/>011b: EN function. When the external input is &gt;1.4V, the MPQ5031 is enabled. When the external input is &lt;1.2V, the MPQ5031 is disabled in a low I<sub>Q</sub> state<br/>100b: SYNC_OUT2. PWM output to sync external buck-boost's switching frequency. It is an open-drain output with a 25% duty cycle, 450kHz frequency, and 180° phase delay based on GPIO5<br/>101b: NTC2 function. See the NTC2 description on page 22 for more details<br/>110b: I2C_SLV_SDA. This pin is an I<sup>2</sup>C slave data pin</p>  |
| D[2:0]  | GPIO5       | <p>Configures the GPIO5 pin. These bits are set to 000b by default.</p> <p>000b: I2C_SLV_SCL. This pin is the I<sup>2</sup>C slave's clock pin<br/>001b: IPWM. The PWM output sets the external buck-boost's PPS CC current limit. It should be internally pulled up to 1.8V with a 2kΩ resistor. The PWM signal frequency is 10kHz<br/>010b: SYNC_OUT1. This is the PWM output to sync the external buck-boost's switching frequency. It is an open-drain output with a 25% duty cycle, 250kHz frequency, and 0° phase delay<br/>011b: This is the PWM output to sync the external buck-boost's switching frequency. It is an open-drain output with a 25% duty cycle, 350kHz frequency, and 0° phase delay<br/>100b: SYNC_OUT1. This is the PWM output to sync the external buck-boost's switching frequency. It is an open-drain output with a 25% duty cycle, 450kHz frequency, and 0° phase delay<br/>101b: ATTACH function. This pin is pulled low once a Type-C port is attached. It has an open drain structure<br/>111b: VBUS_UV_FIXPDO. This pin is a VBUS voltage detection input. Connect a 1/5 resistor divider to VBUS</p> |

**PWRSHA**

Address: 0x0F

Type: Read/Write

| Bits    | Name                        | Description  |
|---------|-----------------------------|--|
| D[15:8] | PWR_SHARE_OUTPUT_THLD       | Sets the threshold of the sink-requested PDO power rating. If the sink-requested PDO power rating is equal to or higher than this threshold, the GPIO2 pin (if GPIO2 is set to PWR_SHARE) pulls low. The default value is 0x3C (60W).<br><br>0x01: 1W<br>0xFF: 255W  |
| D[7:0]  | PWR_SHARE_INPUT_TO_PDP_THLD | Sets the port's PD power rating. If the GPIO2 pin (if GPIO2 is set to PWR_SHARE) is pulled low, the battery voltage is low (VBATT_LOW_PULL_PS_EN = 1b), or NTC2 is triggered (NTC2_PS_EN = 1b), all PDOs with a power rating equal to or higher than this threshold are disabled. The default value is 0x3C (60W).<br><br>0x01: 1W<br>0xFF: 255W |

**STATUS1**

Address: 0x10

Type: Read-Only

This register is read clear.

| Bits    | Name                    | Description  |
|---------|-------------------------|--|
| D[15:5] | PPS_OUTPUT_VOLTAGE      | Records the sink requested for PPS VOUT. In 20mV. This bit is only valid when the selected PDO is APDO.  |
| D[4]    | BATTERY_SHORT           | This bit is set if CCx, DP, or DM is shorted to the input battery.   |
| D[3]    | ANALOG_DETECTED_TYPEC   | Detects if a Type-C device is attached or unattached.  |
| D[2]    | ANA_OTP                 | Indicates if the MPQ5031 enters over-temperature protection (OTP), excluding thermal shutdowns caused by NTC or NTC2. It also indicates if the external power device enters OTP (the digital side provides the OTP information for the external device). |
| D[1]    | PREVIOUSLY_PD_CONNECTED | Indicates whether the MPQ5031 has a PD contract.   |
| D[0]    | LOAD_SHEDDING           | Indicates if the device has entered load-shedding (see Figure 12 on page 22 for more details).   |

**STATUS2**

Address: 0x11

Type: Read-Only

Read clear.

| Bits  | Name                | Description   |
|-------|---------------------|---|
| D[15] | RESERVED            | Reserved.   |
| D[14] | CABLE_CAP           | 1b: The cable can handle 5A<br>0b: The cable can only handle 3A |
| D[13] | CAPABILITY_MISMATCH | A sink request sets the "Capability Mismatch" bit.              |

|          |                           |  |
|----------|---------------------------|--|
| D[12:10] | OBJECT_POSITION           | When a sink is attached, these bits indicate the sink-requested PDO position.<br>000b: Non-PD device is attached<br>001b: Sink requested PDO1 (5V PDO)<br>010b: Sink requested PDO2<br>011b: Sink requested PDO3<br>100b: Sink requested PDO4<br>101b: Sink requested PDO5 |
| D[9:2]   | SINK_REQUEST_CURRENT_APDO | Sink-requested APDO current in 50mA units.   |
| D[1:0]   | RESERVED                  | Reserved.  |

## ID

Address: 0x12

Type: Read-Only

| Bits     | Name      | Description                      |
|----------|-----------|----------------------------------|
| D[15:12] | VENDOR_ID | Vendor ID. The default is 1000b. |
| D[11:0]  | RESERVED  | Reserved.                        |

## CLK\_ON

Address: 0x14

Type: Read/Write

| Bits    | Name   | Description  |
|---------|--------|--|
| D[15:0] | CLK_ON | Enables the digital CLK. Set these bits to 0x55AA to enable the digital clock; set them to 0x0000 to disable the clock.<br><br>When GPIO5 and GPIO6 are configured as I2C_SLV_SCL and I2C_SLV_SDA, the digital CLK should be enabled when sending I <sup>2</sup> C write commands via GPIO5/GPIO6, then the digital CLK should be disabled after the I <sup>2</sup> C command ends. A digital CLK does not need to be enabled when only reading the I <sup>2</sup> C register via GPIO5 and GPIO6. |

## I<sup>2</sup>C Bus Slave Address

The slave address is a 7-bit address followed by an 8th data direction bit (read or write). The A4 to A1 bits are configurable via the OTP.

|                      | A7 | A6 | A5 | A4               | A3               | A2               | A1               |
|----------------------|----|----|----|------------------|------------------|------------------|------------------|
| <b>Setting Value</b> | 0  | 1  | 0  | 1 <sup>(8)</sup> | 0 <sup>(8)</sup> | 0 <sup>(8)</sup> | 0 <sup>(8)</sup> |

**Note:**

8) By default, the slave address is 0x28, A[7:1] = 0101 000.

## GPIO Summary

For more details on the GPIO functions, see the CTL3 register on page 33 and the CTL4 register on page 34.

| Name  | Function Options |                     |                |                  |        |                     |        |    |
|-------|------------------|---------------------|----------------|------------------|--------|---------------------|--------|----|
| GPIO1 | INT              | PDO2_SEL_OUT        | VSEL1          | -                | -      | -                   | -      | -  |
| GPIO2 | PWR_SHARE        | QC_12               | POL            | VBATT_SENSE      | -      | -                   | -      | -  |
| GPIO3 | I2C_ARB          | PDO3_SEL_OUT        | POL            | EN_OFF_DELAY_OUT | ISENS+ | IPWM <sup>(9)</sup> | ATTACH | EN |
| GPIO4 | EN               | NTC2                | VBATT_SENSE    | -                | -      | -                   | -      | -  |
| GPIO5 | SYNC_OUT1        | IPWM <sup>(9)</sup> | VBUS_UV_FIXPDO | I2C_SLV_SCL      | ATTACH | -                   | -      | -  |
| GPIO6 | SYNC_OUT2        | PDO4_SEL_OUT        | VSEL2          | I2C_SLV_SDA      | NTC2   | POL                 | EN     | -  |
| GPIO7 | DISCHG           | EN_OUT              | EN_OUT_MID     | ADJ              | ATTACH | -                   | -      | -  |
| VDRV  | VDRV             | VDRV1               | -              | -                | -      | -                   | -      | -  |

**Note:**

9) IPWM on GPIO3 must be pulled up externally. IPWM on GPIO5 is pulled up internally.

**Table 8: V<sub>OUT</sub> Voltage vs. GPIO Output for Non-I<sup>2</sup>C DC/DC Converter Use Case**

| V <sub>OUT</sub> | PDO2_SEL_OUT (or QC_9) | QC_12      | PDO3_SEL_OUT | PDO4_SEL_OUT |
|------------------|------------------------|------------|--------------|--------------|
| 5V               | Open drain             | Open drain | Open drain   | Open drain   |
| 9V               | 0                      | Open drain | Open drain   | Open drain   |
| 12V              | 0                      | 0          | Open drain   | Open drain   |
| 15V              | 0                      | Open drain | 0            | Open drain   |
| 20V              | 0                      | Open drain | 0            | 0            |

**Table 9: V<sub>OUT</sub> Voltage vs. VSEL1, VSEL2 Output Status <sup>(10)</sup>**

| V <sub>OUT</sub> | VSEL1        | VSEL2      |
|------------------|--------------|------------|
| 5V               | Open drain   | Open drain |
| 9V               | 0            | Open drain |
| 15V              | Open drain   | 0          |
| 20V              | 0            | 0          |
| 12V              | 100kΩ to GND | 0          |

**Notes:**

10) VSEL1 and VSEL2 can be used to control the MP2491C's output voltage.

## APPLICATION INFORMATION

### PCB Layout Guidelines <sup>(11)</sup>

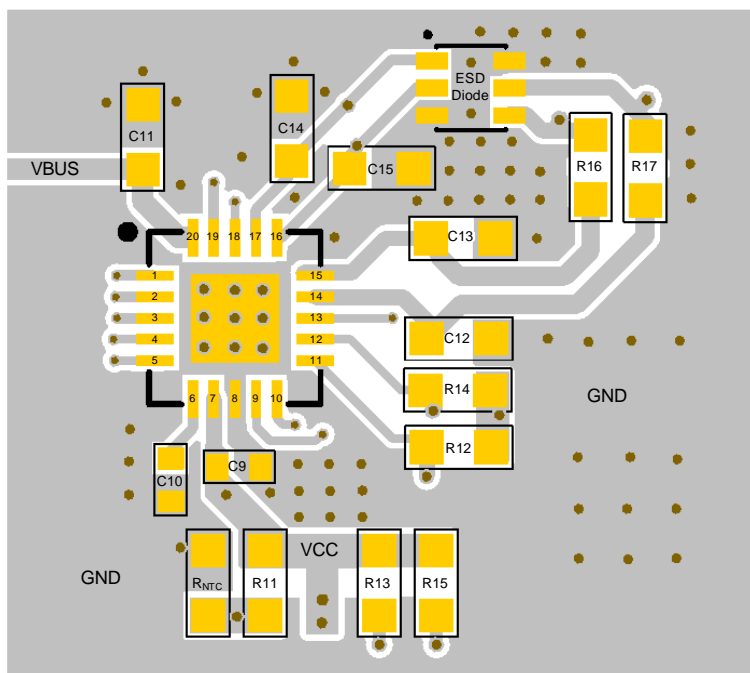
Efficient PCB layout is critical for stable operation and better ESD performance. A 2-layer or 4-layer layout is recommended. For the best results, refer to Figure 19 and follow the guidelines below:

1. Place the VCC and VDD decoupling capacitor as close to the VCC and VDD pins as possible.

2. Put 9 vias on the exposed pad of the IC. Connect the exposed pad to ground.
3. Place the ESD diodes as close to the IC as possible. Use short, direct, and wide traces to connect CC1, CC2, DP, and DM to the cathode of ESD diodes. Connect the anode of ESD diode to ground with multiple vias.
4. Use short, direct, and wide traces to connect CC1 and CC2 to the USB Type-C receptacle.

#### Notes:

- 11) The recommended layout is based on Figure 20 on page 41.



**Figure 19: Recommended PCB Layout**



# TYPICAL APPLICATION CIRCUITS

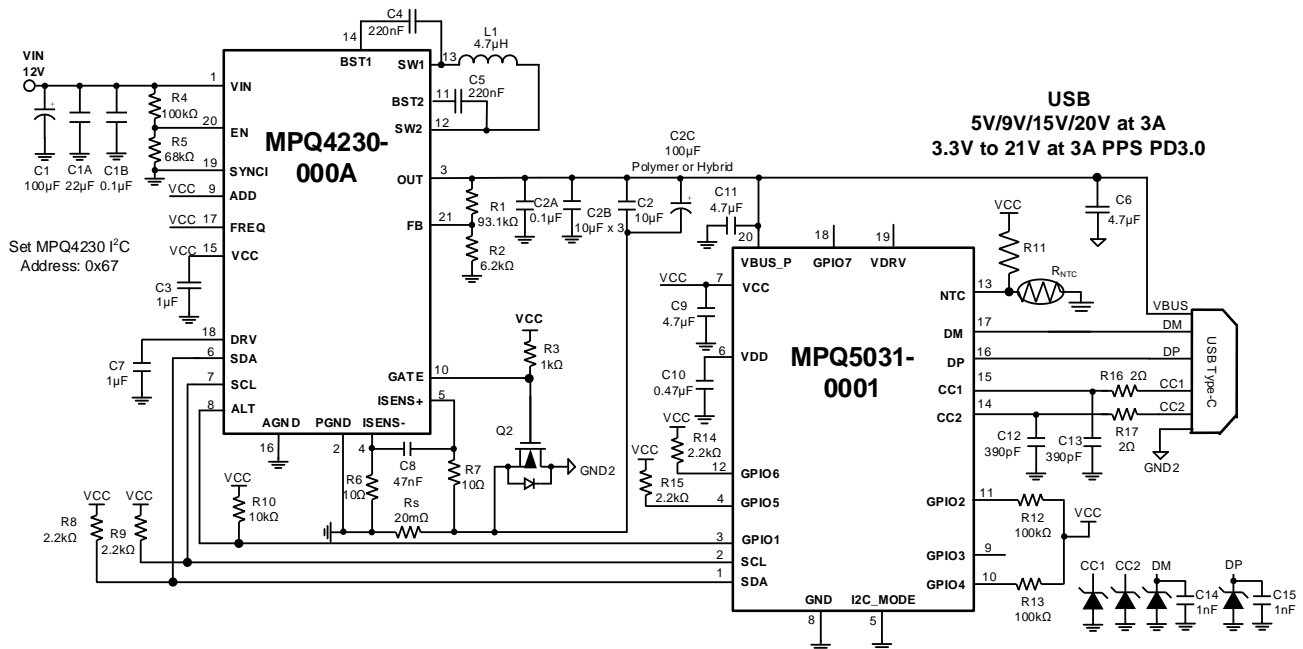


Figure 20: MPQ4230 + MPQ5031 for 60W PD Application (12)

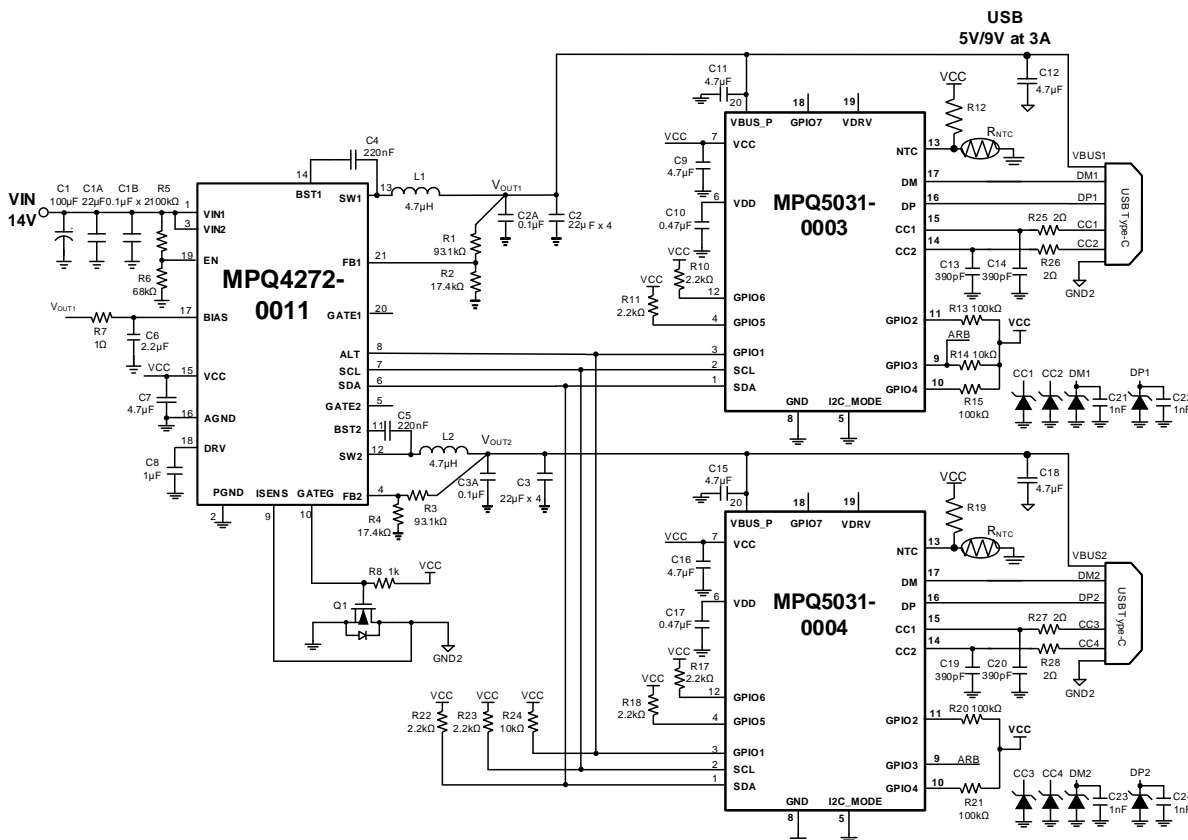


Figure 21: MPQ4272 + MPQ5031 for Dual-Port 27W PD Application (12)

## Note:

12) A TVS and RC filter should be added to the DP/DM/CCx pins to ensure that they pass  $\pm 8\text{kV}/\pm 15\text{kV}$  IEC Contact/Air Discharge ESD.

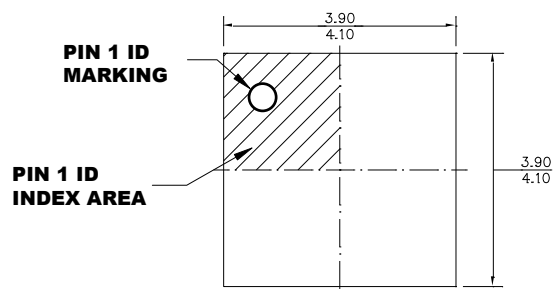
## MPQ5031GRE-0001 CONFIGURATION TABLE

| OTP Items | Enabled/Disabled      | PDO Type                | Voltage               | Current |
|-----------|-----------------------|-------------------------|-----------------------|---------|
| PDO1      | Enabled               | Fixed PDO               | 5V                    | 3A      |
| PDO2      | 1b: Enabled (default) | 0b: Fixed PDO (default) | 9V (default)          | 3A      |
| PDO3      | 1b: Enabled (default) | 0b: Fixed PDO (default) | 15V (default)         | 3A      |
| PDO4      | 1b: Enabled (default) | 0b: Fixed PDO (default) | 20V (default)         | 3A      |
| PDO5      | 1b: Enabled (default) | 1b: APDO (default)      | 3.3V to 21V (default) | 3A      |

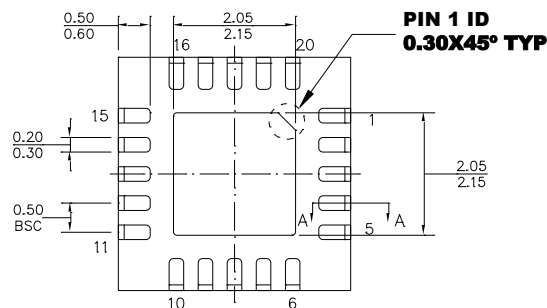
| OTP Items                | Description   | Value   |
|--------------------------|---|---|
| GPIO1                    | Configures the function of the GPIO1 pin.   | 001b: Interrupt input pin (default)                               |
| GPIO2                    | Configures the function of the GPIO2 pin.   | 110b: PWR_SHARE function (default)                                |
| GPIO3                    | Configures the function of the GPIO3 pin.   | 000b: I2C_ARB function (default)                                  |
| GPIO4                    | Configures the function of the GPIO4 pin.   | 00b: Reserved (default)   |
| GPIO5                    | Configures the function of the GPIO5 pin.   | 000b: I2C_SLV_SCL (default)                                       |
| GPIO6                    | Configures the function of the GPIO6 pin.   | 110b: I2C_SLV_SDA (default)                                       |
| GPIO7                    | Configures the function of the GPIO7 pin.   | 011b: EN_OUT_MID function (default)                               |
| VBATT_LOW_PULL_PS_EN     | The PDO list is reduced based on PWR_SHARE_TO_PDP_THLD when a battery voltage low condition is triggered. | 0b: Disabled (default)  |
| VBATT_LOW_PULL_NTC_EN    | Update the PDO list to 5V/2A. Other PDOs are disabled when a battery voltage low condition is triggered.  | 0b: Disabled  |
| NTC2_PS_EN               | Connect NTC2 to power share control.  | 0b: Disabled (default)  |
| LEGACY_CHARGING_MODE_SEL | QC3.0/DCP short mode/Apple divider mode selection.  | 00b: All modes are active   |
| CDP_EN                   | Enables for CDP mode.   | 0b: Non-CDP mode, charging only protocol on DP, DM pins (default) |
| I2C_SLAVE_ADDRESS        | Sets the MPQ5031's I <sup>2</sup> C slave address.  | 28H (default)   |
| TYPE-C_MODE              | Selects 3A or 1.5A Type-C mode.   | 0b: 3A Type-C mode (default)                                      |
| SLAVE_DEVICE_SEL         | Selects the power device incorporated with MPQ5031.   | 001b: MPQ423x, MPQ426x (default)                                  |
| VDRV                     | Sets the VDRV pin function.   | 00b: VDRV function (default)                                      |
| VDRV_EN                  | Enables the VDRV function.  | 0b: Disabled (default)  |
| PFM_PWM                  | Sets the MP28167A and MPQ421x operation mode.   | 1b: PWM mode (default)  |
| FREQ_DITHER              | Enables frequency dithering for the MPQ421x.  | 0b: Fixed frequency mode (default)                                |
| EN_OFF_TIMER             | Sets different EN off timers. Only valid when GPIO4 is set for EN functions.                              | 010b: 20 minutes (default)  |
| NTC_MODE                 | Sets the MPQ5031 behavior when NTC is triggered.  | 1b: The MPQ5031 shuts down  |
| VBUS_UV_THD              | Set the VBUS_P UV threshold.  | 0b: VBUS_P falling threshold is 2.97V (default)                   |
| PWR_SHARE_OUTPUT_THLD    | Sets the sink-requested PDO power rating threshold.   | 60W (default)   |
| PWR_SHARE_TO_PDP_THLD    | Sets the threshold for PDO power rating.  | 60W (default)   |
| USB_SUSPEND              | USB Suspend supported or not.   | 0b: Not supported (default)                                       |
| USBCOMMUNICATE           | USB Communication Capable or not.   | 0b: Not supported (default)                                       |
| LPS                      | LPS compliant when set.   | 101b (default)  |
| TOUCH_CURRENT            | Sets the touch current bits[2:0].   | 000b (default)  |
| TOUCH_TEMP               | Sets the touch temperature default value to 0, 1, or 2.   | 00b (default)   |
| UNCUKEXTMSG              | Sets unchunked extend message bit.  | 1b (default)  |
| OTP_SUFFIX_CODE          | OTP suffix code.  | 0x0001  |

# PACKAGE INFORMATION

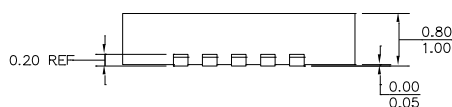
## QFN-20 (4mmx4mm)



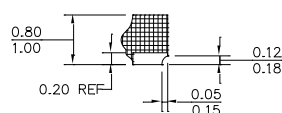
**TOP VIEW**



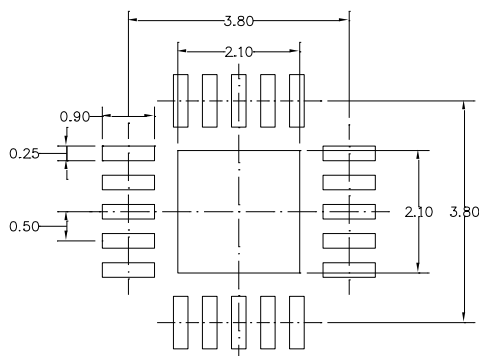
**BOTTOM VIEW**



**SIDE VIEW**



**SECTION A-A**

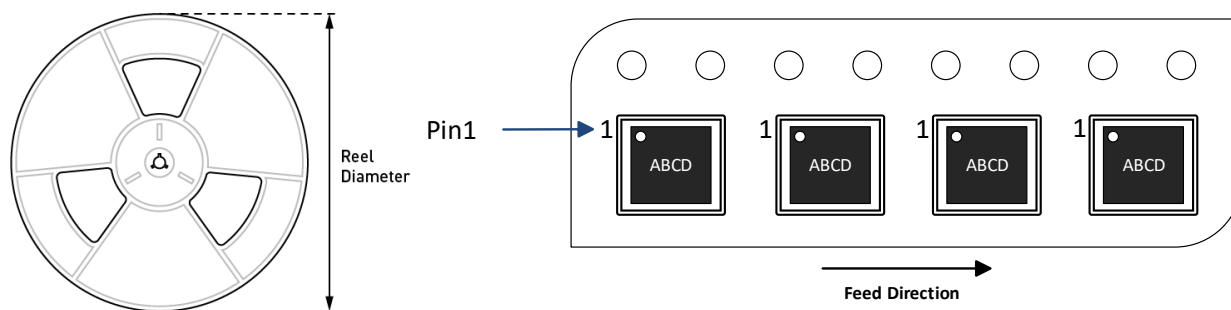


**RECOMMENDED LAND PATTERN**

### NOTE:

- 1) THE LEAD SIDE IS WETTABLE.
- 2) ALL DIMENSIONS ARE IN MILLIMETERS.
- 3) EXPOSED PADDLE SIZE DOES NOT INCLUDE MOLD FLASH.
- 4) LEAD COPLANARITY SHALL BE 0.08 MILLIMETERS MAX.
- 5) JEDEC REFERENCE IS MO-220
- 6) DRAWING IS NOT TO SCALE.

## CARRIER INFORMATION



| Part Number            | Package Description | Quantity/ Reel | Quantity/ Tube | Quantity/ Tray | Reel Diameter | Carrier Tape Width | Carrier Tape Pitch |
|------------------------|---------------------|----------------|----------------|----------------|---------------|--------------------|--------------------|
| MPQ5031GRE-xxxx-AEC1-Z | QFN-20 (4mmx4mm)    | 5000           | N/A            | N/A            | 13in          | 12mm               | 8mm                |

## REVISION HISTORY

| Revision # | Revision Date | Description     | Pages Updated |
|------------|---------------|-----------------|---------------|
| 1.0        | 12/15/2020    | Initial Release | -             |

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