

### Features

- Input Voltage Range: 2.7V to 5.5V
- Three step-down converters with integrated FETs
  - Buck1: 2A
  - Buck2: 2A
  - Buck3: 3A
- Buck 3 to operate in Buck or Switch mode
- Factory Programmable Output Voltage: 0.8 - 3.4V
- Automatic PFM/PWM or forced PWM mode
- Switching frequency 2MHz
- Optional Programmable Sequence Mode
- Power Good and/or Power On Reset Output
- -40°C to +85°C operating temperature range
- Package: QFN 24-Icd 4 x 4mm x 0.8mm (NBG24)

### Description

IDTP9120 is a fully integrated power management IC designed to provide three programmable voltage rails from a single 5V or 3.3V input rail with high efficiency and low quiescent currents in sleep mode or no-load condition.

The device offers selectable direct buck enable inputs or programmable sequencing with power good and power on reset generation.

To support low power operation, the IDTP9120 supports both sleep and standby modes.

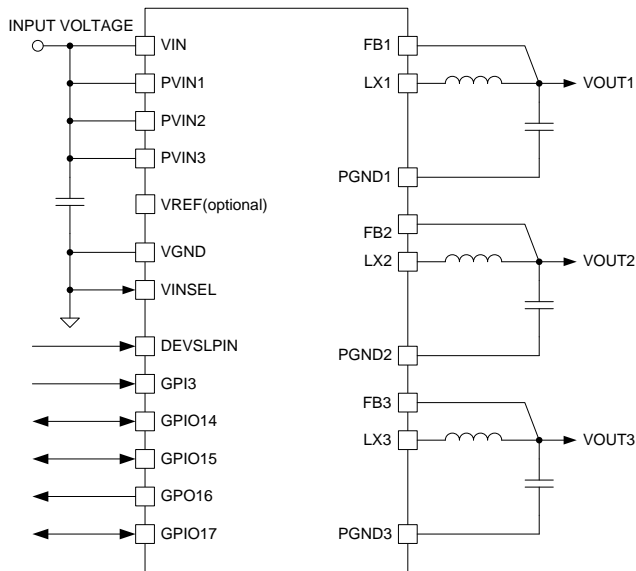
The IDTP9120 is available in a 4mm x 4mm, 24-Icd, QFN package and is guaranteed to operate over the ambient temperature range -40°C to +85°C.

### Applications

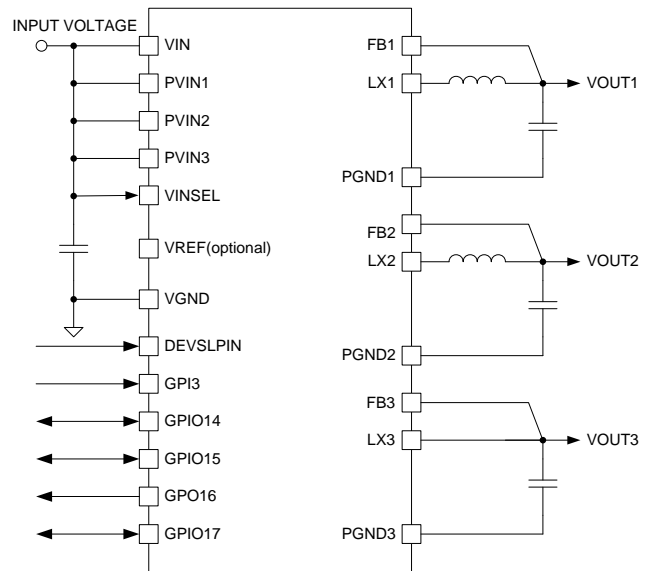
Point of Load Regulation in a variety of low power applications:

- Solid State Disk Drive (SSD) Power Management
- Low Power USB powered applications
- Set Top Box / TV Power Supply
- Portable Gaming

### Simplified Application Diagram



IDTP9120 with VINSEL (pin 4) in Buck Configuration for VOUT3

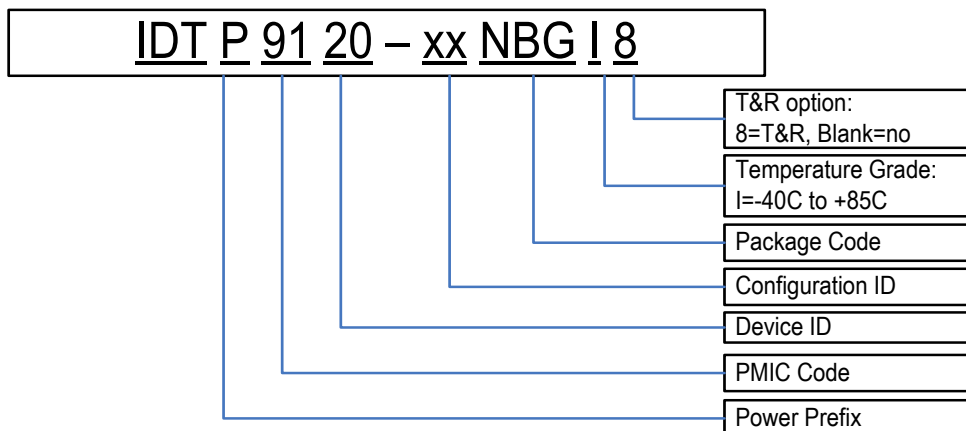


IDTP9120 with VINSEL (pin 4) in Switch Configuration for VOUT3

## ORDERING GUIDE

Table 1 – Ordering Summary

| PART NUMBER   | MARKING      | PACKAGE <sup>1</sup>    | AMBIENT TEMP. RANGE | SHIPPING CARRIER | QUANTITY |
|---------------|--------------|-------------------------|---------------------|------------------|----------|
| P9120-00NBGI  | P9120-00NBGI | QFN-24 4x4x0.75mm 24-ld | -40°C to +85°C      | Tray             | 490      |
| P9120-xxNBGI  | P9120-xxNBGI | QFN-24 4x4x0.75mm 24-ld | -40°C to +85°C      | Tray             | 490      |
| P9120-xxNBGI8 | P9120-xxNBGI | QFN-24 4x4x0.75mm 24-ld | -40°C to +85°C      | Tape and Reel    | 2,500    |



### Additional Ordering Information:

The IDTP9120 will be sampled in “-00” configuration, with all user configurable OTP registers at default state (0). Once a final customer configuration has been defined, a configuration specific “-xx” ID will be assigned and used for order and marking.

## ABSOLUTE MAXIMUM RATINGS

Stresses above the ratings listed below can cause permanent damage to the IDTP9120. These ratings are stress ratings only. Functional operation of the device at these or any other conditions above those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods can affect product reliability. Electrical parameters are guaranteed only over the recommended operating temperature range.

Table 2 – Absolute Maximum Ratings

| SYMBOL                      | PARAMETER                          | MIN  | MAX | UNIT |
|-----------------------------|------------------------------------|------|-----|------|
| PVIN1, PVIN2, PVIN3 to PGND | Regulator input voltage            | -0.3 | 6.0 | V    |
| VIN to GND                  | Supply for device                  | -0.3 | 6.0 | V    |
| LX1, LX2, LX3               | Regulator Switch Nodes             | -0.3 | 6.0 | V    |
| FB1, FB2, FB3               | Regulator Feedback pins            | -0.3 | 3.6 | V    |
| All other pins              |                                    | -0.3 | 6.0 | V    |
| T <sub>J</sub>              | Operating Junction Temperature     |      | 125 | °C   |
| T <sub>S</sub>              | Storage Temperature                |      | 150 | °C   |
| T <sub>SOLDER</sub>         | Soldering Temperature (10 seconds) |      | 260 | °C   |

<sup>1</sup> See Package Information (Page 24) for additional details.

**Table 3- Package Thermal Resistivity**

| SYMBOL        | DESCRIPTION                                     | CONDITIONS          | Value | Units                       |
|---------------|---|---------------------|-------|-----------------------------|
| $\theta_{JA}$ | Thermal Resistance (QFN-24)                     | Junction to Ambient | 40    | $^{\circ}\text{C}/\text{W}$ |
| $\Psi_{JB}$   | Thermal Characterization Parameter (QFN-24)     | Junction to Board   | 23    | $^{\circ}\text{C}/\text{W}$ |
| $P_D$         | Maximum Package Power Dissipation               |                     | 2.5   | W                           |
| ESD Rating    | (HBM) Human Body Model (all pins except 20, 21) | $\pm 2000\text{V}$  |       |                             |
|               | (HBM) Human Body Model (only pins 20, 21)       | $\pm 500\text{V}$   |       |                             |
|               | (CDM) Charged Device Model (all pins)           | $\pm 500\text{V}$   |       |                             |

Per JEDEC spec, the QFN-24 package is rated at MSL3. This thermal rating was calculated based on a JEDEC standard 4-layer board with dimensions 3in x 4.5in in still air conditions. Actual thermal resistance will be affected by PCB size, solder joint quality, PCB layer count, copper thickness, air flow, altitude, and other unlisted variables. For the QFN-24 package, the 2.8mm X 2.8mm EP is connected to ground plane with a matrix of 3x3 PCB thermal VIAs plated through from Top to Bottom layers. Actual thermal resistance will be affected by PCB size, solder joint quality, PCB layer count, copper thickness, air flow, altitude, and other unlisted variables.

## ELECTRICAL CHARACTERISTICS

**Table 4 – General Electrical Characteristics**

Typical values at 25 $^{\circ}\text{C}$ , unless noted.  $V_{PVIN1} = V_{PVIN2} = V_{PVIN3} = V_{in} = 5\text{V}$ .  $C_{O(\text{BUCK}1)} = C_{O(\text{BUCK}2)} = 10\mu\text{F}$ ,  $C_{O(\text{BUCK}3)} = 20\mu\text{F}$ ,  $L1=L2=L3 = 1.0\mu\text{H}$ .

| Symbol              | Parameter                         | Conditions  | Min  | Typ                      | Max  | Unit |
|---------------------|-----------------------------------|---|------|--------------------------|------|------|
| V <sub>VIN</sub>    | Input voltage range               |   | 2.7  |                          | 5.5  | V    |
|                     | UVLO threshold, VIN rising        | VINSEL>1V, Buck3 in Switch (3.3V) Mode  | 2.95 | 3                        | 3.05 | V    |
|                     | UVLO threshold, VIN falling       |   | 2.65 | 2.7                      | 2.75 | V    |
|                     | UVLO threshold, VIN rising        | VINSEL=0V, Buck3 in Buck (5V) Mode  | 4.35 | 4.4                      | 4.45 | V    |
|                     | UVLO threshold, VIN falling       |   | 3.95 | 4.0                      | 4.05 | V    |
| I <sub>Q(VIN)</sub> | VIN quiescent current             | Device in sleep mode (Vref disable, Devslpin floating).                           |      | <1                       |      | μA   |
|                     |                                   | Device in active mode, all Bucks = OFF  |      | 108                      |      | μA   |
| V <sub>IL</sub>     | Low Level Input Voltage           | All inputs  | 0.65 | 0.85                     |      | V    |
| V <sub>IH</sub>     | High Level Input Voltage          | All inputs  |      | 1.25                     | 1.45 | V    |
| I <sub>PD</sub>     | Pull Down Current                 | GPIO14,15,17, and GPI3  |      | 1                        |      | μA   |
| I <sub>PU</sub>     | Pull Up Current                   | DEVSLPIN @ VIN=5V   | 5    | 8                        | 10   | μA   |
| R <sub>PU</sub>     | Pull Up Resistor                  | Selectable for GPIO14,15,17, GPO16 and GPI3                                       |      | 50                       |      | kΩ   |
| T <sub>SD</sub>     | Thermal Shutdown                  |   |      | 135                      |      | °C   |
| V <sub>PG</sub>     | PG Detection Threshold            | % of selected output voltage in Buck Mode, % of V <sub>PVIN3</sub> in Switch mode |      | 10                       |      | %    |
| I <sub>OD</sub>     | Max Drive Output                  | In push-pull configuration, V <sub>OL</sub> =0.4V, V <sub>FBx</sub> ≥ 1.8V        | 4    |                          |      | mA   |
|                     |                                   | In open drain configuration, V <sub>OL</sub> =0.4V                                | 12   |                          |      | mA   |
| V <sub>REF</sub>    | Reference Voltage Output Voltage  |   |      | V <sub>FB(BUCK1)/2</sub> |      | V    |
| C <sub>VREF</sub>   | Output Capacitor V <sub>REF</sub> |   |      | 0.1                      |      | μF   |
| I <sub>VREF</sub>   | Reference Voltage Output Current  |   |      |                          | 1.0  | mA   |

## ELECTRICAL CHARACTERISTICS

**Table 5 – Buck1 Electrical Characteristics**
 $V_{O(BUCK1)} = 1.8V$ .

 Typical values at 25°C, unless noted.  $V_{PVIN1} = V_{PVIN2} = V_{PVIN3} = V_{in} = 5V$ .  $C_{O(BUCK1)} = C_{O(BUCK2)} = 10\mu F$ ,  $C_{O(BUCK3)} = 20\mu F$ ,  $L1=L2=L3 = 1.0\mu H$ .

| Symbol           | Parameter  | Conditions                        | Min  | Typ  | Max  | Unit        |
|------------------|--|-----------------------------------|------|------|------|-------------|
| $V_{PVIN1}$      | Input voltage range  |                                   | 2.7  |      | 5.5  | V           |
| $V_{O(BUCK1)}$   | Output voltage range   |                                   | 0.8  |      | 3.4  | V           |
|                  | Regulation voltage accuracy  |                                   | -2   |      | 2    | %           |
|                  | Line Regulation  | $V_{PVIN1} = 3.0V$ to 5V          |      | 0.01 | 0.04 | %/V         |
|                  | Load Regulation  | $I_{OUT1} = 0.2A$ to 2A, PWM mode |      |      | 0.5  | mV/A        |
|                  | Offset voltage in PFM mode<br>$V_{O(PFM)} = V_{O(PWM)} + V_{offset}$ | PFM mode                          |      | 15   |      | mV          |
| $I_{Q(BUCK1)}$   | Quiescent Current Adder  | Enabled, No load, PFM mode        |      | 25   |      | $\mu A$     |
| $I_{OP(BUCK1)}$  | Continuous operating DC current                                      | $T_J < 115^\circ C$               |      |      | 1.8  | A           |
| $I_{LIM(BUCK1)}$ | Peak Inductor Current  |                                   | 2    | 2.5  |      | A           |
| $R_{(on)}$       | High side switch   |                                   |      | 110  | 153  | m $\Omega$  |
|                  | Low side switch  |                                   |      | 56   | 78   | m $\Omega$  |
| $R_{DIS(BUCK1)}$ | Output discharge resistance  |                                   | 500  | 650  | 900  | $\Omega$    |
| $f_{SW(BUCK1)}$  | Switching frequency  | PWM mode                          | 1.89 | 2    | 2.1  | MHz         |
| $T_{SSR(BUCK1)}$ | Soft-start ramp rate   |                                   | 4    | 8    | 12   | mV/ $\mu s$ |
| $I_{FB1}$        | FB1 input bias current   |                                   |      | 6    | 8    | $\mu A$     |
| $C_{O(BUCK1)}$   | Output Capacitor   |                                   |      | 10   |      | $\mu F$     |
| $L_{O(BUCK1)}$   | Output Inductor  |                                   |      | 1    |      | $\mu H$     |

## ELECTRICAL CHARACTERISTICS

**Table 6 – Buck2 Electrical Characteristics**
 $V_{O(BUCK2)} = 1.2V$ .

 Typical values at 25°C, unless noted.  $V_{PVIN1} = V_{PVIN2} = V_{PVIN3} = V_{in} = 5V$ .  $C_{O(BUCK1)} = C_{O(BUCK2)} = 10\mu F$ ,  $C_{O(BUCK3)} = 20\mu F$ ,  $L1=L2=L3 = 1.0\mu H$ .

| Symbol           | Parameter  | Conditions                        | Min  | Typ  | Max  | Unit        |
|------------------|--|-----------------------------------|------|------|------|-------------|
| $V_{PVIN2}$      | Input voltage range  |                                   | 2.7  |      | 5.5  | V           |
| $V_{O(BUCK2)}$   | Output voltage range   |                                   | 0.8  |      | 3.4  | V           |
|                  | Regulation voltage accuracy  |                                   | -2   |      | 2    | %           |
|                  | Line Regulation  | $V_{PVIN2} = 3.0V$ to 5V          |      | 0.01 | 0.04 | %/V         |
|                  | Load Regulation  | $I_{OUT2} = 0.2A$ to 2A, PWM mode |      |      | 0.5  | mV/A        |
|                  | Offset voltage in PFM mode<br>$V_{O(PFM)} = V_{O(PWM)} + V_{offset}$ | PFM mode                          |      | 15   |      | mV          |
| $I_{Q(BUCK2)}$   | Quiescent Current Adder  | Enabled, No load, PFM mode        |      | 25   |      | $\mu A$     |
| $I_{OP(BUCK2)}$  | Continuous operating DC current                                      | $T_J < 115^\circ C$               |      |      | 1.8  | A           |
| $I_{LIM(BUCK2)}$ | Peak Inductor Current  |                                   | 2    | 2.5  |      | A           |
| $R_{(on)}$       | High side switch   |                                   |      | 110  | 153  | m $\Omega$  |
|                  | Low side switch  |                                   |      | 56   | 78   | m $\Omega$  |
| $R_{DIS(BUCK2)}$ | Output discharge resistance  |                                   | 500  | 650  | 900  | $\Omega$    |
| $f_{SW(BUCK2)}$  | Switching frequency  | PWM mode                          | 1.89 | 2    | 2.1  | MHz         |
| $T_{SSR(BUCK2)}$ | Soft-start ramp rate   |                                   | 4    | 8    | 12   | mV/ $\mu s$ |
| $I_{FB2}$        | FB2 input bias current   |                                   |      | 6    | 8    | $\mu A$     |
| $C_{O(BUCK2)}$   | Output Capacitor   |                                   |      | 10   |      | $\mu F$     |
| $L_{O(BUCK2)}$   | Output Inductor  |                                   |      | 1    |      | $\mu H$     |

## ELECTRICAL CHARACTERISTICS

**Table 7– Buck3 –Electrical Characteristics**
 $V_{O(BUCK3)} = 3.3V$ 

 Typical values at 25°C, unless noted.  $V_{PVIN1} = V_{PVIN2} = V_{PVIN3} = V_{in} = 5V$ .  $C_{O(BUCK1)} = C_{O(BUCK2)} = 10\mu F$ ,  $C_{O(BUCK3)} = 20\mu F$ ,  $L1=L2=L3 = 1.0\mu H$ .

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|--------|-----------|------------|-----|-----|-----|------|
|--------|-----------|------------|-----|-----|-----|------|

**In Buck Mode (VINSEL=LOW)**

|                  |  |  |      |      |      |             |
|------------------|--|--|------|------|------|-------------|
| $V_{PVIN3}$      | Input voltage range  |  | 2.7  |      | 5.5  | V           |
| $V_{O(BUCK3)}$   | Output voltage range   |  | 0.8  |      | 3.4  | V           |
|                  | Regulation voltage accuracy  |  | -2   |      | 2    | %           |
|                  | Line Regulation  | $V_{PVIN3} = 3.6V$ to $5V$             |      | 0.01 | 0.15 | %/V         |
|                  | Load Regulation  | $I_{OUT3} = 0.2A$ to $2.4A$ , PWM mode |      | 0.4  | 0.5  | mV/A        |
|                  | Offset voltage in PFM mode<br>$V_{O(PFM)} = V_{O(PWM)} + V_{offset}$ | PFM mode                               |      | 15   |      | mV          |
| $I_{Q(BUCK3)}$   | Quiescent Current Adder  | Enabled, No load, PFM mode             |      | 28   |      | $\mu A$     |
| $I_{OP(BUCK3)}$  | Continuous operating DC current                                      | $T_J < 115^\circ C$                    |      |      | 2.3  | A           |
| $I_{LIM(BUCK3)}$ | Peak Inductor Current  |  | 2.6  | 3    |      | A           |
| $R_{(on)}$       | High side switch   |  |      | 64   | 93   | m $\Omega$  |
|                  | Low side switch  |  |      | 45   | 61   | m $\Omega$  |
| $R_{DIS(BUCK3)}$ | Output discharge resistance  |  | 500  | 650  | 900  | $\Omega$    |
| $f_{SW(BUCK3)}$  | Switching frequency  | PWM mode                               | 1.89 | 2    | 2.1  | MHz         |
| $T_{SSR(BUCK3)}$ | Soft-start ramp rate   |  |      | 8    | 12   | mV/ $\mu s$ |
| $I_{FB3}$        | FB3 input bias current   |  |      | 9    | 11   | $\mu A$     |
| $C_{O(BUCK3)}$   | Output Capacitor   |  |      | 20   |      | $\mu F$     |
| $L_{O(BUCK3)}$   | Output Inductor  |  |      | 1    |      | $\mu H$     |

**In Switch Mode (VINSEL=HIGH),  $C_{O(BUCK3)} = 10\mu F$ ,  $V_{PVIN3} = 3.3V$** 

|                   |                                 |                     |     |    |     |             |
|-------------------|---------------------------------|---------------------|-----|----|-----|-------------|
| $V_{PVIN3}$       | Input voltage range             |                     | 2.7 |    | 3.6 | V           |
| $I_{SHDN(BUCK3)}$ | Shutdown current                |                     |     | 1  |     | $\mu A$     |
| $I_{Q(BUCK3)}$    | Quiescent Current               | No load             |     | 10 |     | $\mu A$     |
| $I_{OP(BUCK3)}$   | Continuous operating DC current | $T_J < 115^\circ C$ |     |    | 2.4 | A           |
| $I_{LIM(BUCK3)}$  | Current Limitation              |                     | 2.8 | 3  |     | A           |
| $R_{(on)}$        | High side switch                |                     |     | 64 | 93  | m $\Omega$  |
| $R_{DIS(BUCK3)}$  | Output discharge resistance     |                     | 300 |    | 800 | $\Omega$    |
| $T_{SSR(BUCK3)}$  | Soft-start ramp rate            |                     |     | 16 |     | mV/ $\mu s$ |
| $C_{O(BUCK3)}$    | Output Capacitor                |                     |     | 2  |     | $\mu F$     |

## PIN CONFIGURATION AND DESCRIPTION

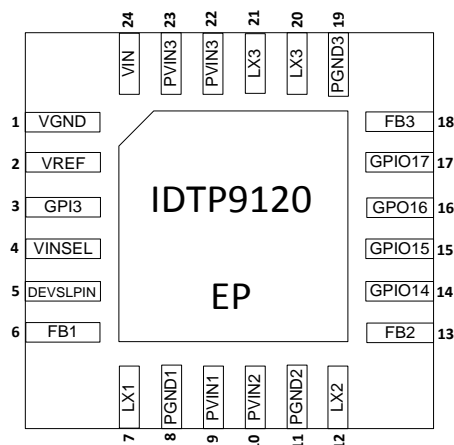


Figure 1, Device Pinout (Top View), 0.5mm pitch QFN-24, 4x4x0.75mm

Table 8 – Pin Functions by Pin Number

| #  | Label    | Type | Description  |
|----|----------|------|--|
| 1  | VGND     | GND  | Device ground connection   |
| 2  | VREF     | A    | Reference output [VREF=VOUT(Buck1)/2]  |
| 3  | GPI3     | DI   | General Purpose Input (see Modes of Operation, page 9)   |
| 4  | VINSEL   | DI   | Logic input to select function of Channel 3 (Logic Low = Buck operation, High = Switch operation) and UVLO thresholds. |
| 5  | DEVSLPIN | DI   | Logic input to activate sleep mode (Logic Low = Normal operation, Floating = Sleep operation).                         |
| 6  | FB1      | A    | Feedback connection Buck 1   |
| 7  | LX1      | A    | Inductor connection Buck 1   |
| 8  | PGND1    | GND  | Power ground Buck 1  |
| 9  | PVIN1    | PWR  | Power supply input Buck 1  |
| 10 | PVIN2    | PWR  | Power supply input Buck 2  |
| 11 | PGND2    | GND  | Power ground Buck 2  |
| 12 | LX2      | A    | Inductor connection Buck 2   |
| 13 | FB2      | A    | Feedback connection Buck 2   |
| 14 | GPIO14   | DIO  | General Purpose Input / Output (see Modes of Operation, page 9)  |
| 15 | GPIO15   | DIO  | General Purpose Input / Output (see Modes of Operation, page 9)  |
| 16 | GPO16    | DO   | General Purpose Output (see Modes of Operation, page 9)  |
| 17 | GPIO17   | DIO  | General Purpose Input / Output (see Modes of Operation, page 9)  |
| 18 | FB3      | A    | Feedback connection Buck 3 (Buck Mode) or Output (Switch Mode)   |
| 19 | PGND3    | GND  | Power ground Buck 3  |
| 20 | LX3      | A    | Inductor connection Buck 3 (Buck Mode) or Output (Switch Mode)   |
| 21 | LX3      | A    |  |
| 22 | PVIN3    | PWR  | Power supply input Buck 3  |
| 23 | PVIN3    | PWR  |  |
| 24 | VIN      | PWR  | Device supply input  |
| EP | EP       | GND  | Exposed pad, connect to heat sink ground plane   |



## FUNCTIONAL DESCRIPTION:

### Overview

The IDTP9120 support several modes to control the 3 Buck regulators and to generate status information like PG (power good) or POR (power on reset).

Various device features can be configured during production using one time programmable fuse memory (OTP). During evaluation, the options can be evaluated using the IDTP9120 Evaluation Kit (IDTP9120-EVAL).

The IDTP9120 OTP memory is organized into four fuse banks with 34 bits each. Bank0 and 1 are used for IDT internal trimming and calibration. Bank2 and 3 are used for customer specific device configuration.

### Modes of Operation

#### Device Power States

Device operates in three basic power states controlled by the DEVSLPIN pin and one optional state (standby) when in Mode 3.

#### Regulator Control Options (Mode 0..3)

The IDTP9120 supports four different control options for the Buck regulator. The functionality of GPI3, GPIO14,15,17 and GPO16 is different for each of the options. (MODE[1:0] = OTP Bank3[1:0])

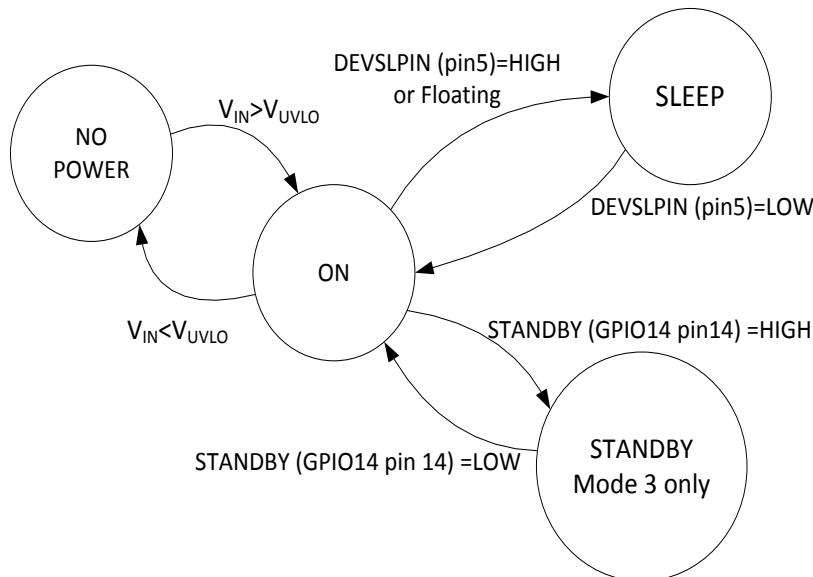


Figure 2. Device Power States

Table 9 – Buck Control Options

| MODE[1:0]      | DESCRIPTION  | GPI3 | GPIO14   | GPIO15   | GPO16 | GPIO17    |
|----------------|--|------|----------|----------|-------|-----------|
| 0<br>(Default) | Buck regulators controlled by individual enable pins (EN1, EN2, EN3)                       | NC   | EN1      | EN2      | PORB  | EN3       |
| 1              | Special Sequencing Option.   | NC   | COLDBOOT | SOCREADY | PORB  | DEVSLPRLY |
| 2              | Buck regulators controlled by master enable pin (MEN) w/ sequence                          | MEN  | PORB     | PG1      | PG2   | PG3       |
| 3              | Buck regulators controlled by master enable pin (MEN) w/ sequence and standby mode support | MEN  | STANDBY  | PG1      | PG2   | PG3/PORB  |

### Mode0 – Individual Buck control

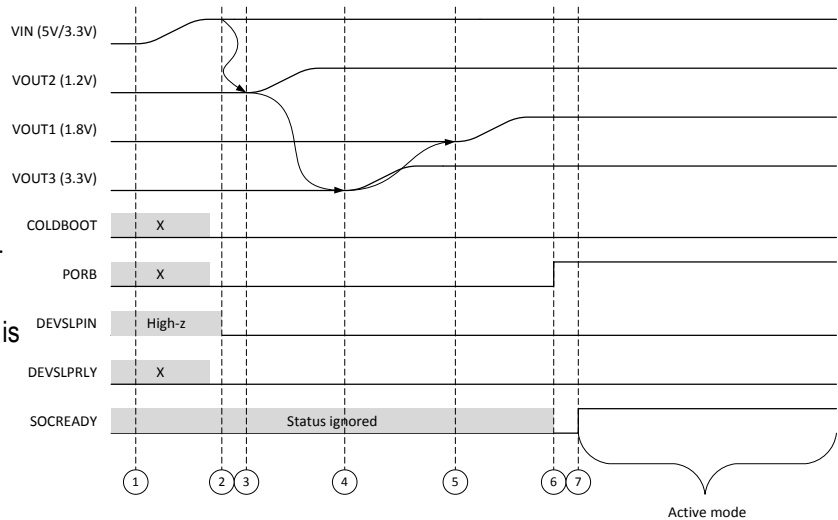
With IDTP9120 configured for mode0, all three regulators are individually controlled via ENx input pin. The PORB output can be configured to indicate various power up conditions.

### Mode1 – Special Sequencing Option

With IDTP9120 configured for mode1, a specific state machine will control the regulators. The sequence has been implemented for specific controllers used in solid state disk (SSD) applications. The sequencing details are documented in the following state diagrams. For further details on the “Special Sequencing Option”, please contact IDT.

### Device Start Up:

- (1) Input supply ramps-up.
- (2) DEVSLPIN is pulled low, device starts-up.
- (3) Device started-up, VOUT2 starts-up.
- (4) VOUT2 ramped-up, VOUT3 starts-up.
- (5) VOUT3 ramped-up, VOUT1 starts-up.
- (6) PORB de-asserts high.
- (7) SOCREADY (from controller) asserts high.



**Note:** Buck Voltages and Sequence shown is default and can be re-programmed.

Figure 3, Mode1 - Device Start Up

### Device enters DevSlp:

- (1) DEVSLPIN asserts high.
- (2) If SOCREADY is high, DEVSLPRLY is asserted high. Otherwise DEVSLPIN is ignored, DEVSLPRLY remains low.
- (3) Device is waiting for SOCREADY to de-assert low. SOCREADY is expected to go low within 500ms.
- (4) PORB is asserted low.
- (5) DEVSLPRLY de-asserts low.
- (6) VOUT2 shuts down.
- (7) VOUT2 ramped-down. VOUT3 shuts down.
- (8) VOUT1 shuts down.

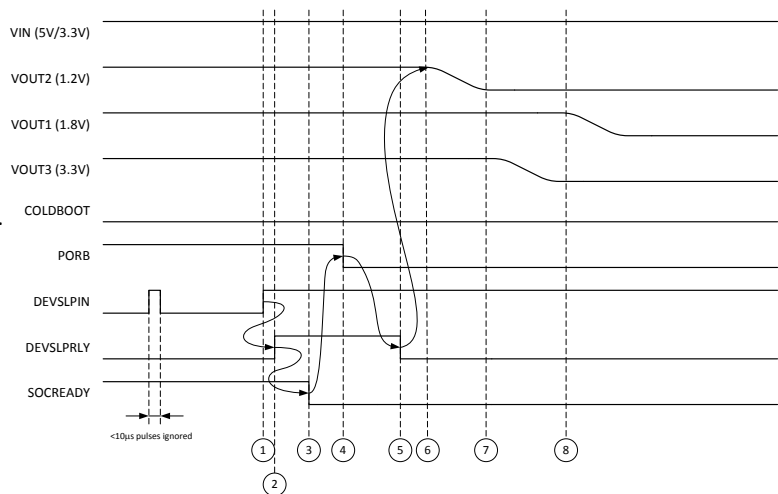


Figure 4, Mode1 - Device enters DevSlp

### Device exits DevSlp:

- (1) DEVSLPIN de-asserts low.
- (2) COLDBOOT de-asserts high, VOUT2 starts-up.
- (3) VOUT2 ramped-up, VOUT3 starts-up.
- (4) VOUT3 ramped-up, VOUT1 starts-up.
- (5) VOUT1 ramped-up, PORB de-asserts high.
- (6) Device is waiting for SOCREADY to assert high.
- (7) COLDBOOT asserts low.

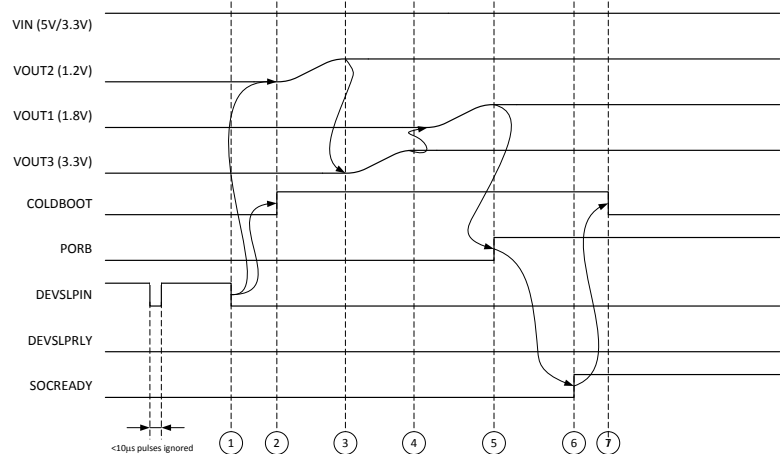


Figure 5. Mode1 - Device enters DevSlp

### Device shut-down:

- (1) VIN falls below the UVLO threshold, PORB asserts low.
- (2) After 2ms delay, VOUT1 ramps down.
- (3) VOUT3 ramps down.
- (4) VOUT2 and VREF ramp down.

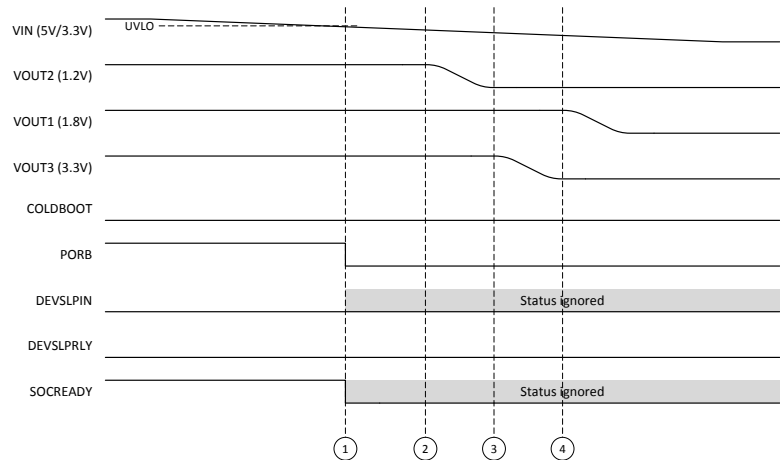


Figure 6. Mode1 - Device shut-down

### Mode2 – Master Enable pin (MEN) with sequence

With IDTP9120 configured for mode2, a configurable state machine will ramp up/down all 3 regulators controlled by the MEN pin. The PORB output can be configured to indicate various power up conditions. Individual Power Good output pins indicate the regulator output being established.

### Mode3 – Master Enable pin (MEN) with sequence and Standby Mode

With IDTP9120 configured for mode3, a configurable state machine will ramp up/down all 3 regulators controlled by the MEN pin. The PORB output can be configured to indicate various power up conditions. Individual Power Good output pins indicate the regulator output being established.

In addition to mode2, mode3 supports the STANDBY mode entered by asserting the STANDBY pin. During standby, Buck1,2 and/or 3 will be turned off without sequencing. The configuration is programmable via OTP.

## Pin Description

### DEVSLPIN

This pin allows the IC to enter and exit SLEEP mode. Sleep mode is the lowest power state of the device and is activated when DEVSLPIN is logic HIGH. The device will be in “normal operation” when DEVSLPIN is logic LOW. See figure 2 – Device Power States. For 1uA sleep mode operation, leave this pin floating. In floating operation, it is internally pulled up to ~1.5V. If pulled to Vin (between 3.0V and 6.0V), leakage current will flow between ~10uA to ~18uA respectively.

### VINSEL

This pin allows the function of Buck 3 to be changed to a Switch function. Logic LOW on this pin puts the channel into Buck configuration, and a Logic HIGH on this pin puts the channel into Switch configuration. The UVLO threshold is also dependent on the VINSEL configuration. See **Table 4 – General Electrical Characteristics** for details.

### PVIN1, PVIN2, PVIN3

PVINx is each buck converters’ respective power supply input. They provide power to the internal MOSFETs for the switch mode regulator. Their operating range is 2.7V to 5.5V, and a 10μF capacitor must be placed as close as possible to each of the respective pins. A second 10μF capacitor should be used with PVIN3 because of the greater current sourcing capability of this channel. Because the capacitance value decreases with voltage, a 10V rated X7R ceramic capacitors must be used. X7R is preferred over X5R because the derating with X7R is less. For best performance, each of these power supply inputs is to be connected together on a dedicated circuit board power plane, and the trace going from these pins, to the dedicated power plane, must be made as short as possible. Y5V capacitors are not recommended because of their general low performance with respect to temperature, voltage derating, and higher resistance at high frequencies, minimizing their ability to filter out high frequency noise.

### VIN

VIN is the power supply input for the bias and control portion of the integrated circuit. It too has an operating range of 2.7V to 5.5V, and a 2.2μF 10V rated X7R capacitor must be placed as close as possible to its pin. VIN should also be tied to the same power plane that the PVINx pins are tied to with as short a trace as possible. Do not use Y5V capacitors.

### PGND1, PGND2, PGND3

These are the dedicated ground pins for each of the respective power supplies. The traces from these pins, to a dedicated ground plane must be made as short and wide as possible.

### VGND

VGND is the ground pin for the bias and control portion of the integrated circuit. The trace from this pin, to a dedicated ground plane, should be made as short as possible.

### EP

This is the exposed pad on the bottom side of the IC. It must be connected to a top or bottom circuit board ground plane to maximize the thermal dissipation performance of the IC.

### VREF

The Vref pin tracks the output voltage of Buck 1, at half its value. A 2.2μF 6.3V rated X7R capacitor must be connected at this pin when enabled. This feature should be disabled in the OTP setting and left floating when not needed.

### FB1, FB2, FB3

FB1, FB2, FB3 are the respective feedback pins of the output voltage for each buck converter. The LSB of the outputs for each channel is 25mV from 0.8000V to 3.3375V. In the layout, the feedback traces should be kept as short as possible and should never run parallel to the inductors nor to the inductor trace leading to the inductor switching pin. Feedback traces should always cross inductors and inductor traces on separate planes and at right angles.

### LX1, LX2, LX3

LX1, LX2, LX3 are the switching pins of the respective buck converters. The IDTP9120 is optimized for 1μH small footprint chip inductors, and connect to the switching pins. The inductors must be placed as close as possible to the LX pins themselves.

### GPI3, GPIO14, GPIO15, GPO16, GPIO17

These pins have multiple functions, see Table 9 for device mode depended mode function.

## Component Selection

The IDTP9120 is a high performance triple DC-DC step down converter that satisfies the solution size demands of miniature portable electronic devices. It has two 2A outputs and one 3A output in a 4mm x 4mm QFN package. Only three external components are required per channel (Cin, Cout, L). Because it is designed to automatically switch to a pulse frequency modulation scheme at light loads, the IDTP9120 is able to maintain high efficiency across the entire load range while providing ultra-fast load transient response.

### Input Capacitor

A 10μF ceramic capacitor or greater must be placed close to each PVIN pin for each channel for bypassing. For the VIN pin, a 2.2μF 10V capacitor is sufficient because the VIN pin is powering the low power internal circuitry of the IC.

### Output Capacitor

A 10μF or greater ceramic capacitor must be placed close to each output inductor. Increasing the output capacitance will lower output ripple and improve load transient response but could also increase solution size or cost. The voltage rating of the output capacitor must be at least 6.3V.

### Inductor Selection

The IDTP9120 has been designed for use with a 1.0μH inductor. A larger value inductor will produce lower output voltage ripple, but a slightly smaller inductor value will produce faster transient response. The best compromise is a 1.0μH inductor. The inductor must be rated for the maximum peak current. Selection of the inductor needs to ensure maximum operating current not just the DC current, and can be rated for a 40°C temperature rise. This maximum operating current or peak current for a buck converter can be calculated using equation 1

$$I_{peak} = I_{out} * \left[ 1 + \frac{r}{2} \right] \quad \text{eq (1);}$$

where r is the inductor current ripple ratio and equal to eq (2).

$$r = V_{out} * \left[ \frac{1 - \frac{V_{out}}{V_{in}}}{I_{out} * L * f} \right] \quad \text{eq (2);}$$

where L and f are the inductor and switching frequency.

Simplifying gives equation 3:

$$I_{peak} = I_{out} + V_{out} * \left[ \frac{1 - \frac{V_{out}}{V_{in}}}{2 * L * f} \right] \quad \text{eq (3).}$$

Equation 3 shows that the peak inductor current is inversely related to the switching frequency and inductance. In other words, the lower the switching frequency or inductance, the higher the peak current. Peak current also increases as input voltage increases. The value of the inductor depends on the application. A validated inductor is the Toko 1239AS-H-1R0M.

## Typical Operating Characteristics

Typical values at 25°C, unless noted.  $V_{PVIN1} = V_{PVIN2} = V_{PVIN3} = V_{in} = 5V$ .  $C_{O(BUCK1)} = C_{O(BUCK2)} = 10\mu F$ ,  $C_{O(BUCK3)} = 20\mu F$ ,  $L1=L2=L3 = 1.0\mu H$ .

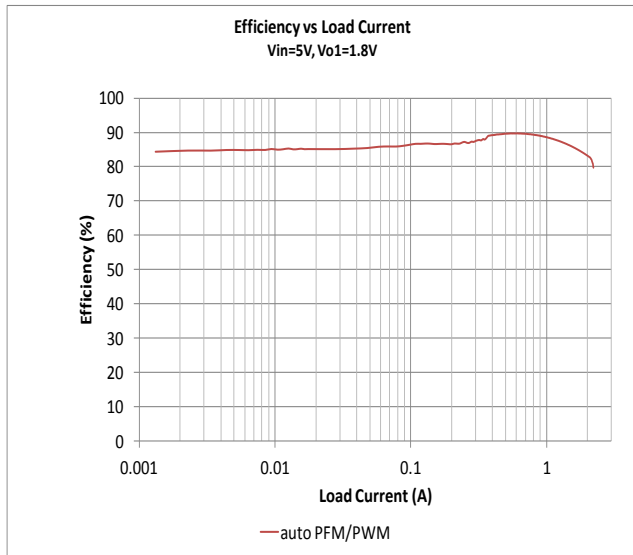


Figure 7. Channel 1 Efficiency

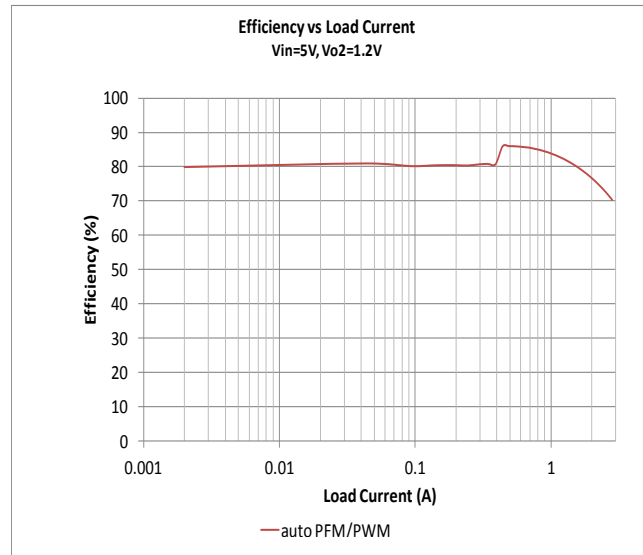


Figure 8. Channel 2 Efficiency

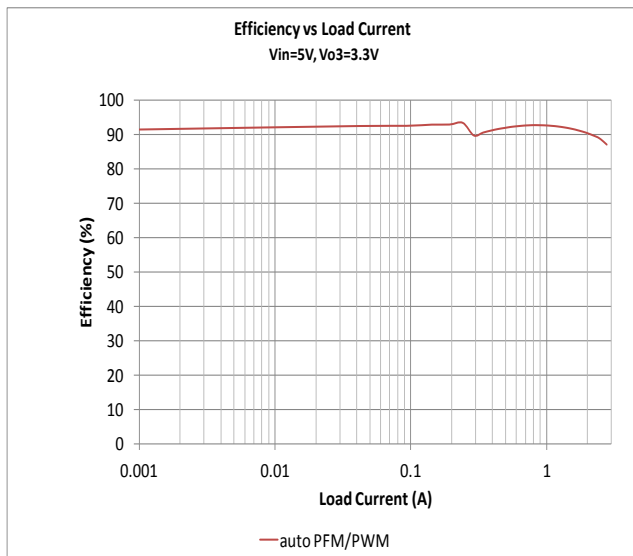


Figure 9. Channel 3 Efficiency

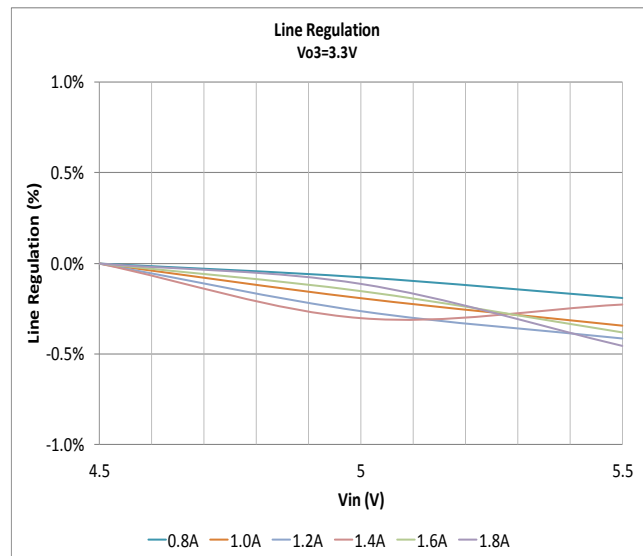
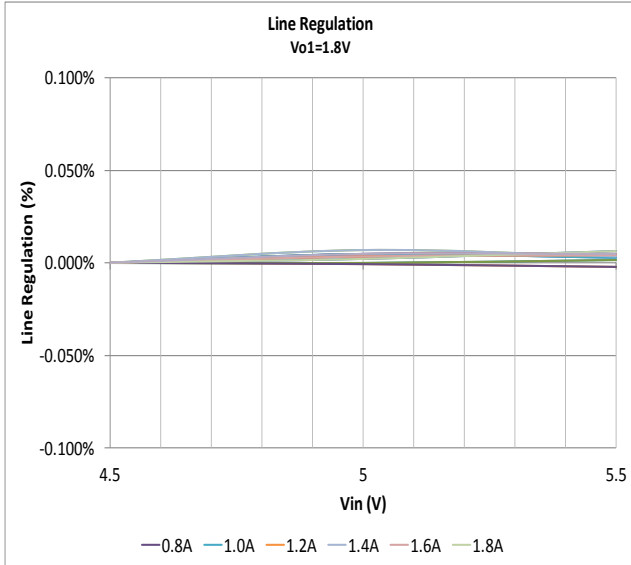
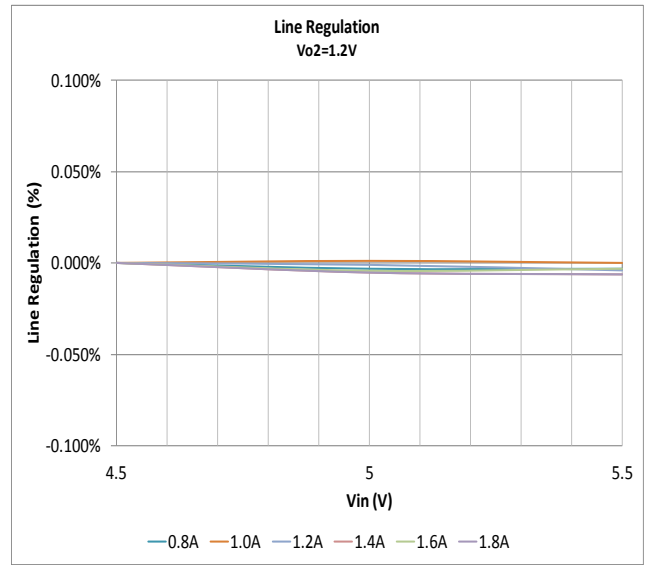


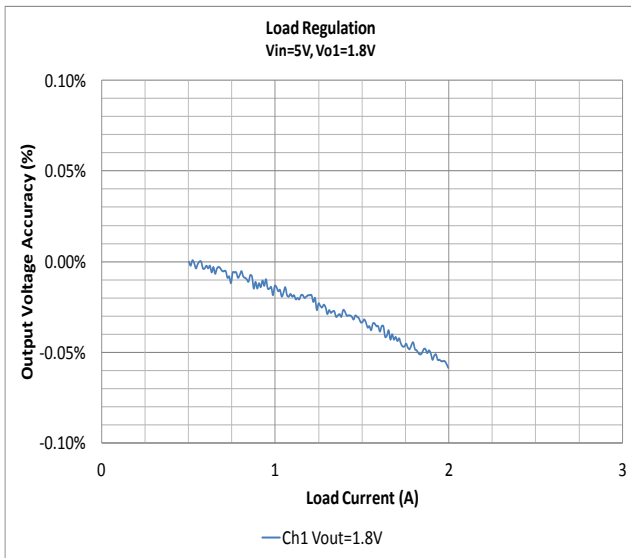
Figure 10. Channel 3 Line Regulation



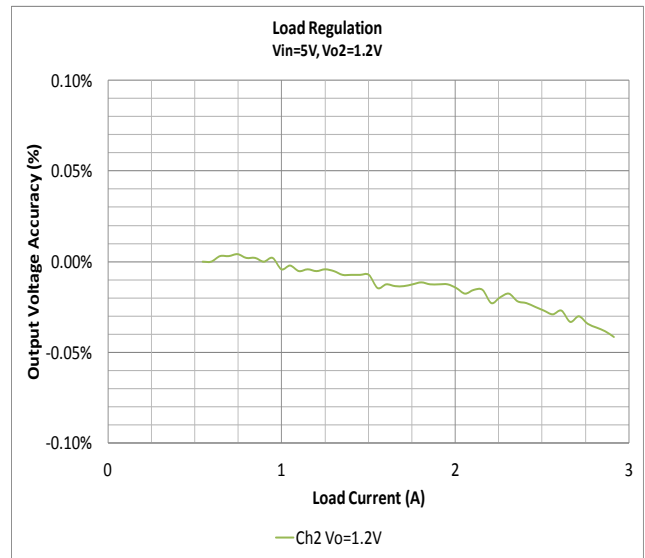
**Figure 11. Channel 1 Line Regulation**



**Figure 12. Channel 2 Line Regulation**



**Figure 13. Channel 1 Load Regulation**



**Figure 14. Channel 2 Load Regulation**

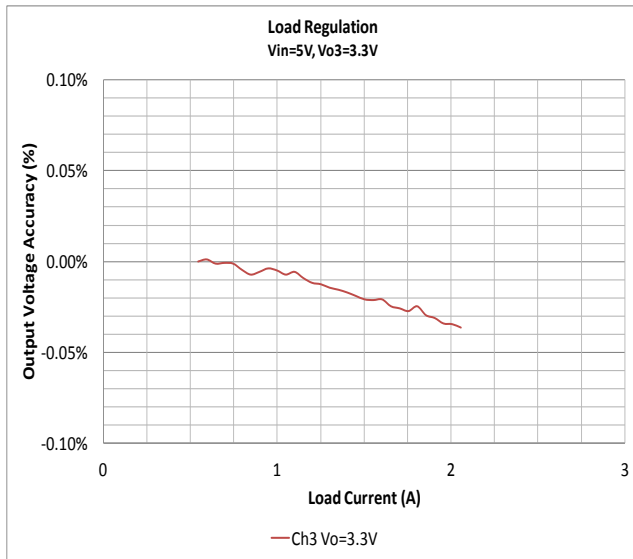


Figure 15. Channel 3 Load Regulation

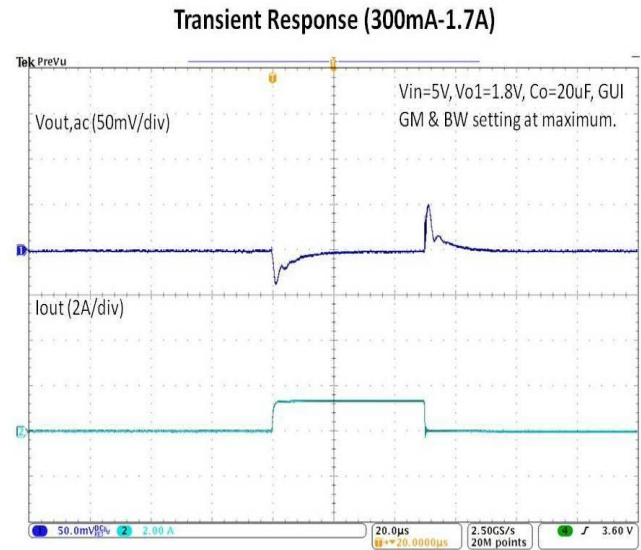


Figure 16. Channel 1 Load Transient Response

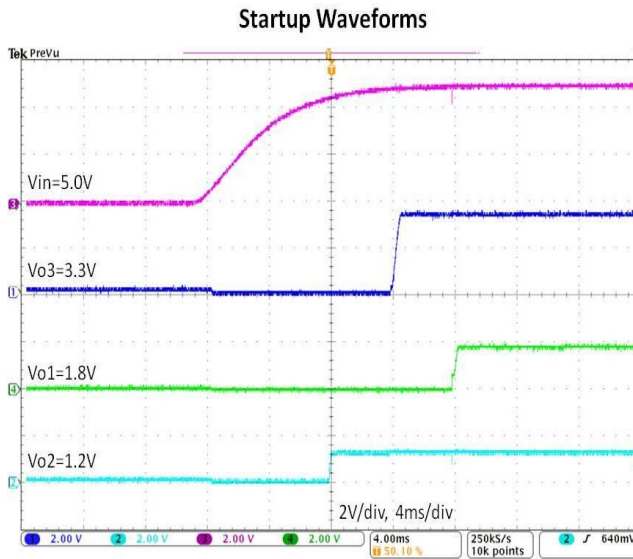


Figure 17. All Channel Startup Waveforms

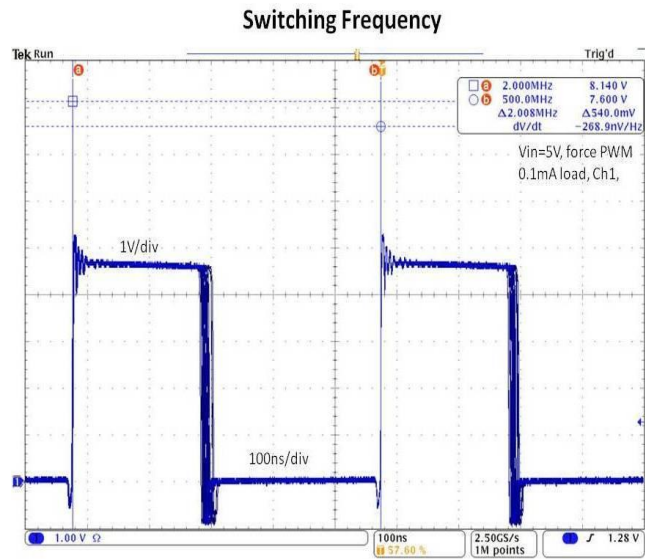


Figure 18. Channel 1 Switch Node Switching Frequency



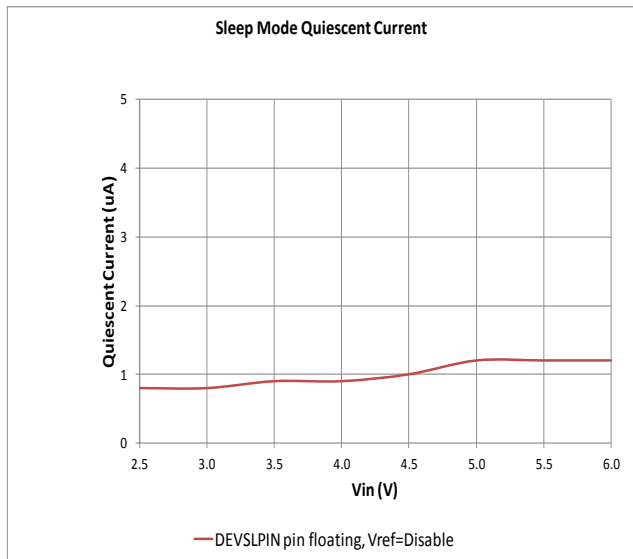


Figure 19. Sleep Quiescent Current

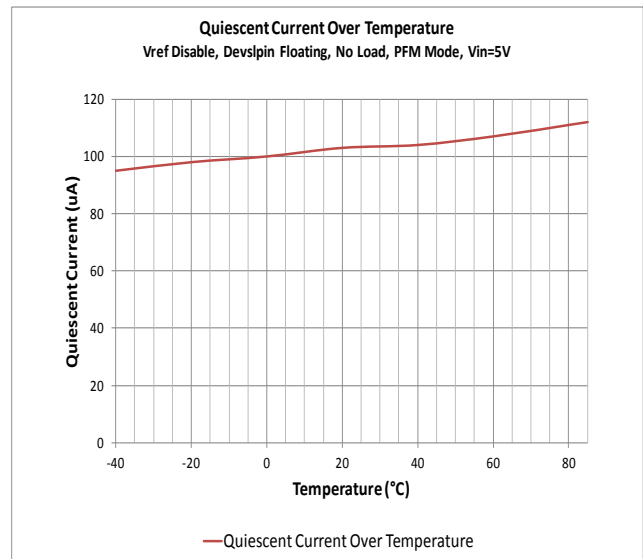


Figure 20. Quiescent Current Over Temperature

## OTP Register Mapping

The following table lists all configurable OTP registers available in the IDTP9120.

The registers can be programmed for evaluation purpose using the IDTP9120 Evaluation Kit (IDTP9120-EVAL) with the included GUI software. The final production configuration will be programmed by IDT during final test.

### (Bank T0)

| Trim Bits<br>(Default) | Parametric Trim Descriptions   |
|------------------------|--|
| T0[29]<br>(0)          | DEVSLP Mode Support: Sets device behavior when supply is initially applied.<br>0 : Device always powers up independent of DEVSLPIN pin state.<br>SSD (Solid State Disk) application mode.<br>1 : Device powers up only when DEVSLPIN is low. |

### (Bank T1)

| Trim Bits<br>(Default) | Parametric Trim Descriptions   |
|------------------------|--|
| T1[22:21]<br>(00)      | Buck1 Slope Compensation Select: Device option for Buck 1. To be selected based on inductor value and expected PWM duty cycle.<br>00 : Slope comp=Nominal<br>01 : Slope comp=+20%<br>10 : Slope comp=+100%<br>11 : Slope comp=+40% |
| T1[24:23]<br>(00)      | Buck2 Slope Compensation Select: Device option for Buck 2. To be selected based on inductor value and expected PWM duty cycle.<br>00 : Slope comp=Nominal<br>01 : Slope comp=+20%<br>10 : Slope comp=+100%<br>11 : Slope comp=+40% |
| T1[26:25]<br>(00)      | Buck3 Slope Compensation Select: Device option for Buck 3. To be selected based on inductor value and expected PWM duty cycle.<br>00 : Slope comp=Nominal<br>01 : Slope comp=+20%<br>10 : Slope comp=+100%<br>11 : Slope comp=+40% |

**(Bank T2)**

| Trim Bits<br>(Default) | Parametric Trim Descriptions   |
|------------------------|--|
| T2[0]<br>(0)           | Buck1 Transconductance Selection: Relevant for all modes<br>0 : Nominal<br>1 : 3x transconductance                 |
| T2[1]<br>(0)           | Buck1 Bandwidth Selection: Relevant for all modes<br>0 : Nominal<br>1 : 2x bandwidth                               |
| T2[2]<br>(0)           | Buck1 Forced PWM Mode: Relevant for all modes<br>0 : Auto-switching between PWM & PFM modes<br>1 : Forced PWM mode |
| T2[3]<br>(0)           | Buck2 Transconductance Selection:<br>0 : Nominal<br>1 : 3x transconductance  |
| T2[4]<br>(0)           | Buck2 Bandwidth Selection:<br>0 : Nominal<br>1 : 2x bandwidth  |
| T2[5]<br>(0)           | Buck2 Forced PWM Mode:<br>0 : Auto-switching between PWM & PFM modes<br>1 : Forced PWM mode                        |
| T2[6]<br>(0)           | Buck3 Transconductance Selection:<br>0 : Nominal<br>1 : 3x transconductance  |
| T2[7]<br>(0)           | Buck3 Bandwidth Selection:<br>0 : Nominal<br>1 : 2x bandwidth  |
| T2[8]<br>(0)           | Buck3 Forced PWM Mode:<br>0 : Auto-switching between PWM & PFM modes<br>1 : Forced PWM mode                        |
| T2[10:9]<br>(00)       | Power-Off Sequencer Delay 1: Relevant only when mode[1:0]≠'00'<br>00 : 0.5ms<br>01 : 1ms<br>10 : 2ms<br>11 : 4ms   |
| T2[12:11]<br>(00)      | Power-Off Sequencer Delay 2: Relevant only when mode[1:0]≠'00'<br>00 : 0.5ms<br>01 : 1ms<br>10 : 2ms<br>11 : 4ms   |

(Bank T2)

| Trim Bits (Default) | Parametric Trim Descriptions   |
|---------------------|--|
| T2[15:13]<br>(000)  | Buck Power-Off Sequence Selection: Relevant only when mode[1:0]≠'00'<br>000 : Buck2 → Buck3 → Buck1<br>001 : Buck2 → Buck1 → Buck3<br>010 : Buck1 → Buck2 → Buck3<br>011 : Buck1 → Buck3 → Buck2<br>100 : Buck3 → Buck1 → Buck2<br>101 : Buck3 → Buck2 → Buck1<br>110 : Buck1 → Buck2 & Buck3<br>111 : Buck2 → Buck1 & Buck3 |
| T2[18:16]<br>(000)  | PORB Output Boolean Operator Selection: PG=Power Good<br>000 : PG1 & PG2 & PG3<br>001 : PG1<br>010 : PG2<br>011 : PG3<br>100 : PG1 & PG2<br>101 : PG1 & PG3<br>110 : PG2 & PG3<br>111 : reserved   |
| T2[19]<br>(0)       | GPI3 Internal Pull-up Enable:<br>0 : Disable (1μA pull-down to VGND)<br>1 : Enable (100kΩ pull-up to VIN)  |
| T2[20]              | Unused   |
| T2[21]<br>(0)       | GPIO14 Internal Pull-up Enable:<br>0 : Disable (1μA pull-down to VGND when pin configured as input)<br>1 : Enable (50kΩ pull-up to supply voltage selected by gpio14_vio)  |
| T2[22]<br>(0)       | GPIO14 Open-Drain Output Select:<br>Relevant only when pin configured as output.<br>0 : Push-pull output<br>1 : Open-drain output  |
| T2[23]<br>(0)       | GPIO14 I/O Voltage Select: For both input buffer and push-pull output driver.<br>0 : VOUT3 (FB3)<br>1 : VOUT1 (FB1)  |
| T2[24]<br>(0)       | GPIO15 Internal Pull-up Enable:<br>0 : Disable (1μA pull-down to VGND when pin configured as input)<br>1 : Enable (50kΩ pull-up to supply voltage selected by gpio15_vio)  |
| T2[25]<br>(0)       | GPIO15 Open-Drain Output Select:<br>Relevant only when pin configured as output.<br>0 : Push-pull output<br>1 : Open-drain output  |
| T2[26]<br>(0)       | GPIO15 I/O Voltage Select: For both input buffer and push-pull output driver.<br>0 : VOUT3 (FB3)<br>1 : VOUT1 (FB1)  |
| T2[27]<br>(0)       | GPO16 Internal Pull-up Enable:<br>0 : Disable<br>1 : Enable (50kΩ pull-up to supply voltage selected by gpo16_vo)  |

|               |   |
|---------------|---|
| T2[28]<br>(0) | GPO16 Open-Drain Output Select:<br>0 : Push-pull output<br>1 : Open-drain output  |
| T2[29]<br>(0) | GPO16 Output Voltage Select: For push-pull output driver.<br>0 : VOUT3 (FB3)<br>1 : VOUT1 (FB1)   |
| T2[30]<br>(0) | GPIO17 Internal Pull-up Enable:<br>0 : Disable (1 $\mu$ A pull-down to VGND when pin configured as input)<br>1 : Enable (50k $\Omega$ pull-up to supply voltage selected by gpio17_vio) |
| T2[31]<br>(0) | GPIO17 Open-Drain Output Select:<br>Relevant only when pin configured as output.<br>0 : Push-pull output<br>1 : Open-drain output   |
| T2[32]<br>(0) | GPIO17 I/O Voltage Select: For both input buffer and push-pull output driver.<br>0 : VOUT3 (FB3)<br>1 : VOUT1 (FB1)   |
| T2[33]<br>(0) | VREF Output Disable:<br>0 : VREF = 0.5 x VOUT1(FB1)<br>1 : VREF output disabled   |

### (Bank T3)

| Trim Bits<br>(Default) | Parametric Trim Descriptions  |
|------------------------|---|
| T3[1:0]<br>(00)        | Device I/O Configuration and Control:<br>00 : Individual regulator enable via pins<br>01 : Special Sequence mode<br>10 : Master enable control with programmable sequencing<br>11 : Master enable control with programmable sequencing + SLEEP mode support   |
| T3[2]<br>(0)           | TSD & UVLO Fault Disable:<br>Used for device characterization and burn-in only.<br>0 : Fault event shuts down all Buck regulators (programmed sequence)<br>1 : Fault ignored  |
| T3[5:3]<br>(000)       | Buck Power-On Sequence Selection: Relevant only when mode[1:0]≠'00'<br>000 : Buck2 → Buck3 → Buck1<br>001 : Buck3 → Buck1 → Buck2<br>010 : Buck3 → Buck2 → Buck1<br>011 : Buck1 → Buck3 → Buck2<br>100 : Buck2 → Buck1 → Buck3<br>101 : Buck1 → Buck2 → Buck3<br>110 : Buck2 & Buck3 → Buck1<br>111 : Buck1 & Buck3 → Buck2 |
| T3[6]<br>(0)           | Buck1 SLEEP Mode Support: Relevant only when mode[1:0]='11'<br>0 : Buck1 not affected by SLEEP mode<br>1 : Buck1 supports SLEEP mode control  |

**(Bank T3)**

| Trim Bits<br>(Default) | Parametric Trim Descriptions   |   |
|------------------------|--|---|
| T3[7]<br>(0)           | Buck2 SLEEP Mode Support: Relevant only when mode[1:0]='11'<br>0 : Buck2 not affected by SLEEP mode<br>1 : Buck2 supports SLEEP mode control |   |
| T3[8]<br>(0)           | Buck3 SLEEP Mode Support: Relevant only when mode[1:0]='11'<br>0 : Buck3 not affected by SLEEP mode<br>1 : Buck3 supports SLEEP mode control |   |
| T3[10:9]<br>(00)       | Power-On Sequencer Delay 1: Relevant only when mode[1:0]≠'00'<br>00 : 0.5ms<br>01 : 1ms<br>10 : 2ms<br>11 : 4ms                              |   |
| T3[12:11]<br>(00)      | Power-On Sequencer Delay 2: Relevant only when mode[1:0]≠'00'<br>00 : 0.5ms<br>01 : 1ms<br>10 : 2ms<br>11 : 4ms                              |   |
| T3[19:13]<br>(0x00)    | Vout1:<br>(1.800V)   | 000d : 1.800V(Vout1) / 1.200V(Vout2) / 3.300V(Vout3)<br>001d : 0.800V<br>002d : 0.825V<br>003d : 0.850V<br>: :<br>: :<br>100d : 3.275V<br>101d : 3.300V<br>102d : 3.325V<br>≥103d : 3.3375V |
| T3[26:20]<br>(0x00)    | Vout2:<br>(1.200V)   |   |
| T3[33:27]<br>(0x00)    | Vout3:<br>(3.300V)   |   |

## APPLICATION INFORMATION

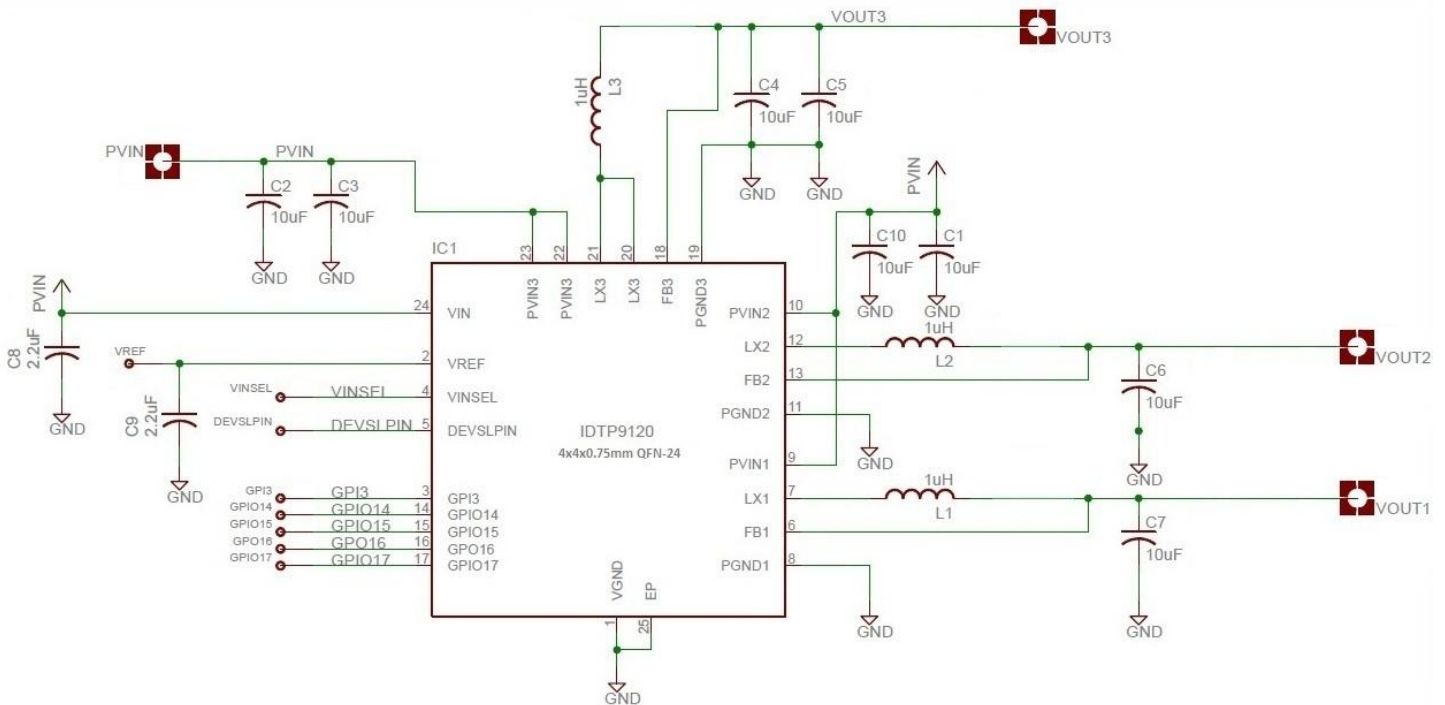


Figure 21. Minimum component schematic of IDTP9120.

## BILL OF MATERIALS

| #          | Description     | Package   | Manufacturer Part Number |
|------------|-----------------|-----------|--------------------------|
| IC1        | IDTP9120-00NBGI | 4X4QFN    | IDT                      |
| L1-L3      | 1uH             | 2520/1008 | TOKO 1239AS-H-1R0M       |
| C1-C3, C10 | 10uF, 10v, X7R  | 0805/2012 | C0805C106K8RACTU         |
| C4-C7      | 10uF, 6.3v, X7R | 1206/3216 | C1206C106K9RACTU         |
| C8-C9      | 2.2uF, 10v, X7R | 0603/1608 | 06036C225KAT2A           |

## PACKAGE INFORMATION

Please refer to the documents located under <http://www.idt.com/package/nbg24> for detailed package outline, recommended footprint, carrier and RoHS information. IDTP9120 is using the P1-NBG24 package option (EP size: 2.8mm)



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