

## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

### General Description

DA9130 is a power management IC (PMIC) suitable for supplying CPUs, GPUs, DDR memory rails in single in-line pin package (SIPP) modules, mobile, portable and consumer applications.

DA9130 operates as a single-channel dual-phase buck converter, each phase requiring a small external 0.22  $\mu$ H inductor. It is capable of delivering up to 10 A output current at a 0.3 V to 1.9 V output voltage range. The 2.8 V to 5.5 V input voltage range is suitable for a wide variety of low-voltage systems.

With remote sensing, the DA9130 guarantees the highest accuracy and supports multiple PCB routing scenarios without loss of performance.

The pass devices are fully integrated, so no external FETs or Schottky diodes are needed.

A programmable soft start-up can be enabled, which limits the inrush current from the input node and secures a slope-controlled rail activation.

The dynamic voltage control (DVC) supports adaptive adjustment of the supply voltage dependent on the processor load, via either a direct register write using the communication interface (I<sup>2</sup>C-compatible) or with a programmable input pin.

A configurable GPI allows multiple I<sup>2</sup>C address selection for multiple instances of DA9130 in the same application.

DA9130 has integrated over-temperature and over-current protection for increased system reliability, without the need for external sensing components.

### Key Features

- 2.8 V to 5.5 V input voltage
- 0.3 V to 1.9 V output voltage
- Up to 10 A output current
- 4 MHz nominal switching frequency
- Dual-phase operation
- 220 nH inductor per phase
- 20  $\mu$ F output capacitor
- $\pm 1$  % output voltage accuracy (static)
- $\pm 5$  % load transient (dynamic)
- Programmable GPIOs
- Programmable soft startup
- I<sup>2</sup>C-compatible interface (FM+)
- Voltage, current, and temperature supervision
- 24-pin FCQFN package, wettable flanks (nom. 3.3 mm x 4.8 mm)
- 218 mm<sup>2</sup> total solution area
- -40 °C to +105 °C ambient temperature range
- AEC-Q100 Grade 2 qualified version also available for Automotive applications (DA9130-A)

### Benefits

- High Efficiency buck converters deliver outstanding thermal performance
- Fully integrated switching FET's means no external FETs or Schottky diodes are required
- Remote sensing guarantees the highest accuracy and supports multiple PCB routing scenarios without loss of performance.
- Fully programmable soft-start limits the inrush current from the input to give a slope-controlled output voltage.
- Dynamic voltage control (DVC) enables adaptive adjustment of the device output voltage depending on the load. This increases efficiency when the downstream circuitry enters low power or idle mode, resulting in power savings.
- Configurable GPIOs support a range of features including I<sup>2</sup>C, DVC and Power-Good indicator.

# DA9130

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- Optimized BoM cost and footprint: Each output requires a very small inductor and capacitor delivering parts and cost savings
- Cycle by cycle current limiting for superior over-current protection

### Applications

- Switches and routers
- Smart metering
- Industrial automation
- Wireless
- Consumer products
- SoC/FPGA high performance processing system requiring efficient, high current, power delivery
- SIPP modules (SoC, DRAM)

### System Diagrams

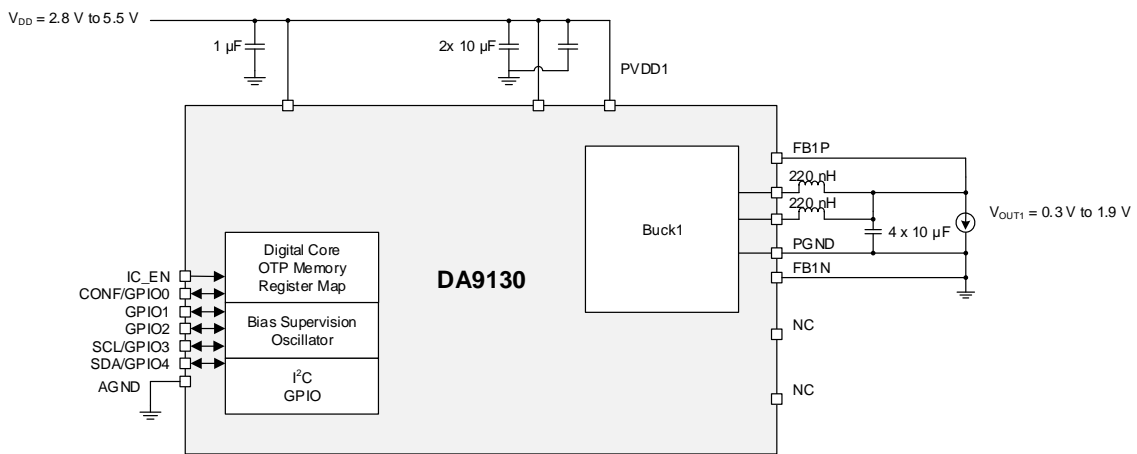


Figure 1: Simplified Schematic Diagram

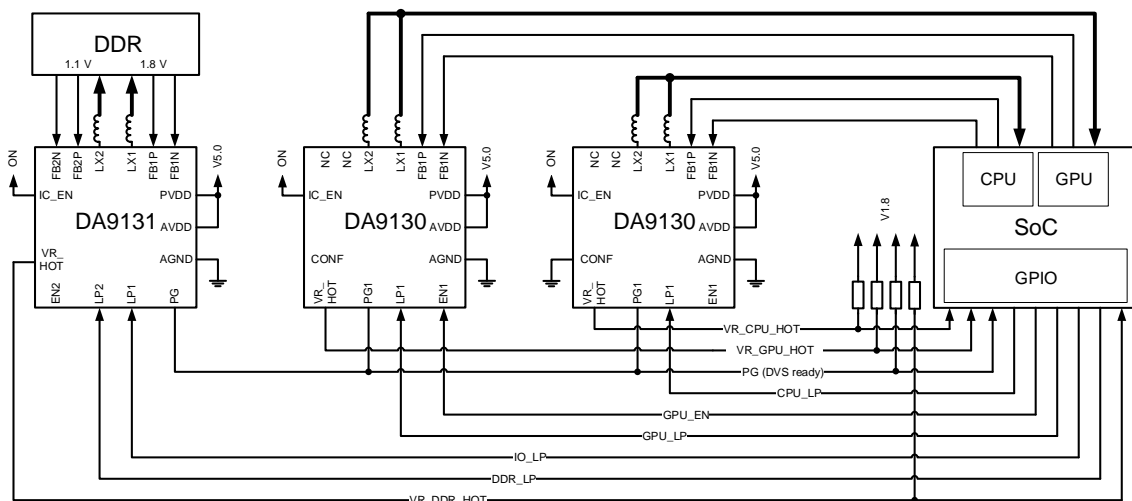


Figure 2: Typical Application Diagram (Port Control)

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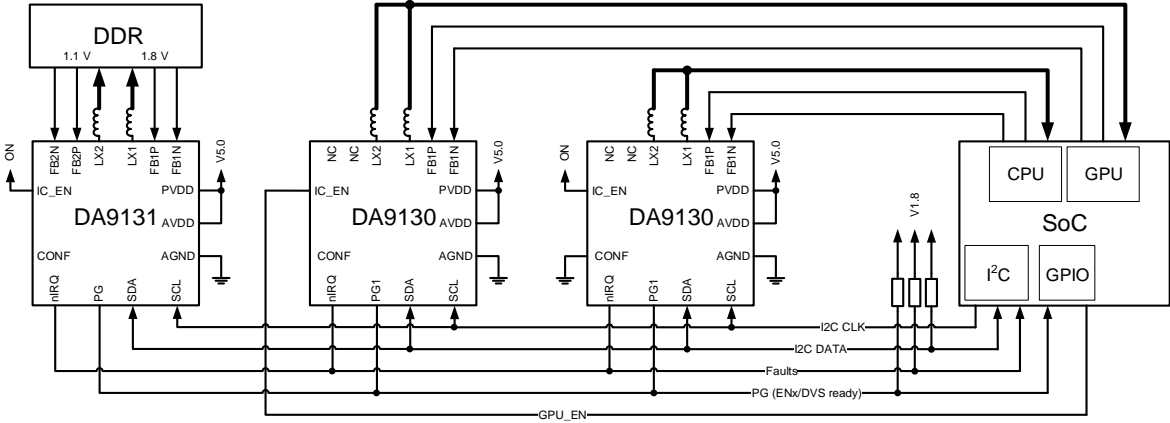


Figure 3: Typical Application Diagram (I<sup>2</sup>C Control)

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## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

### 1 Terms and Definitions

ATE	Automated test equipment
CPU	Central processing unit
DDR	Dual data rate
DVC	Dynamic voltage control
FET	Field effect transistor
FM+	Fast mode plus
GBD	Guaranteed by design
GBQ	Guaranteed by qualification
GBSPC	Guaranteed by statistical process characterization
GPI	General purpose input
GPIO	General purpose input/output
GPU	Graphics processing unit
IC	Integrated circuit
HW	Hardware
OTP	One time programmable
PCB	Printed circuit board
PRS	Product requirements specification
SCL	Serial clock
SDA	Serial data
SIPP	Single in-line pin package
SW	Software

## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

### 2 Pinout

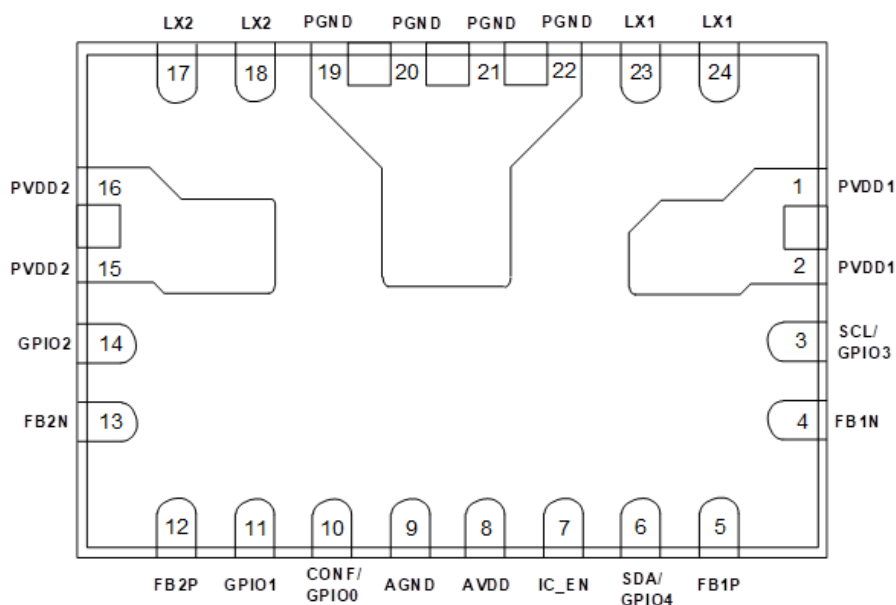


Figure 4: DA9130 Pinout Diagram (Bottom View)

Table 1: Pin Description

Pin #	Pin Name	Type (Table 2)	Drive per pin (mA)	Description
1, 2	PVDD1	PS	5000	Supply for Ch1
3	SCL/GPIO3	DIO	15	SCL
4	FB1N	AI	10	Negative feedback for Ch 1
5	FB1P	AI	10	Positive feedback for Ch 1
6	SDA/GPIO4	DIO	15	SDA
7	IC_EN	DI	10	IC enable.
8	AVDD	PS	10	Analog supply
9	AGND	PS	10	Analog ground
10	CONF/GPIO0	DIO	10	GPIO
11	GPIO1	DIO	10	GPIO
12	FB2P	AI	10	Positive feedback for Ch 2
13	FB2N	AI	10	Negative feedback for Ch 2
14	GPIO2	DIO	10	GPIO
15, 16	PVDD2	PS	5000	Supply for Ch2
17, 18	LX2	AO	5000	Buck output of Ch 2
19, 20, 21, 22	PGND	PS	5000	Power ground
23, 24	LX1	AO	5000	Buck output of Ch 1



## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

**Table 2: Pin Type Definition**

Pin Type	Description	Pin Type	Description
DI	Digital input	AI	Analog input
DIO	Digital input/output	AO	Analog output
PS	Power supply		

### 3 Characteristics

#### 3.1 Absolute Maximum Ratings

Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, so functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specification are not implied. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.

**Table 3: Absolute Maximum Ratings**

Parameter	Description	Conditions	Min	Max	Unit
T <sub>STG</sub>	Storage temperature		-65	150	°C
T <sub>J</sub>	Junction temperature		-40	150	°C
V <sub>SYS</sub>	System supply voltage		-0.3	6.0	V
V <sub>PIN</sub>	Voltage on pins		-0.3	6.0	V

#### 3.2 Recommended Operating Conditions

**Table 4: Recommended Operating Conditions**

Parameter	Description (Error! Reference source not found.)	Conditions (Note 1)	Min	Typ	Max	Unit
V <sub>SYS</sub>	System supply voltage		2.8		5.5	V
V <sub>PIN</sub>	Voltage on pins		-0.3		V <sub>SYS</sub> + 0.3	V
T <sub>J</sub>	Junction temperature		-40		125	°C
T <sub>A</sub>	Ambient temperature		-40		105	°C

**Note 1** Within the specified limits, a lifetime of 10 years is guaranteed. If operating outside of these recommended conditions, please consult with Renesas.

**Note 2** V<sub>SYS</sub>, V<sub>IN</sub>, V<sub>PVDD</sub> and V<sub>AVDD</sub> should be connected together. The pin names are different for routing purposes.

## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

### 3.3 Thermal Characteristics

#### 3.3.1 Thermal Ratings

**Table 5: Package Ratings**

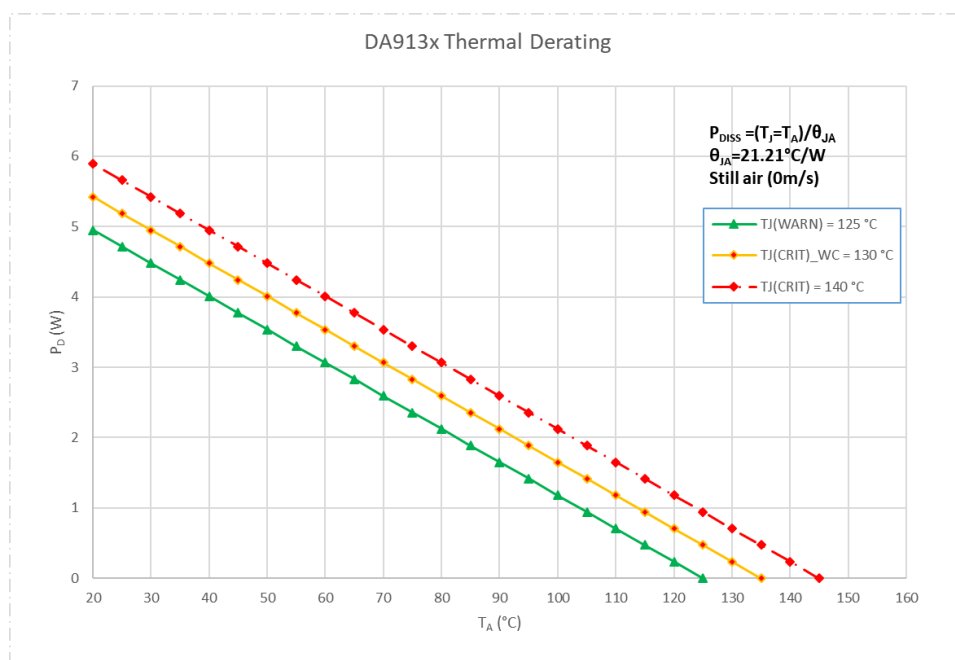
Parameter	Description	Conditions	Min	Typ	Max	Unit
$\theta_{JA}$	Package thermal resistance	Note 1		21.21		°C/W
$\theta_{JB}$	Thermal resistance junction to board	Note 1		12.37		°C/W
$\theta_{JC}$	Thermal resistance junction to case	Without PCB		32		°C/W

**Note 1** Obtained from package thermal simulations, JEDEC 2S2P four layer board (76.2 mm x 114 mm x 1.6 mm), 70  $\mu\text{m}$  (2 oz) copper thickness power planes, 35  $\mu\text{m}$  (1 oz) copper thickness signal layer traces, natural convection (still air), see Section 6.1.

#### 3.3.2 Power Dissipation

**Table 6: Power Dissipation**

Parameter	Description	Conditions	Min	Typ	Max	Unit
$P_{D\_Twarn}$	Power dissipation	@105 °C ambient, $T_{J\_WARN}$		0.94		W
$P_{D\_Tcrit}$	Power dissipation	@105 °C ambient, $T_{CRIT}$	1.41	1.65		W
$P_{D\_70}$	Power dissipation	@70°C ambient		2.43		W



**Figure 5: Power Derating Curve**

## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

### 3.3.3 ESD Characteristics

**Table 7: ESD Characteristics**

Parameter	Description	Conditions	Value	Unit
V <sub>ESD_HBM</sub>	ESD protection, human body model (HBM)		2	kV
V <sub>ESD_CDM</sub>	Maximum ESD protection	Charged device model (CDM)	500	V

### 3.4 Buck Characteristics

Unless otherwise noted, the following is valid for T<sub>J</sub> = -40 °C to +125 °C, V<sub>SYS</sub> = 2.8 V to 5.5 V.

**Table 8: Buck Electrical Characteristics**

Parameter	Description	Conditions	Min	Typ	Max	Unit
<b>External Electrical Conditions</b>						
V <sub>IN</sub>	Input voltage	V <sub>IN</sub> = V <sub>SYS</sub>	2.8		5.5	V
C <sub>OUT</sub>	Output capacitance, per phase, including voltage and temperature coefficient		-40 %	20	+30 %	μF
ESR <sub>COUT</sub>	Output capacitor series resistance, per phase	f > 100 kHz		1		mΩ
L	Inductor value, per phase, including current and temperature dependence		-50 %	220	+20 %	nH
DCR <sub>L</sub>	Inductor DC resistance			8	13	mΩ
<b>Electrical Performance</b>						
V <sub>OUT</sub>	Output voltage, configurable in 10 mV steps	I <sub>OUT</sub> = 0 mA to I <sub>MAX</sub> at 25 °C ambient 2.8 V < V <sub>OUT</sub> + 1 V < V <sub>IN</sub> ≤ 5.5 V	0.3		1.9	V
I <sub>LIM</sub>	Current limit, configurable per phase <a href="#">Note 1</a> <a href="#">Note 2</a>	CHx_ILIM = 1010	-20 %	8	+20 %	A
I <sub>MAX</sub>	Output current <a href="#">Note 3</a>	V <sub>IN</sub> ≥ V <sub>OUT</sub> + 1 V 5 A per phase	10			A
V <sub>OUT_ACC</sub>	Output voltage accuracy, including static line and load regulation	V <sub>OUT</sub> ≥ 1 V	-1		1	%
V <sub>OUT_ACC</sub>	Output voltage accuracy, including static line and load regulation	V <sub>OUT</sub> < 1 V	-10		10	mV

## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

Parameter	Description	Conditions	Min	Typ	Max	Unit
V <sub>THR_PG_HYS</sub>	Power-good voltage threshold hysteresis	V <sub>OUT</sub> = V <sub>THR_PG_DWN</sub>	60	80	100	mV
V <sub>THR_PG_DWN</sub>	Power-good voltage threshold for falling	V <sub>OUT</sub> = V <sub>BUCK</sub>	-160	-130	-80	mV
V <sub>THR_HV</sub>	High V <sub>OUT</sub> voltage threshold	V <sub>OUT</sub> = V <sub>BUCK</sub>	100	150	200	mV
V <sub>OUT_TR_LINE</sub>	Line transient response	V <sub>IN</sub> = 3 V to 3.6 V I <sub>OUT</sub> = 0.5 * I <sub>MAX</sub> dt = 10 μs		15		mV
f <sub>SW</sub>	Switching frequency			4		MHz
t <sub>ON_MIN</sub>	Minimum turn-on pulse 0 % duty is also supported		5	7	11	ns
t <sub>BUCK_EN</sub>	Turn-on time	CHx_EN = high			20	μs
R <sub>PD</sub>	Output pull-down resistance for each phase at the LX node, see BUCK<x>_PD_DIS	V <sub>IN</sub> = 3.7 V V <sub>OUT</sub> = 0.5 V	145	150	161	Ω
R <sub>ON_P MOS</sub>	On resistance of switching PMOS, per phase	V <sub>IN</sub> = 3.7 V	17	25	37	mΩ
R <sub>ON_N MOS</sub>	On resistance of switching NMOS, per phase	V <sub>IN</sub> = 3.7 V	6	10	16	mΩ
<b>PWM Mode</b>						
I <sub>THR_1PH_TO_2PH</sub>	Current threshold for automatic phase shedding 1-phase to 2-phase			2.25		A
I <sub>THR_2PH_TO_1PH</sub>	Current threshold for automatic phase shedding 2-phase to 1-phase			1.7		A
I <sub>Q_PWM_2PH</sub>	Quiescent current, per phase	V <sub>IN</sub> = 3.7 V No load		16		mA
η <sub>PWM</sub>	Efficiency, phase shedding	V <sub>IN</sub> = 3.6 V V <sub>OUT</sub> = 1 V I <sub>OUT</sub> = 5 % (I <sub>MAX</sub> ) to 80 % (I <sub>MAX</sub> )		85		%

## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

Parameter	Description	Conditions	Min	Typ	Max	Unit
<b>AUTO Mode</b>						
$V_{OUT\_TR\_LD\_2PH}$	Load transient response, phase shedding enabled	$V_{OUT} = 1\text{ V}$ $I_{OUT} = 2.5\text{ to }7.5\text{ A at }25\text{ }^{\circ}\text{C}$ ambient $di/dt = 5\text{ A}/\mu\text{s}$	-25		45	mV
<b>PFM Mode</b>						
$I_{Q\_PFM\_2PH}$	Quiescent current in PFM	$V_{IN} = 3.7\text{ V}$ No load No switching		164		$\mu\text{A}$
$\eta_{PFM}$	Efficiency	$V_{IN} = 3.6\text{ V}$ $V_{OUT} = 1\text{ V}$ $I_{OUT} = 10\text{ mA}$		83		%

**Note 1**  $t_{ON} > 40\text{ ns}$

**Note 2** The value is configured by OTP and should not be modified while the buck is active.

**Note 3** For short durations to meet peak current requirements,  $I_{OUT}$  can be operated at up to 10 % higher than the specified maximum operating condition. The part should not be operated in this mode for extended periods and is not guaranteed for continuous operation.

### 3.5 Performance and Supervision Characteristics

**Table 9: Electrical Characteristics**

Parameter	Description	Conditions	Min	Typ	Max	Unit
<b>Electrical Performance</b>						
$V_{THR\_POR}$	Power-on-reset threshold	Threshold for AVDD falling		2.1	2.25	V
$V_{THR\_POR\_HYS}$	Power-on-reset hysteresis			200		mV
$T_{WARN}$	Thermal warning temperature threshold		115	125	135	$^{\circ}\text{C}$
$T_{CRIT}$	Thermal shutdown temperature threshold		130	140	150	$^{\circ}\text{C}$
$I_{IN\_OFF}$	Supply current	OFF state $T_A = 27\text{ }^{\circ}\text{C}$ $IC\_EN = 0$		0.1	1	$\mu\text{A}$
$I_{IN\_ON}$	Supply current	ON state $T_A = 27\text{ }^{\circ}\text{C}$ $IC\_EN = 1$ Buck off	5	10	20	$\mu\text{A}$

## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

### 3.6 Digital IO Characteristics

**Table 10: Digital I/O Electrical Characteristics**

Parameter	Description	Conditions	Min	Typ	Max	Unit
<b>Electrical Performance</b>						
V <sub>IH_EN</sub>	Input high voltage, IC enable		1.2		AVDD	V
V <sub>IL_EN</sub>	Input low voltage, IC enable				0.4	V
t <sub>IC_EN</sub>	IC enable time				1000	μs
V <sub>IH_GPIO_SCL_SDA</sub>	Input high voltage GPIO, SCL, SDA		1.2		AVDD	V
V <sub>IL_GPIO_SCL_SDA</sub>	Input low voltage GPIO, SCL, SDA				0.4	V
V <sub>OH_GPIO</sub>	Output high voltage GPIO	Push-pull mode I <sub>OUT</sub> = 1 mA	0.8*AV DD		AVDD	V
V <sub>OL_GPIO</sub>	Output low voltage GPIO	Push-pull mode I <sub>OUT</sub> = 1 mA			0.2*AV DD	V
V <sub>OL_SDA</sub>	Output low voltage SDA	I <sub>OUT</sub> = 3 mA		0.24		V
R <sub>PD</sub>	GPIO pull-down resistor	V <sub>sys</sub> = 3.7 V Note 1	9	15	24	kΩ
R <sub>PU</sub>	GPIO pull-up resistor	V <sub>sys</sub> = 3.7 V Note 1	28	45	70	kΩ

**Note 1** Resistance may have greater variation, depending on voltage and temperature.

### 3.7 Timing Characteristics

**Table 11: I2C Electrical Characteristics**

Parameter	Description	Conditions	Min	Typ	Max	Unit
<b>Electrical Performance</b>						
t <sub>BUS</sub>	Bus free time between a STOP and START condition		0.5			μs
C <sub>BUS</sub>	Bus line capacitive load				150	pF
f <sub>SCL</sub>	SCL clock frequency		20 Note 1		1000	kHz
t <sub>LO_SCL</sub>	SCL low time		0.5			μs
t <sub>HI_SCL</sub>	SCL high time		0.26			μs
t <sub>RISE</sub>	SCL and SDA rise time	Requirement for input			1000	ns

## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

Parameter	Description	Conditions	Min	Typ	Max	Unit
t <sub>FALL</sub>	SCL and SDA fall time	Requirement for input			300	ns
t <sub>SETUP_START</sub>	Start condition setup time		0.26			μs
t <sub>HOLD_START</sub>	Start condition hold time		0.26			μs
t <sub>SETUP_STOP</sub>	Stop condition setup time		0.26			μs
t <sub>DATA</sub>	Data valid time				0.45	μs
t <sub>DATA_ACK</sub>	Data valid acknowledge time				0.45	μs
t <sub>SETUP_DATA</sub>	Data setup time		50			ns
t <sub>HOLD_DATA</sub>	Data hold time		0			ns

**Note 1** Minimum clock frequency is limited to 20 kHz if I2C\_TIMEOUT is enabled

High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

3.8 Typical Performance

The static efficiency measurements depicted in Figure 6 and Figure 7 were performed at room temperature on a DA913X-30-A evaluation board.

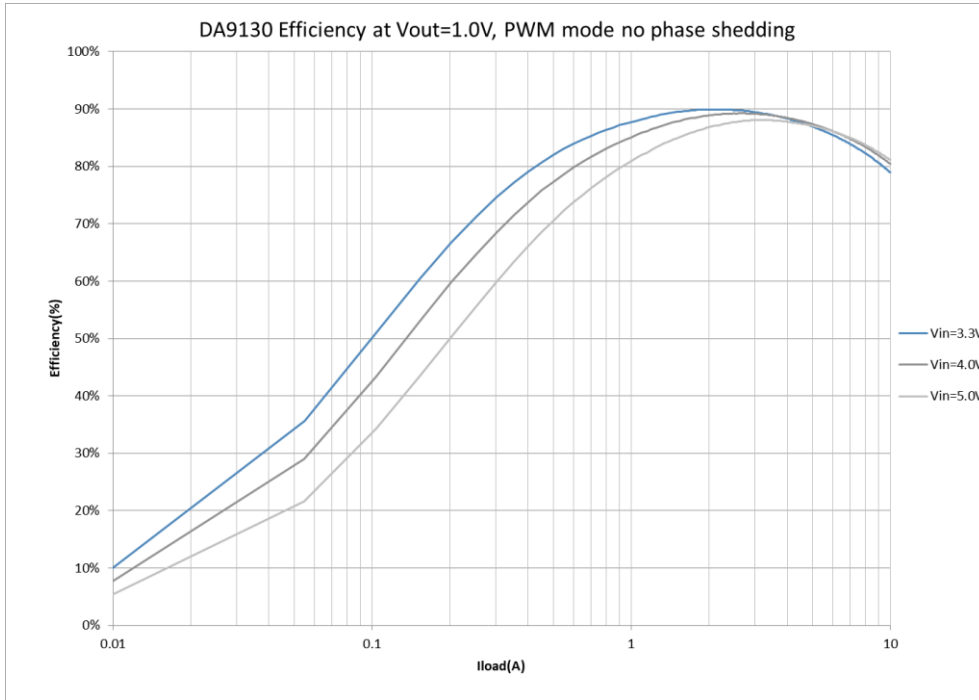


Figure 6: DA9130 Efficiency, PWM Mode with no Phase Shedding

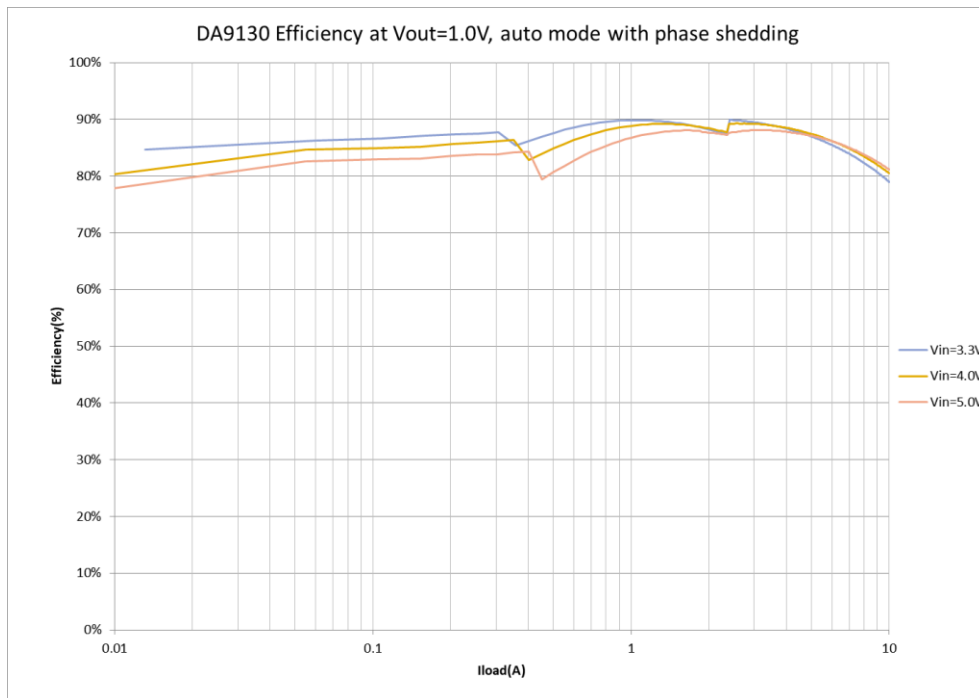


Figure 7: DA9130 Efficiency, Auto Mode with Phase Shedding



## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

### 4 Functional Description

#### 4.1 DC-DC Buck Converter

DA9130 operates as a single-channel dual-phase buck converter capable of delivering up to 10 A output current at a 0.3 V to 1.9 V output voltage range.

The buck converter has two voltage registers. One defines the normal output voltage, while the other offers an alternative retention voltage. In this way, different application power modes can easily be supported. The voltage selection can be operated either via GPI or via control interface to guarantee the maximum flexibility according to the specific host processor status in the application.

When a buck is enabled, its output voltage is monitored and a power good signal indicates that the buck output voltage has reached a level higher than the  $V_{THR\_PG\_HYS}$  threshold. The power good status is lost when the voltage drops below  $V_{THR\_PG\_DWN}$  or increases above  $V_{THR\_HV}$ . The status of the power good indicator can be read back via I<sup>2</sup>C from the PG1 status bit. It can be also individually assigned to any of the GPIOs by setting the GPIO mode registers to PG1 output.

The buck converter is capable of supporting DVC transitions that occur when:

- the active and selected A- or B-voltage is updated to a new target value
- the voltage selection is changed from the A- to B-voltage (or B- to A-voltage) using CH1\_VSEL

The DVC controller operates in pulse width modulation (PWM) mode with synchronous rectification.

The slew rate of the DVC transition is programmed at 10 mV per 8  $\mu$ s, 4  $\mu$ s, 2  $\mu$ s, 1  $\mu$ s, or 0.5  $\mu$ s in register bits CH1\_SR\_DVC.

A pull-down resistor (typically 150  $\Omega$ ) for each phase is always activated unless it is disabled by setting register bits CH1\_PD\_DIS to 1.

##### 4.1.1 Switching Frequency

The buck switching frequency, nominally 4 MHz, can be tuned using register bit OSC\_TUNE. The internal 8 MHz oscillator frequency is tuned in  $\pm 160$  kHz steps. This impacts the buck converter frequency in steps of 80 kHz and helps to mitigate possible disturbances to other high frequency systems in the application.

##### 4.1.2 Operation Modes and Phase Selection

The buck converters can operate in PWM and PFM modes. The operating mode is selected using register bits CH1\_<A or B>\_MODE.

Phase shedding automatically changes between 1- and 2-phase operation at a typical current of 2.0 A.

If the automatic operation mode is selected on CH1\_<A or B>\_MODE, the buck converter automatically changes between synchronous PWM mode and PFM depending on the load current. This improves the efficiency across the whole range of output load currents.

##### 4.1.3 Output Voltage Selection

The switching converter can be configured using the I<sup>2</sup>C interface.

Two output voltages can be pre-configured in registers CH1\_<A or B>\_VOUT. The output voltage can be selected by either toggling register bit CH1\_VSEL or by re-programming the selected voltage control register. Both changes will result in ramped voltage transitions. After being enabled, the buck converter will, by default, use the register settings in CH1\_A\_VOUT unless the output voltage selection is configured via the GPI port.

Registers CH1\_VMAX limit the output voltage that can be set for each of the respective buck converters.

## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

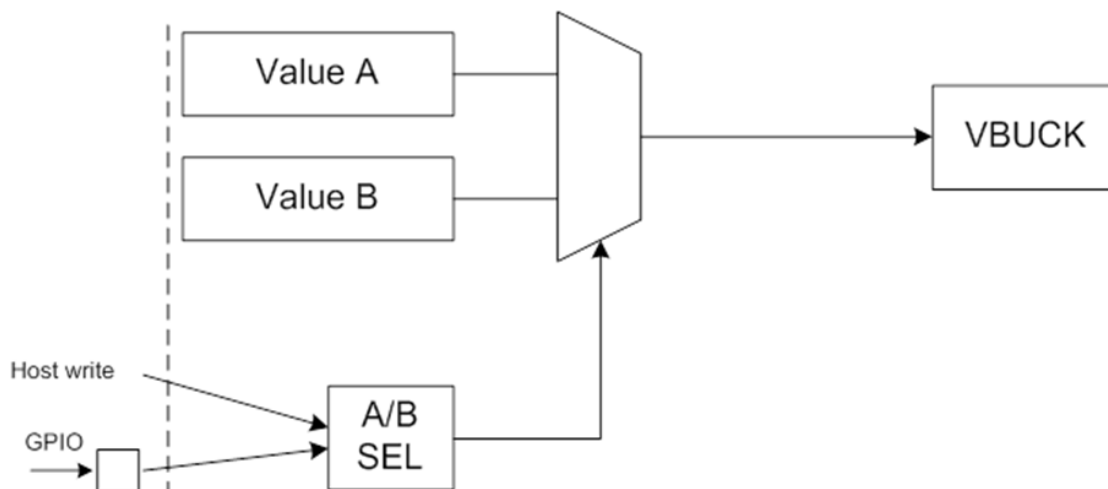


Figure 8: Buck Output Voltage Control Concept

### 4.1.4 Soft Start-Up and Shutdown

To limit in-rush current from VSYS, the buck converter can perform a soft-start after being enabled. The start-up behavior is a compromise between acceptable inrush current from the battery and turn-on time. Ramp times can be configured in register CH1\_SR\_STARTUP. Rates higher than 20 mV/μs may produce overshoot during the start-up phase, so it should be considered carefully.

A ramped power down can be selected in register bits CH1\_SR\_SHDN. When no ramp is selected (immediate power down), the output node will be discharged only by the pull-down resistor, if enabled in register CH1\_PD\_DIS.

### 4.1.5 Current Limit

The integrated current limit protects the power stages and external coil from excessive current. The buck current limit should be configured to at least 40 % higher than the required maximum output current.

When the current limit is reached, the buck converter generates an event and an interrupt to the host processor unless the interrupt has been masked using register M\_OC1 in SYS\_MASK\_1. Register bit OC\_DVC\_MASK is used to mask over-current events during DVC transitions.

### 4.1.6 Thermal Protection

DA9130 is protected from internal overheating by thermal shutdown.

There are two kinds of flags concerning thermal protection, thermal warning and thermal critical. The warning flag is asserted when  $T_J > T_{WARN}$  and the critical flag is asserted when  $T_J > T_{CRIT}$ . When the critical flag is asserted, Buck1 is shut down immediately.

Table 12: Thermal Protection Control Registers

Category	Register name	Description
Status	TEMP_WARN	Asserted as long as the thermal warning threshold is reached
	TEMP_CRIT	Asserted as long as the thermal shutdown threshold is reached
IRQ event	E_TEMP_WARN	TEMP_WARN caused event
	E_TEMP_CRIT	TEMP_CRIT caused event
IRQ mask	M_TEMP_WARN	TEMP_WARN event IRQ mask
	M_TEMP_CRIT	TEMP_CRIT event IRQ mask

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Category	Register name	Description
	M_VR_HOT	TEMP_WARN status IRQ mask

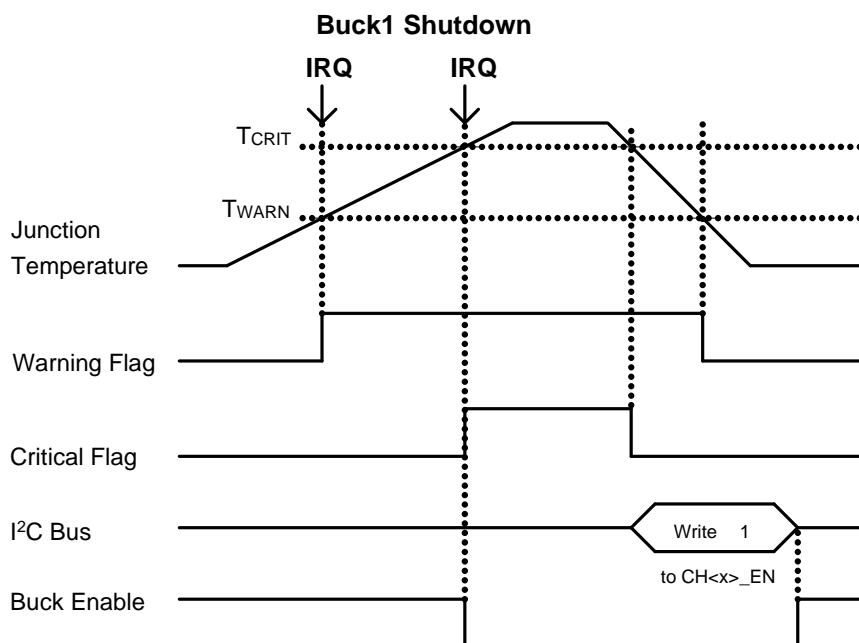


Figure 9: Thermal Protection Operation

## 4.2 Internal Circuits

### 4.2.1 IC\_EN/Chip Enable/Disable

IC\_EN is chip enable/disable control input. When IC\_EN = 0, all blocks except for low I<sub>Q</sub> POR are powered-down and buck output is pulled-down.

### 4.2.2 nIRQ/Interrupt

The interrupt triggers events. Trigger conditions and control registers for each interrupt event are listed in Table 13.

Some of these events are categorized as fault events and affect device operation (for example, buck disable), see Section 4.1.6.

Table 13: Interrupt List

Name	Polarity (Note 1)	Trigger	IRQ Status Register	IRQ Mask Register	Deglitch Period
Thermal warning (event)	N	T <sub>J</sub> rising above T <sub>WARN</sub>	E_TEMP_WARN	M_TEMP_WARN	0 s
Thermal critical (event)	N	T <sub>J</sub> rising above T <sub>CRIT</sub>	E_TEMP_CRIT	M_TEMP_CRIT	0 s
System Good (event)	P	Buck1 PG event	E_SG	M_SG	0s

## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

Name	Polarity (Note 1)	Trigger	IRQ Status Register	IRQ Mask Register	Deglitch Period
Buck1 power-good (event)	P	Buck1 $V_{OUT}$ is in power-good voltage range (not under- or over-voltage)	E_PG1	M_PG1	0 s
Buck1 over-voltage (event)	N	Buck1 $V_{OUT}$ rising above over-voltage threshold (target voltage + 150 mV)	E_OV1	M_OV1	Rise:8 $\mu$ s Fall:8 $\mu$ s
Buck1 under-voltage (event)	N	Buck1 $V_{OUT}$ falling below under-voltage threshold (target voltage - $V_{TH\_PG}$ )	E_UV1	M_UV1	0 s
Buck1 over-current (event)	N	Buck1 current rising above over-current threshold	E_OC1	M_OC1	0 s
Buck1 power-good (status) (Note 2)	P	Buck1 $V_{OUT}$ is in power-good voltage range (not under- or over-voltage)	PG1	M_PG1_STAT (Note 3)	0 s
System good (status) (Note 2)	P	Buck1 PG is active	SG	S_PG_STAT (Note 3)	0 s
Thermal warning (status) (Note 2)	N	$T_J$ rising above $T_{WARN}$	TEMP_WARN	M_VR_HOT (Note 3)	0 s
GPIO0 change (event)	N	Detect GPIO0 change for active trigger selected GPIO0_TRIG register	E_GPIO0	M_GPIO0	100 $\mu$ s/ 1 ms/ 10 ms/ 100 ms
GPIO1 change (event)	N	Detect GPIO1 change for active trigger selected GPIO1_TRIG register	E_GPIO1	M_GPIO1	
GPIO2 change (event)	N	Detect GPIO2 change for active trigger selected GPIO2_TRIG register	E_GPIO2	M_GPIO2	

**Note 1** Polarity at the source of the flag: P = active-high, N = active-low.  
General rule is: normal system state is high, and abnormal system state is low (for example, PG = high means power-good, TEMP\_CRIT = low when TEMP critical state).

**Note 2** Interrupt outputs the status as is. I<sup>2</sup>C write is not required for interrupt clear.

**Note 3** OTP load value defined by CONF pin setting if CONF\_EN = 1.

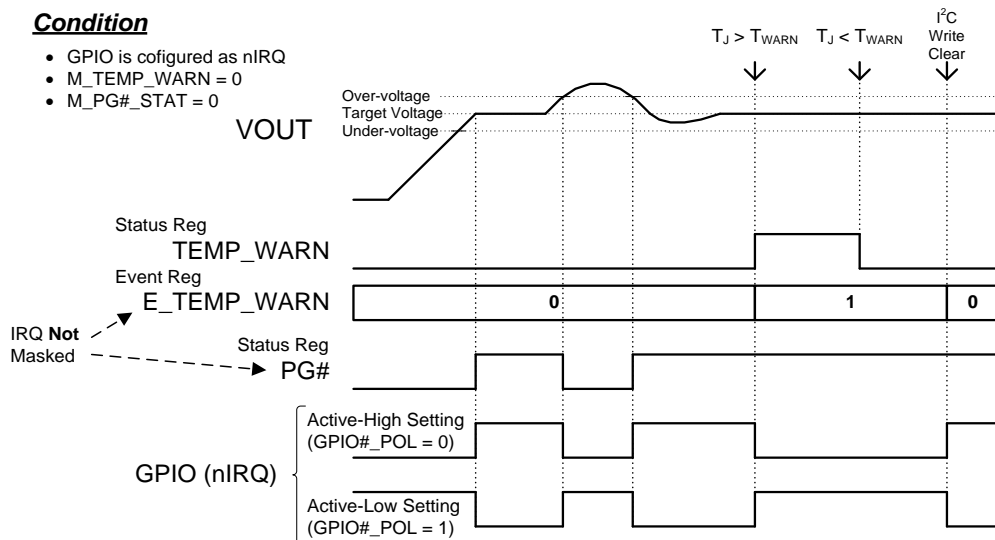
## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

**Table 14: Interrupt Registers Except for Power Good Status**

Register	Description
E_<name>	Read-only interrupt event register 0: No interrupt 1: Interrupt occurred <b>Cleared after being written to I<sup>2</sup>C. Set until IRQ is removed.</b>
M_<name>	Interrupt mask register 0: Not masked 1: Masked. No IRQ signal sent. Event register (E_<name>) is updated.

**Table 15: Interrupt Registers for Power Good and Temp Warning Status**

Register	Description
PG<x>	Buck<x> power good status. Asserted as long as the buck<x> output voltage is in range (under-voltage threshold < buck output voltage < over-voltage threshold) 0: Not power good 1: Power good
M_PG<x>_STAT	Power good status interrupt mask register 0: Not masked 1: Masked. No IRQ signal sent. Power good status register (PG<x>) is updated
TEMP_WARN	Asserted as long as the thermal warning threshold ( $T_{WARN}$ ) is reached 0: Junction temperature is below $T_{WARN}$ 1: Junction temperature is above $T_{WARN}$
M_VR_HOT	Temperature warning status (TEMP_WARN) interrupt mask register 0: Not masked 1: Masked. No IRQ signal sent. Temperature warning status register (TEMP_WARN) is updated
SG	System good. Asserted as long as the buck1 PG signal is high 0: Not system good 1: System good


**Figure 10: Interrupt Operation Example**

## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

### 4.2.3 GPIO

#### 4.2.3.1 GPIO Pin Assignment

The DA9130 provides up to five GPIO pins, three if the I<sup>2</sup>C is enabled, see [Table 16](#). These registers are OTP programmable. When CONF\_EN = 1 GPIO0 can be used for chip configuration.

Any register settings for GPIO3 and GPIO4 are ignored and GPIO3 and GPIO4 function as SCL and SDA respectively if I2C\_EN = 1.

**Table 16: GPIO Pin Assignment**

OTP Option		GPIO Pin					Available GPIOs
I2C_EN	CONF_EN	CONF/ GPIO0	GPIO1	GPIO2	SCL/ GPIO3	SDA/ GPIO4	
1'b0	1'b0	GPIO0	GPIO1	GPIO2	GPIO3	GPIO4	5
	1'b1	CONF	GPIO1	GPIO2	GPIO3	GPIO4	4
1'b1	1'b0	GPIO0	GPIO1	GPIO2	SCL	SDA	3
	1'b1	CONF	GPIO1	GPIO2	SCL	SDA	2

#### 4.2.3.2 GPIO Function

The GPIOs pins are configurable as the following functions in register GPIO<x>\_MODE (x = 0 to 4):

- Buck1 enable input (EN1)
- Buck1 DVC control input (DVC1)
- Buck1 OTP setting reload input (RELOAD)
- Buck1 power good output (PG1)
- System good output (SG)
- Interrupt output (nIRQ)

**Table 17: GPIO Function Configuration**

GPIO<x>_MODE[3:0]	Function	IO Condition
4'h0	GPIO disable	HiZ
4'h1	EN1	In
4'h2	Reserved	In
4'h3	Reserved	In
4'h4	DVC1	In
4'h5	Reserved	In
4'h6	Reserved	In
4'h7	RELOAD	In
4'h8	PG1	Out
4'h9	Reserved	Out
4'hA	Reserved	Out
4'hB	SG	Out
4'hC	nIRQ	Out
4'hD	Reserved	HiZ
4'hE	Low level	Out

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GPIO<x>_MODE[3:0]	Function	IO Condition
4'hF	High level	Out

### 4.2.3.3 Chip Configuration Select (CONF)

GPIO0 functions as chip configuration select (CONF) input when CONF\_EN = 1.

Three different chip configurations can be selected according to the CONF pin level, whether it is HIGH, LOW, or Hi-Z. [Table 18](#) lists the device configurations that can be modified if CONF\_EN = 1.

**Table 18: GPIO0-Configurable Registers when CONF\_EN = 1**

Register Name	Description
IF_SLAVE_ADDR[6:0]	I <sup>2</sup> C slave address
CH1_A_MODE[1:0]	CH1_A Operation mode select
CH1_B_MODE[1:0]	CH1_B Operation mode select
CH1_VSEL	CH1 output voltage and operation selection
CH1_EN	CH1 enable
CH1_A_VOUT[7:0]	CH1 output voltage setting A
CH1_B_VOUT[7:0]	CH1 output voltage setting B
M_PG1_STAT	IRQ mask setting for CH1 power good status
M_VR_HOT	IRQ mask setting for temp warning status
GPIO1_MODE[3:0]	GPIO1 mode setting
GPIO2_MODE[3:0]	GPIO2 mode setting
GPIO1_OBUF	GPIO1 output buffer select
GPIO2_OBUF	GPIO2 output buffer select
GPIO1_TRIG[1:0]	GPIO1 input trigger select
GPIO1_POL	GPIO1 polarity select
GPIO1_PUPD	GPIO1 pull-up/pull-down enable
GPIO1_DEB[1:0]	GPIO1 input debounce time setting
GPIO1_DEB_RISE	GPIO1 input debounce rising edge enable
GPIO1_DEB_FALL	GPIO1 input debounce falling edge enable
GPIO2_TRIG[1:0]	GPIO2 input trigger select
GPIO2_POL	GPIO2 polarity select
GPIO2_PUPD	GPIO2 pull-up/pull-down enable
GPIO2_DEB[1:0]	GPIO2 input debounce time setting
GPIO2_DEB_RISE	GPIO2 input debounce rising edge enable
GPIO2_DEB_FALL	GPIO2 input debounce falling edge enable

## 4.3 Operating Modes

### 4.3.1 ON

DA9130 is ON when the IC\_EN port is higher than  $V_{IH\_EN}$  and the supply voltage is higher than  $V_{THR\_POR}$ . Once enabled, the host processor can start communicating with DA9130 using the control interface, after the  $t_{IC\_EN}$  delay.

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### 4.3.2 OFF

DA9130 is OFF when the IC\_EN port is lower than  $V_{IL\_EN}$ . In OFF, the bucks are always disabled and LX nodes are pulled down by (typically 150  $\Omega$ ) internal pull-down resistors.

## 4.4 I<sup>2</sup>C Communication

All features of DA9130 can be controlled with the I<sup>2</sup>C interface which is enabled or disabled in register I2C\_EN.

I2C_EN	Description
0	I <sup>2</sup> C disable: SCL/GPIO3 and SDA/GPIO4 pins can be used as GPIO
1	I <sup>2</sup> C enable: SCL/GPIO3 and SDA/GPIO4 pins are used as I <sup>2</sup> C clock input and I <sup>2</sup> C data input/output.

GPIO3 functions as the I<sup>2</sup>C clock and GPIO4 carries all the power manager bidirectional I<sup>2</sup>C data. The I<sup>2</sup>C interface is open-drain supporting multiple devices on a single line. The bus lines have to be pulled high by external pull-up resistors (2 k $\Omega$  to 20 k $\Omega$ ). The standard frequency of the I<sup>2</sup>C bus is 1 MHz in fast-mode plus (FM+), 400 kHz in fast-mode, or 100 kHz in standard mode.

### 4.4.1 I<sup>2</sup>C Protocol

All data is transmitted across the I<sup>2</sup>C bus in eight-bit groups. To send a bit, the SDA line is driven towards the intended state while the SCL is low (a low SDA indicates a zero bit). Once the SDA has settled, the SCL line is brought high and then low. This pulse on SCL clocks the SDA bit into the receiver's shift register.

A two-byte serial protocol is used containing one byte for address and one byte data. Data and address transfer are transmitted MSB first for both read and write operations. All transmissions begin with the START condition from the master while the bus is in idle state (the bus is free). It is initiated by a high to low transition on the SDA line while the SCL is in the high state (a STOP condition is indicated by a low to high transition on the SDA line while the SCL is in the high state).



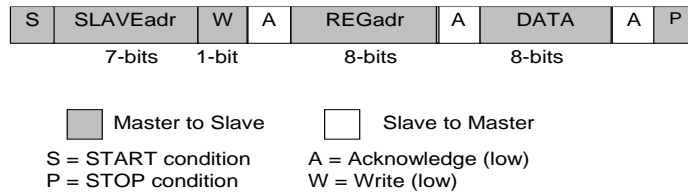
Figure 11: I<sup>2</sup>C START and STOP Condition Timing

The I<sup>2</sup>C bus is monitored for a valid slave address whenever the interface is enabled. It responds immediately when it receives its own slave address. The acknowledge is done by pulling the SDA line low during the following clock cycle (white blocks marked with A in [Figure 12](#) and [Figure 13](#)).

The protocol for a register write from master to slave consists of a START condition, a slave address with read/write bit, and the eight-bit register address followed by eight bits of data, terminated by a STOP condition. DA9130 responds to all bytes with acknowledge (A), see [Figure 12](#).

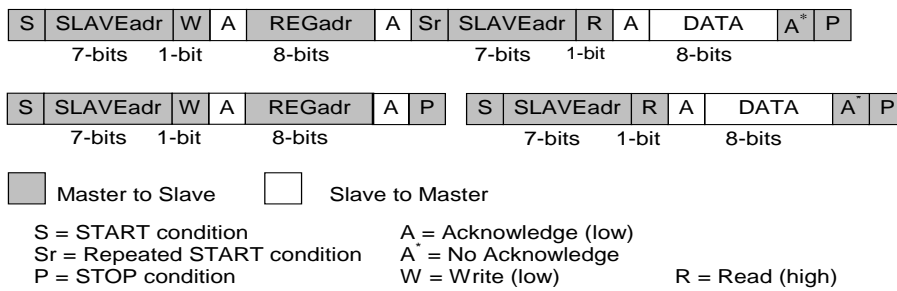


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**Figure 12: I<sup>2</sup>C Byte Write (SDA Line)**

When the host reads data from a register it first has to write to DA9130 with the target register address and then read from DA9130 with a repeated START, or alternatively a second START, condition. After receiving the data, the host sends no acknowledge (A\*) and terminates the transmission with a STOP condition, see [Figure 13](#).



**Figure 13: I<sup>2</sup>C Byte Read (SDA Line) Examples**

## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

### 5 Register Definitions

#### 5.1 Register Map

Table 19: Register Map

Addr	Register	7	6	5	4	3	2	1	0	
<b>System Module</b>										
<b>System</b>										
0x0001	<a href="#">SYS_STATUS_0</a>	Reserved	Reserved	Reserved	Reserved	Reserved	SG	TEMP_CRIT	TEMP_WARN	
0x0002	<a href="#">SYS_STATUS_1</a>	Reserved	Reserved	Reserved	Reserved	PG1	OV1	UV1	OC1	
0x0003	<a href="#">SYS_STATUS_2</a>	Reserved	Reserved	Reserved	Reserved	Reserved	GPIO2	GPIO1	GPIO0	
0x0004	<a href="#">SYS_EVENT_0</a>	Reserved	Reserved	Reserved	Reserved	Reserved	E_SG	E_TEMP_CRIT	E_TEMP_WARN	
0x0005	<a href="#">SYS_EVENT_1</a>	Reserved	Reserved	Reserved	Reserved	E_PG1	E_OV1	E_UV1	E_OC1	
0x0006	<a href="#">SYS_EVENT_2</a>	Reserved	Reserved	Reserved	Reserved	Reserved	E_GPIO2	E_GPIO1	E_GPIO0	
0x0007	<a href="#">SYS_MASK_0</a>	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	M_TEMP_CRIT	M_TEMP_WARN	
0x0008	<a href="#">SYS_MASK_1</a>	Reserved	Reserved	Reserved	Reserved	M_PG1	M_OV1	M_UV1	M_OC1	
0x0009	<a href="#">SYS_MASK_2</a>	Reserved	Reserved	Reserved	Reserved	Reserved	M_GPIO2	M_GPIO1	M_GPIO0	
0x000A	<a href="#">SYS_MASK_3</a>	Reserved	Reserved	Reserved	Reserved	M_VR_HOT	Reserved	Reserved	M_PG1_STAT	
0x000B	<a href="#">SYS_CONFIG_0</a>	Reserved				Reserved				
0x000C	<a href="#">SYS_CONFIG_1</a>	Reserved				Reserved				
0x000D	<a href="#">SYS_CONFIG_2</a>	Reserved	OC_LATCHOFF<1:0>		OC_DVC_MASK	PG_DVC_MASK<1:0>		Reserved	Reserved	
0x000E	<a href="#">SYS_CONFIG_3</a>	Reserved	OSC_TUNE<2:0>			Reserved	Reserved	I2C_TIMEOUT	Reserved	
0x0010	<a href="#">SYS_GPIO0_0</a>	Reserved	Reserved	Reserved	GPIO0_MODE<3:0>				GPIO0_OBUF	
0x0011	<a href="#">SYS_GPIO0_1</a>	GPIO0_DEB_FALL	GPIO0_DEB_RISE	GPIO0_DEB<1:0>		GPIO0_P_UPD	GPIO0_PO_L	GPIO0_TRIG<1:0>		
0x0012	<a href="#">SYS_GPIO1_0</a>	Reserved	Reserved	Reserved	GPIO1_MODE<3:0>				GPIO1_OBUF	
0x0013	<a href="#">SYS_GPIO1_1</a>	GPIO1_DEB_FALL	GPIO1_DEB_RISE	GPIO1_DEB<1:0>		GPIO1_P_UPD	GPIO1_PO_L	GPIO1_TRIG<1:0>		
0x0014	<a href="#">SYS_GPIO2_0</a>	Reserved	Reserved	Reserved	GPIO2_MODE<3:0>				GPIO2_OBUF	
0x0015	<a href="#">SYS_GPIO2_1</a>	GPIO2_DEB_FALL	GPIO2_DEB_RISE	GPIO2_DEB<1:0>		GPIO2_P_UPD	GPIO2_PO_L	GPIO2_TRIG<1:0>		

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Addr	Register	7	6	5	4	3	2	1	0
<b>Buck Control</b>									
<b>Buck1</b>									
0x0020	BUCK_BUCK1_0	Reserved	CH1_SR_DVC_DWN<2:0>			CH1_SR_DVC_UP<2:0>			CH1_EN
0x0021	BUCK_BUCK1_1	Reserved	CH1_SR_SHDN<2:0>			CH1_SR_STARTUP<2:0>			CH1_PD_DIS
0x0022	BUCK_BUCK1_2	Reserved	Reserved	Reserved	Reserved	CH1_ILIM<3:0>			
0x0023	BUCK_BUCK1_3	CH1_VMAX<7:0>							
0x0024	BUCK_BUCK1_4	Reserved	Reserved	Reserved	CH1_VSE L	CH1_B_MODE<1:0>		CH1_A_MODE<1:0>	
0x0025	BUCK_BUCK1_5	CH1_A_VOUT<7:0>							
0x0026	BUCK_BUCK1_6	CH1_B_VOUT<7:0>							
0x0027	BUCK_BUCK1_7	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved
<b>Serialization</b>									
0x0048	OTP_DEVICE_ID	DEV_ID<7:0>							
0x0049	OTP_VARIANT_ID	MRC<3:0>				VRC<3:0>			
0x004A	OTP_CUSTOMER_ID	CUST_ID<7:0>							
0x004B	OTP_CONFIG_ID	CONFIG_REV<7:0>							

## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

### 5.1.1 System

**Table 20: SYS\_STATUS\_0 (0x0001)**

Bit	Type	Symbol	Description
[2]	R	SG	Asserted whilst PG1 is asserted
[1]	R	TEMP_CRIT	Asserted whilst the thermal shutdown threshold is exceeded
[0]	R	TEMP_WARN	Asserted whilst the thermal warning threshold is exceeded

**Table 21: SYS\_STATUS\_1 (0x0002)**

Bit	Type	Symbol	Description
[3]	R	PG1	Asserted whilst Buck1 output voltage is in range
[2]	R	OV1	Asserted whilst Buck1 output is over-voltage
[1]	R	UV1	Asserted whilst Buck1 output is under-voltage
[0]	R	OC1	Asserted whilst Buck1 output is over-current

**Table 22: SYS\_STATUS\_2 (0x0003)**

Bit	Type	Symbol	Description
[2]	R	GPIO2	GPIO2 status
[1]	R	GPIO1	GPIO1 status
[0]	R	GPIO0	GPIO0 status

**Table 23: SYS\_EVENT\_0 (0x0004)**

Bit	Type	Symbol	Description
[2]	R	E_SG	SG event. Similar to PG1. Write 1 to clear this bit after the event source has been released.
[1]	R	E_TEMP_CRIT	TEMP_CRIT event. Write 1 to clear this bit after the event source has been released.
[0]	R	E_TEMP_WARN	TEMP_WARN event. Write 1 to clear this bit after the event source has been released.

**Table 24: SYS\_EVENT\_1 (0x0005)**

Bit	Type	Symbol	Description
[3]	RW	E_PG1	PG1 caused event. Write 1 to clear this bit after the event source has been released.
[2]	RW	E_OV1	OV1 caused event. Write 1 to clear this bit after the event source has been released.
[1]	RW	E_UV1	UV1 caused event. Write 1 to clear this bit after the event source has been released.
[0]	RW	E_OC1	OC1 caused event. Write 1 to clear this bit after the event source has been released.

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**Table 25: SYS\_EVENT\_2 (0x0006)**

Bit	Type	Symbol	Description
[2]	RW	E_GPIO2	GPIO2 event. Write 1 to clear this bit after the event source has been released.
[1]	RW	E_GPIO1	GPIO1 event. Write 1 to clear this bit after the event source has been released.
[0]	RW	E_GPIO0	GPIO0 event. Write 1 to clear this bit after the event source has been released.

**Table 26: SYS\_MASK\_0 (0x0007)**

Bit	Type	Symbol	Description
[2]	RW	M_SG	SG IRQ mask
[1]	RW	M_TEMP_CRIT	TEMP_CRIT IRQ mask
[0]	RW	M_TEMP_WARN	TEMP_WARN IRQ mask

**Table 27: SYS\_MASK\_1 (0x0008)**

Bit	Type	Symbol	Description
[3]	RW	M_PG1	PG1 event IRQ mask
[2]	RW	M_OV1	OV1 event IRQ mask
[1]	RW	M_UV1	UV1 event IRQ mask
[0]	RW	M_OC1	OC1 event IRQ mask

**Table 28: SYS\_MASK\_2 (0x0009)**

Bit	Type	Symbol	Description
[2]	RW	M_GPIO2	GPIO2 IRQ mask
[1]	RW	M_GPIO1	GPIO1 IRQ mask
[0]	RW	M_GPIO0	GPIO0 IRQ mask

**Table 29: SYS\_MASK\_3 (0x000A)**

Bit	Type	Symbol	Description
[3]	RW	M_VR_HOT	Temp warning status IRQ mask. Initial value is determined by CONF pin setting at the start-up if CONF_EN = 1, see Section 4.2.3.3
[0]	RW	M_PG1_STAT	PG1 status IRQ mask. Initial value is determined by CONF pin setting at the start-up if CONF_EN = 1, see Section 4.2.3.3

## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

**Table 30: SYS\_CONFIG\_2 (0x000D)**

Bit	Type	Symbol	Description										
[6:5]	RW	OC_LATCHOFF	<p>Over-current latch-off setting. BUCK shut-down after OCP for 8 <math>\mu</math>s/1 ms/3 ms unless disable setting. IRQ is generated unless IRQ is masked.</p> <table> <thead> <tr> <th>Value</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0x0</td> <td>Latch off disable</td> </tr> <tr> <td>0x1</td> <td>Latch off after 8 <math>\mu</math>s of OCP signal</td> </tr> <tr> <td>0x2</td> <td>Latch off after 1 ms of OCP signal</td> </tr> <tr> <td>0x3</td> <td>Latch off after 3 ms of OCP signal</td> </tr> </tbody> </table>	Value	Description	0x0	Latch off disable	0x1	Latch off after 8 $\mu$ s of OCP signal	0x2	Latch off after 1 ms of OCP signal	0x3	Latch off after 3 ms of OCP signal
Value	Description												
0x0	Latch off disable												
0x1	Latch off after 8 $\mu$ s of OCP signal												
0x2	Latch off after 1 ms of OCP signal												
0x3	Latch off after 3 ms of OCP signal												
[4]	RW	OC_DVC_MASK	Over-current event (IRQ and latch-off feature) mask during DVC ramp-up and ramp-down										
[3:2]	RW	PG_DVC_MASK	<p>Power-good mask during DVC</p> <table> <thead> <tr> <th>Value</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0x0</td> <td>No mask</td> </tr> <tr> <td>0x1</td> <td>Mask as not power good during DVC</td> </tr> <tr> <td>0x2</td> <td>Mask as power good during DVC</td> </tr> <tr> <td>0x3</td> <td>Reserved</td> </tr> </tbody> </table>	Value	Description	0x0	No mask	0x1	Mask as not power good during DVC	0x2	Mask as power good during DVC	0x3	Reserved
Value	Description												
0x0	No mask												
0x1	Mask as not power good during DVC												
0x2	Mask as power good during DVC												
0x3	Reserved												

**Table 31: SYS\_CONFIG\_3 (0x000E)**

Bit	Type	Symbol	Description																		
[6:4]	RW	OSC_TUNE	<p>Tune oscillator frequency, tuned frequency = Current + OSC_TUNE * 160 kHz</p> <table> <thead> <tr> <th>Value</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0x3</td> <td>3</td> </tr> <tr> <td>0x2</td> <td>2</td> </tr> <tr> <td>0x1</td> <td>1</td> </tr> <tr> <td>0x0</td> <td>0</td> </tr> <tr> <td>0x7</td> <td>-1</td> </tr> <tr> <td>0x6</td> <td>-2</td> </tr> <tr> <td>0x5</td> <td>-3</td> </tr> <tr> <td>0x4</td> <td>-4</td> </tr> </tbody> </table>	Value	Description	0x3	3	0x2	2	0x1	1	0x0	0	0x7	-1	0x6	-2	0x5	-3	0x4	-4
Value	Description																				
0x3	3																				
0x2	2																				
0x1	1																				
0x0	0																				
0x7	-1																				
0x6	-2																				
0x5	-3																				
0x4	-4																				
[1]	RW	I2C_TIMEOUT	Enable automatic reset of 2-wire interface (if SDA stays low for >50 ms).																		

## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

**Table 32: SYS\_GPIO0\_0 (0x0010)**

Bit	Type	Symbol	Description
[4:1]	RW	GPIO0_MODE	GPIO function mode select <b>Value</b> <b>Description</b> 0x0          GPIO disable 0x1          EN1 input 0x2          Reserved 0x3          Reserved 0x4          DVC1 input 0x5          Reserved 0x6          Reserved 0x7          RELOAD input 0x8          PG1 output 0x9          Reserved 0xA          Reserved 0xB          Reserved 0xC          nIRQ output 0xD          Reserved 0xE          Low output 0xF          High output
[0]	RW	GPIO0_OBUF	GPIO output buffer select <b>Value</b> <b>Description</b> 0x0          open-drain output 0x1          push-pull output

**Table 33: SYS\_GPIO0\_1 (0x0011)**

Bit	Type	Symbol	Description
[7]	RW	GPIO0_DEB_FALL	GPI debounce falling edge
[6]	RW	GPIO0_DEB_RISE	GPI debounce rising edge
[5:4]	RW	GPIO0_DEB	GPI debounce time <b>Value</b> <b>Description</b> 0x0          100 $\mu$ s debounce 0x1          1 ms debounce 0x2          10 ms debounce 0x3          100 ms debounce
[3]	RW	GPIO0_PUPD	GPIO pull-up/pull-down enable <b>Value</b> <b>Description</b> 0x0          GPI: pull-down disabled, GPO: pull-up to AVDD disabled

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			0x1	GPI: pull-down enabled, GPO: pull-up to AVDD enabled
[2]	RW	GPIO0_POL	GPIO polarity <b>Value</b> <b>Description</b> 0x0            GPIO is active-high 0x1            GPIO is active-low	
[1:0]	RW	GPIO0_TRIG	GPI trigger type <b>Value</b> <b>Description</b> 0x0            Dual-edge triggered 0x1            Pos-edge triggered 0x2            Neg-edge triggered 0x3            Reserved (No trigger)	

**Table 34: SYS\_GPIO1\_0 (0x0012)**

Bit	Type	Symbol	Description
[4:1]	RW	GPIO1_MODE	GPIO function mode select. Initial value is determined by CONF pin setting at the start-up in CONF_EN = 1 <b>Value</b> <b>Description</b> 0x0            GPIO disable 0x1            EN1 input 0x2            Reserved 0x3            Reserved 0x4            DVC1 input 0x5            Reserved 0x6            Reserved 0x7            RELOAD input 0x8            PG1 output 0x9            Reserved 0xA            Reserved 0xB            Reserved 0xC            nIRQ output 0xD            Reserved 0xE            Low output 0xF            High output
[0]	RW	GPIO1_OBUF	GPIO output buffer select. Initial value is determined by CONF pin setting at the start-up in CONF_EN = 1 <b>Value</b> <b>Description</b> 0x0            open-drain output 0x1            push-pull output



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**Table 35: SYS\_GPIO1\_1 (0x0013)**

Bit	Type	Symbol	Description										
[7]	RW	GPIO1_DEB_FALL	GPI debounce falling edge. Initial value is determined by CONF pin setting at the start-up in CONF_EN = 1										
[6]	RW	GPIO1_DEB_RISE	GPI debounce rising edge. Initial value is determined by CONF pin setting at the start-up in CONF_EN = 1										
[5:4]	RW	GPIO1_DEB	<p>GPI debounce time. Initial value is determined by CONF pin setting at the start-up in CONF_EN = 1</p> <table border="1"> <thead> <tr> <th>Value</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0x0</td> <td>100 <math>\mu</math>s debounce</td> </tr> <tr> <td>0x1</td> <td>1 ms debounce</td> </tr> <tr> <td>0x2</td> <td>10 ms debounce</td> </tr> <tr> <td>0x3</td> <td>100 ms debounce</td> </tr> </tbody> </table>	Value	Description	0x0	100 $\mu$ s debounce	0x1	1 ms debounce	0x2	10 ms debounce	0x3	100 ms debounce
Value	Description												
0x0	100 $\mu$ s debounce												
0x1	1 ms debounce												
0x2	10 ms debounce												
0x3	100 ms debounce												
[3]	RW	GPIO1_PUPD	<p>GPIO pull-up/pull-down enable. Initial value is determined by CONF pin setting at the start-up in CONF_EN = 1</p> <table border="1"> <thead> <tr> <th>Value</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0x0</td> <td>GPI: pull-down disabled, GPO: pull-up to AVDD disabled</td> </tr> <tr> <td>0x1</td> <td>GPI: pull-down enabled, GPO: pull-up to AVDD enabled</td> </tr> </tbody> </table>	Value	Description	0x0	GPI: pull-down disabled, GPO: pull-up to AVDD disabled	0x1	GPI: pull-down enabled, GPO: pull-up to AVDD enabled				
Value	Description												
0x0	GPI: pull-down disabled, GPO: pull-up to AVDD disabled												
0x1	GPI: pull-down enabled, GPO: pull-up to AVDD enabled												
[2]	RW	GPIO1_POL	<p>GPIO polarity. Initial value is determined by CONF pin setting at the start-up in CONF_EN = 1</p> <table border="1"> <thead> <tr> <th>Value</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0x0</td> <td>GPIO is active-high</td> </tr> <tr> <td>0x1</td> <td>GPIO is active-low</td> </tr> </tbody> </table>	Value	Description	0x0	GPIO is active-high	0x1	GPIO is active-low				
Value	Description												
0x0	GPIO is active-high												
0x1	GPIO is active-low												
[1:0]	RW	GPIO1_TRIG	<p>GPI trigger type. Initial value is determined by CONF pin setting at the start-up in CONF_EN = 1</p> <table border="1"> <thead> <tr> <th>Value</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0x0</td> <td>Dual-edge triggered</td> </tr> <tr> <td>0x1</td> <td>Pos-edge triggered</td> </tr> <tr> <td>0x2</td> <td>Neg-edge triggered</td> </tr> <tr> <td>0x3</td> <td>Reserved (No trigger)</td> </tr> </tbody> </table>	Value	Description	0x0	Dual-edge triggered	0x1	Pos-edge triggered	0x2	Neg-edge triggered	0x3	Reserved (No trigger)
Value	Description												
0x0	Dual-edge triggered												
0x1	Pos-edge triggered												
0x2	Neg-edge triggered												
0x3	Reserved (No trigger)												

## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

**Table 36: SYS\_GPIO2\_0 (0x0014)**

Bit	Type	Symbol	Description																																		
[4:1]	RW	GPIO2_MODE	<p>GPIO function mode select. Initial value is determined by CONF pin setting at the start-up in CONF_EN = 1</p> <table border="1"> <thead> <tr> <th>Value</th> <th>Description</th> </tr> </thead> <tbody> <tr><td>0x0</td><td>GPIO disable</td></tr> <tr><td>0x1</td><td>EN1 input</td></tr> <tr><td>0x2</td><td>Reserved</td></tr> <tr><td>0x3</td><td>Reserved</td></tr> <tr><td>0x4</td><td>DVC1 input</td></tr> <tr><td>0x5</td><td>Reserved</td></tr> <tr><td>0x6</td><td>Reserved</td></tr> <tr><td>0x7</td><td>RELOAD input</td></tr> <tr><td>0x8</td><td>PG1 output</td></tr> <tr><td>0x9</td><td>Reserved</td></tr> <tr><td>0xA</td><td>Reserved</td></tr> <tr><td>0xB</td><td>Reserved</td></tr> <tr><td>0xC</td><td>nIRQ output</td></tr> <tr><td>0xD</td><td>Reserved</td></tr> <tr><td>0xE</td><td>Low output</td></tr> <tr><td>0xF</td><td>High output</td></tr> </tbody> </table>	Value	Description	0x0	GPIO disable	0x1	EN1 input	0x2	Reserved	0x3	Reserved	0x4	DVC1 input	0x5	Reserved	0x6	Reserved	0x7	RELOAD input	0x8	PG1 output	0x9	Reserved	0xA	Reserved	0xB	Reserved	0xC	nIRQ output	0xD	Reserved	0xE	Low output	0xF	High output
Value	Description																																				
0x0	GPIO disable																																				
0x1	EN1 input																																				
0x2	Reserved																																				
0x3	Reserved																																				
0x4	DVC1 input																																				
0x5	Reserved																																				
0x6	Reserved																																				
0x7	RELOAD input																																				
0x8	PG1 output																																				
0x9	Reserved																																				
0xA	Reserved																																				
0xB	Reserved																																				
0xC	nIRQ output																																				
0xD	Reserved																																				
0xE	Low output																																				
0xF	High output																																				
[0]	RW	GPIO2_OBUF	<p>GPIO output buffer select. Initial value is determined by CONF pin setting at the start-up in CONF_EN = 1</p> <table border="1"> <thead> <tr> <th>Value</th> <th>Description</th> </tr> </thead> <tbody> <tr><td>0x0</td><td>open-drain output</td></tr> <tr><td>0x1</td><td>push-pull output</td></tr> </tbody> </table>	Value	Description	0x0	open-drain output	0x1	push-pull output																												
Value	Description																																				
0x0	open-drain output																																				
0x1	push-pull output																																				

**Table 37: SYS\_GPIO2\_1 (0x0015)**

Bit	Type	Symbol	Description										
[7]	RW	GPIO2_DEB_FALL	GPI debounce falling edge. Initial value is determined by CONF pin setting at the start-up in CONF_EN = 1										
[6]	RW	GPIO2_DEB_RISE	GPI debounce rising edge. Initial value is determined by CONF pin setting at the start-up in CONF_EN = 1										
[5:4]	RW	GPIO2_DEB	<p>GPI debounce time. Initial value is determined by CONF pin setting at the start-up in CONF_EN = 1</p> <table border="1"> <thead> <tr> <th>Value</th> <th>Description</th> </tr> </thead> <tbody> <tr><td>0x0</td><td>100 <math>\mu</math>s debounce</td></tr> <tr><td>0x1</td><td>1 ms debounce</td></tr> <tr><td>0x2</td><td>10 ms debounce</td></tr> <tr><td>0x3</td><td>100 ms debounce</td></tr> </tbody> </table>	Value	Description	0x0	100 $\mu$ s debounce	0x1	1 ms debounce	0x2	10 ms debounce	0x3	100 ms debounce
Value	Description												
0x0	100 $\mu$ s debounce												
0x1	1 ms debounce												
0x2	10 ms debounce												
0x3	100 ms debounce												

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[3]	RW	GPIO2_PUPD	<p>GPIO pull-up/pull-down enable. Initial value is determined by CONF pin setting at the start-up in CONF_EN = 1</p> <table border="1"> <thead> <tr> <th>Value</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0x0</td> <td>GPI: pull-down disabled, GPO: pull-up to AVDD disabled</td> </tr> <tr> <td>0x1</td> <td>GPI: pull-down enabled, GPO: pull-up to AVDD enabled</td> </tr> </tbody> </table>	Value	Description	0x0	GPI: pull-down disabled, GPO: pull-up to AVDD disabled	0x1	GPI: pull-down enabled, GPO: pull-up to AVDD enabled				
Value	Description												
0x0	GPI: pull-down disabled, GPO: pull-up to AVDD disabled												
0x1	GPI: pull-down enabled, GPO: pull-up to AVDD enabled												
[2]	RW	GPIO2_POL	<p>GPIO polarity. Initial value is determined by CONF pin setting at the start-up in CONF_EN = 1</p> <table border="1"> <thead> <tr> <th>Value</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0x0</td> <td>GPIO is active-high</td> </tr> <tr> <td>0x1</td> <td>GPIO is active-low</td> </tr> </tbody> </table>	Value	Description	0x0	GPIO is active-high	0x1	GPIO is active-low				
Value	Description												
0x0	GPIO is active-high												
0x1	GPIO is active-low												
[1:0]	RW	GPIO2_TRIG	<p>GPI trigger type. Initial value is determined by CONF pin setting at the start-up in CONF_EN = 1</p> <table border="1"> <thead> <tr> <th>Value</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0x0</td> <td>Dual-edge triggered</td> </tr> <tr> <td>0x1</td> <td>Pos-edge triggered</td> </tr> <tr> <td>0x2</td> <td>Neg-edge triggered</td> </tr> <tr> <td>0x3</td> <td>Reserved (No trigger)</td> </tr> </tbody> </table>	Value	Description	0x0	Dual-edge triggered	0x1	Pos-edge triggered	0x2	Neg-edge triggered	0x3	Reserved (No trigger)
Value	Description												
0x0	Dual-edge triggered												
0x1	Pos-edge triggered												
0x2	Neg-edge triggered												
0x3	Reserved (No trigger)												

### 5.1.2 Buck1

**Table 38: BUCK\_BUCK1\_0 (0x0020)**

Bit	Type	Symbol	Description																		
[6:4]	RW	CH1_SR_DVC_DWN	<p>Voltage slew-rate for DVC ramp-down</p> <table border="1"> <thead> <tr> <th>Value</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0x0</td> <td>10 mV/8 <math>\mu</math>s</td> </tr> <tr> <td>0x1</td> <td>10 mV/4 <math>\mu</math>s</td> </tr> <tr> <td>0x2</td> <td>10 mV/2 <math>\mu</math>s</td> </tr> <tr> <td>0x3</td> <td>10 mV/<math>\mu</math>s</td> </tr> <tr> <td>0x4</td> <td>20 mV/<math>\mu</math>s</td> </tr> <tr> <td>0x5</td> <td>Reserved</td> </tr> <tr> <td>0x6</td> <td>Reserved</td> </tr> <tr> <td>0x7</td> <td>Reserved</td> </tr> </tbody> </table>	Value	Description	0x0	10 mV/8 $\mu$ s	0x1	10 mV/4 $\mu$ s	0x2	10 mV/2 $\mu$ s	0x3	10 mV/ $\mu$ s	0x4	20 mV/ $\mu$ s	0x5	Reserved	0x6	Reserved	0x7	Reserved
Value	Description																				
0x0	10 mV/8 $\mu$ s																				
0x1	10 mV/4 $\mu$ s																				
0x2	10 mV/2 $\mu$ s																				
0x3	10 mV/ $\mu$ s																				
0x4	20 mV/ $\mu$ s																				
0x5	Reserved																				
0x6	Reserved																				
0x7	Reserved																				
[3:1]	RW	CH1_SR_DVC_UP	<p>Voltage slew-rate for DVC ramp-up</p> <table border="1"> <thead> <tr> <th>Value</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0x0</td> <td>10 mV/8 <math>\mu</math>s</td> </tr> <tr> <td>0x1</td> <td>10 mV/4 <math>\mu</math>s</td> </tr> <tr> <td>0x2</td> <td>10 mV/2 <math>\mu</math>s</td> </tr> <tr> <td>0x3</td> <td>10 mV/<math>\mu</math>s</td> </tr> <tr> <td>0x4</td> <td>20 mV/<math>\mu</math>s</td> </tr> </tbody> </table>	Value	Description	0x0	10 mV/8 $\mu$ s	0x1	10 mV/4 $\mu$ s	0x2	10 mV/2 $\mu$ s	0x3	10 mV/ $\mu$ s	0x4	20 mV/ $\mu$ s						
Value	Description																				
0x0	10 mV/8 $\mu$ s																				
0x1	10 mV/4 $\mu$ s																				
0x2	10 mV/2 $\mu$ s																				
0x3	10 mV/ $\mu$ s																				
0x4	20 mV/ $\mu$ s																				

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			0x5	40 mV/μs
			0x6	Reserved
			0x7	Reserved
[0]	RW	CH1_EN	Channel enable. Initial value is determined by CONF pin setting at the start-up in CONF_EN = 1	

**Table 39: BUCK\_BUCK1\_1 (0x0021)**

Bit	Type	Symbol	Description	
[6:4]	RW	CH1_SR_SHDN	Voltage slew-rate during shut-down	
			<b>Value</b>	<b>Description</b>
			0x0	10 mV/8 μs
			0x1	10 mV/4 μs
			0x2	10 mV/2 μs
			0x3	10 mV/μs
			0x4	20 mV/μs
			0x5	Reserved
			0x6	Reserved
			0x7	Immediate power-down
[3:1]	RW	CH1_SR_STARTUP	Voltage slew-rate during startup	
			<b>Value</b>	<b>Description</b>
			0x0	10 mV/8 μs
			0x1	10 mV/4 μs
			0x2	10 mV/2 μs
			0x3	10 mV/μs
			0x4	20 mV/μs
			0x5	40 mV/μs
			0x6	Reserved
			0x7	Reserved
[0]	RW	CH1_PD_DIS	Pull-down while buck is disabled. 0: enable, 1: disable	

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**Table 40: BUCK\_BUCK1\_2 (0x0022)**

Bit	Type	Symbol	Description																																		
[3:0]	RW	CH1_ILIM	<p>Select OCP threshold per phase (A). The value is configured by OTP and should not be modified while the buck is active.</p> <table border="1"> <thead> <tr> <th>Value</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0x0</td> <td>Reserved</td> </tr> <tr> <td>0x1</td> <td>3.5</td> </tr> <tr> <td>0x2</td> <td>4.0</td> </tr> <tr> <td>0x3</td> <td>4.5</td> </tr> <tr> <td>0x4</td> <td>5.0</td> </tr> <tr> <td>0x5</td> <td>5.5</td> </tr> <tr> <td>0x6</td> <td>6.0</td> </tr> <tr> <td>0x7</td> <td>6.5</td> </tr> <tr> <td>0x8</td> <td>7.0</td> </tr> <tr> <td>0x9</td> <td>7.5</td> </tr> <tr> <td>0xA</td> <td>8.0</td> </tr> <tr> <td>0xB</td> <td>8.5</td> </tr> <tr> <td>0xC</td> <td>9.0</td> </tr> <tr> <td>0xD</td> <td>9.5</td> </tr> <tr> <td>0xE</td> <td>10.0</td> </tr> <tr> <td>0xF</td> <td>Disable</td> </tr> </tbody> </table>	Value	Description	0x0	Reserved	0x1	3.5	0x2	4.0	0x3	4.5	0x4	5.0	0x5	5.5	0x6	6.0	0x7	6.5	0x8	7.0	0x9	7.5	0xA	8.0	0xB	8.5	0xC	9.0	0xD	9.5	0xE	10.0	0xF	Disable
Value	Description																																				
0x0	Reserved																																				
0x1	3.5																																				
0x2	4.0																																				
0x3	4.5																																				
0x4	5.0																																				
0x5	5.5																																				
0x6	6.0																																				
0x7	6.5																																				
0x8	7.0																																				
0x9	7.5																																				
0xA	8.0																																				
0xB	8.5																																				
0xC	9.0																																				
0xD	9.5																																				
0xE	10.0																																				
0xF	Disable																																				

**Table 41: BUCK\_BUCK1\_3 (0x0023)**

Bit	Type	Symbol	Description																		
[7:0]	RW	CH1_VMAX	<p>VOOUT max setting (V): From 0.30 V (0x1E) to 1.90 V (0xBE) in 10 mV steps. This is a read-only register.</p> <table border="1"> <thead> <tr> <th>Value</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0x1E</td> <td>0.3</td> </tr> <tr> <td>0x1F</td> <td>0.31</td> </tr> <tr> <td>0x20</td> <td>0.32</td> </tr> <tr> <td colspan="2">Continuing through...</td> </tr> <tr> <td>0x99</td> <td>1.53</td> </tr> <tr> <td colspan="2">To...</td> </tr> <tr> <td>0xBD</td> <td>1.89</td> </tr> <tr> <td>0xBE</td> <td>1.9</td> </tr> </tbody> </table>	Value	Description	0x1E	0.3	0x1F	0.31	0x20	0.32	Continuing through...		0x99	1.53	To...		0xBD	1.89	0xBE	1.9
Value	Description																				
0x1E	0.3																				
0x1F	0.31																				
0x20	0.32																				
Continuing through...																					
0x99	1.53																				
To...																					
0xBD	1.89																				
0xBE	1.9																				

## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

**Table 42: BUCK\_BUCK1\_4 (0x0024)**

Bit	Type	Symbol	Description										
[4]	RW	CH1_VSEL	Output voltage and operation selection: 0: A, 1: B. Initial value is determined by CONF pin setting at the start-up in CONF_EN = 1										
[3:2]	RW	CH1_B_MODE	Operation mode selection. Initial value is determined by CONF pin setting at the start-up in CONF_EN = 1  <table border="1"> <thead> <tr> <th>Value</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0x0</td> <td>Force PFM operation</td> </tr> <tr> <td>0x1</td> <td>Force PWM operation (full phase)</td> </tr> <tr> <td>0x2</td> <td>Force PWM operation (with phase shedding)</td> </tr> <tr> <td>0x3</td> <td>Auto mode</td> </tr> </tbody> </table>	Value	Description	0x0	Force PFM operation	0x1	Force PWM operation (full phase)	0x2	Force PWM operation (with phase shedding)	0x3	Auto mode
Value	Description												
0x0	Force PFM operation												
0x1	Force PWM operation (full phase)												
0x2	Force PWM operation (with phase shedding)												
0x3	Auto mode												
[1:0]	RW	CH1_A_MODE	Operation mode selection. Initial value is determined by CONF pin setting at the start-up in CONF_EN = 1  <table border="1"> <thead> <tr> <th>Value</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0x0</td> <td>Force PFM operation</td> </tr> <tr> <td>0x1</td> <td>Force PWM operation (full phase)</td> </tr> <tr> <td>0x2</td> <td>Force PWM operation (with phase shedding)</td> </tr> <tr> <td>0x3</td> <td>Auto mode</td> </tr> </tbody> </table>	Value	Description	0x0	Force PFM operation	0x1	Force PWM operation (full phase)	0x2	Force PWM operation (with phase shedding)	0x3	Auto mode
Value	Description												
0x0	Force PFM operation												
0x1	Force PWM operation (full phase)												
0x2	Force PWM operation (with phase shedding)												
0x3	Auto mode												

**Table 43: BUCK\_BUCK1\_5 (0x0025)**

Bit	Type	Symbol	Description																				
[7:0]	RW	CH1_A_VOUT	Output voltage setting A: Initial value is determined by CONF pin setting at the start-up in CONF_EN = 1 From 0.30 V (0x1E) to 1.90 V (0xBE) in steps of 10 mV (default 1.0 V) Write-protected when value is written below 0.30 V or above 1.90 V  <table border="1"> <thead> <tr> <th>Value</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0x1E</td> <td>0.3</td> </tr> <tr> <td>0x1F</td> <td>0.31</td> </tr> <tr> <td>0x20</td> <td>0.32</td> </tr> <tr> <td colspan="2">Continuing through...</td> </tr> <tr> <td>0x64</td> <td>1</td> </tr> <tr> <td colspan="2">To...</td> </tr> <tr> <td>0xBC</td> <td>1.88</td> </tr> <tr> <td>0xBD</td> <td>1.89</td> </tr> <tr> <td>0xBE</td> <td>1.9</td> </tr> </tbody> </table>	Value	Description	0x1E	0.3	0x1F	0.31	0x20	0.32	Continuing through...		0x64	1	To...		0xBC	1.88	0xBD	1.89	0xBE	1.9
Value	Description																						
0x1E	0.3																						
0x1F	0.31																						
0x20	0.32																						
Continuing through...																							
0x64	1																						
To...																							
0xBC	1.88																						
0xBD	1.89																						
0xBE	1.9																						

## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

**Table 44: BUCK\_BUCK1\_6 (0x0026)**

Bit	Type	Symbol	Description																				
[7:0]	RW	CH1_B_VOUT	<p>Output voltage setting B: Initial value is determined by CONF pin setting at the start-up in CONF_EN = 1 From 0.30 V (0x1E) to 1.90 V (0xBE) in steps of 10 mV (default 1.0 V) Write-protected when value is written below 0.30 V or above 1.90 V</p> <table border="1"> <thead> <tr> <th>Value</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0x1E</td> <td>0.3</td> </tr> <tr> <td>0x1F</td> <td>0.31</td> </tr> <tr> <td>0x20</td> <td>0.32</td> </tr> <tr> <td colspan="2">Continuing through...</td> </tr> <tr> <td>0x64</td> <td>1</td> </tr> <tr> <td colspan="2">To...</td> </tr> <tr> <td>0xBC</td> <td>1.88</td> </tr> <tr> <td>0xBD</td> <td>1.89</td> </tr> <tr> <td>0xBE</td> <td>1.9</td> </tr> </tbody> </table>	Value	Description	0x1E	0.3	0x1F	0.31	0x20	0.32	Continuing through...		0x64	1	To...		0xBC	1.88	0xBD	1.89	0xBE	1.9
Value	Description																						
0x1E	0.3																						
0x1F	0.31																						
0x20	0.32																						
Continuing through...																							
0x64	1																						
To...																							
0xBC	1.88																						
0xBD	1.89																						
0xBE	1.9																						

### 5.1.3 Serialization

**Table 45: OTP\_DEVICE\_ID (0x0048)**

Bit	Type	Symbol	Description
[7:0]	R	DEV_ID	Device ID

**Table 46: OTP\_VARIANT\_ID (0x0049)**

Bit	Type	Symbol	Description
[7:4]	R	MRC	Mask Revision Code
[3:0]	R	VRC	Chip Variant Code

**Table 47: OTP\_CUSTOMER\_ID (0x004A)**

Bit	Type	Symbol	Description
[7:0]	R	CUST_ID	Customer ID

**Table 48: OTP\_CONFIG\_ID (0x004B)**

Bit	Type	Symbol	Description
[7:0]	R	CONFIG_REV	OTP Variant

# DA9130

## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

### 6 Package Information

#### 6.1 Package Outlines

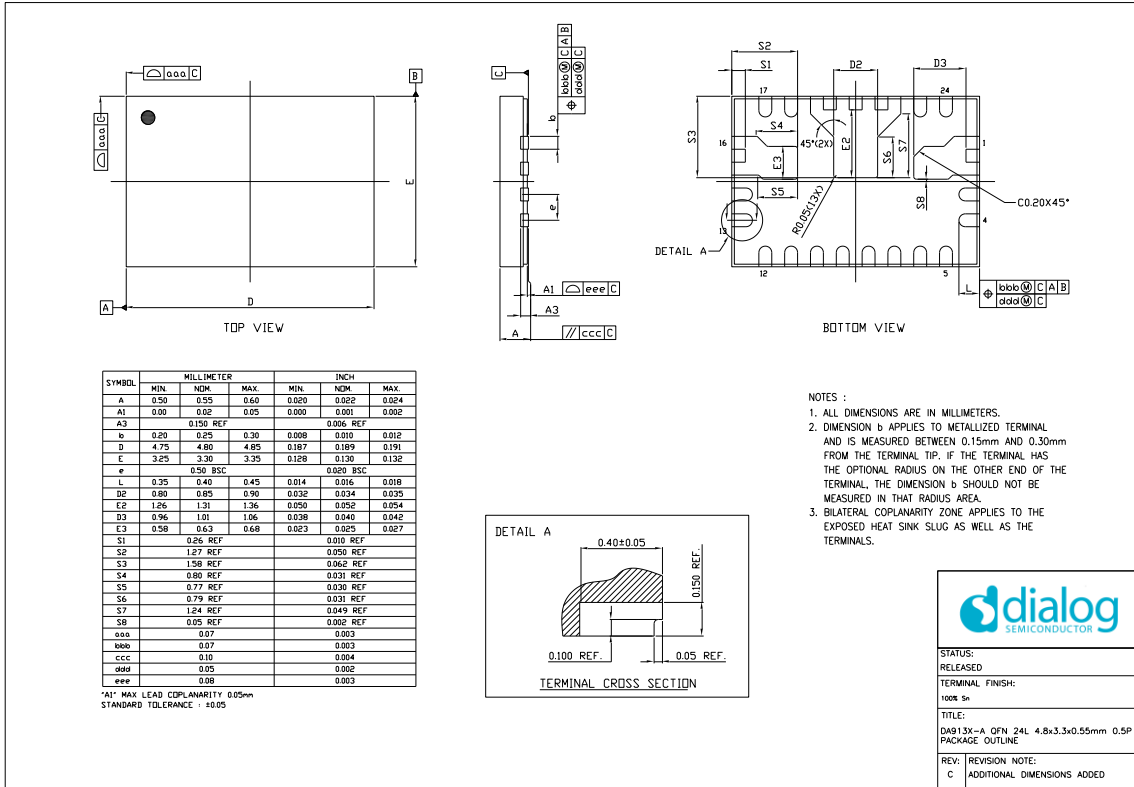


Figure 14: Package Outline Drawing



## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

### 6.2 Package Marking

Package Marking		
A1 Corner >	Marking Content	Format
1st	•	Pin 1 ID
2nd	<b>D A 9 1 3 0</b>	Orientation/Part No.
3rd	<b>x x A T y y</b>	OTP/Option/Year
4th	<b>W W z z z z</b>	Date Code
Date Code Format: yy = Year, ww = Week, zzzz = Traceability		
xx identifies the OTP Variant		
A or AT optionally indicate the Automotive and Automotive high temp test options.		

### 6.3 Moisture Sensitivity Level

The moisture sensitivity level (MSL) is an indicator for the maximum allowable time period (floor lifetime) in which a moisture sensitive plastic device, once removed from the dry bag, can be exposed to an environment with a specified maximum temperature and a maximum relative humidity before the solder reflow process. The MSL classification is defined in [Table 49](#).

For detailed information on MSL levels refer to the IPC/JEDEC standard J-STD-020, which can be downloaded from <http://www.jedec.org>.

The FCQFN package is qualified for MSL 3.

**Table 49: MSL Classification**

MSL Level	Floor Lifetime	Conditions
MSL 4	72 hours	30 °C / 60 % RH
MSL 3	168 hours	30 °C / 60 % RH
MSL 2A	4 weeks	30 °C / 60 % RH
MSL 2	1 year	30 °C / 60 % RH
MSL 1	Unlimited	30 °C / 60 % RH

### 6.4 Soldering Information

Refer to the IPC/JEDEC standard J-STD-020 for relevant soldering information. This document can be downloaded from <http://www.jedec.org>.

## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

### 7 Ordering Information

The ordering number consists of the part number followed by a suffix indicating the packing method. For details and availability, please consult your Renesas [local sales representative](#).

**Table 50: Ordering Information**

Part Number	Package	Package Description	MOQ
DA9130-xxRT2	24 FCQFN wettable flanks, 3.3 x 4.8	T&R, 4800 pcs	3 Reels - 14400
DA9130-xxRT1	24 FCQFN wettable flanks	Tray, 490 pcs	30 Trays - 14700 pcs

### 8 Application Information

The following recommended components are examples selected from requirements of a typical application.

#### 8.1 Capacitor Selection

Ceramic capacitors are used as bypass capacitors at all VDD and output rails. When selecting a capacitor, especially for types with high capacitance at smallest physical dimension, the DC bias characteristic has to be taken into account.

**Table 51: Recommended Consumer Grade Capacitor Types**

Application	Value (μF)	Size	Temp. Char.	Tol. (%)	V-Rate (V)	Type
VOUT output bypass	10	0402	X5R	20	6.3	Murata GRM155R60J106ME15
PVDDx bypass	10	0603	X5R	20	25	Murata GRM188R61E106MA73
AVDD bypass	1	0402	X5R	10	10	Murata GRM155R61A105KE15

**Table 52: Recommended Automotive Grade Capacitor Types**

Application	Value (μF)	Size	Temp. Char.	Tol. (%)	V-Rate (V)	Type
VOUT output bypass	10	0805	X7R ±15%	±10	6.3	TDK CGA4J1X7R0J106K125AC
PVDDx bypass	10	3216	X7R ±15%	±10	16	Murata GCM31CR71C106KA64L
AVDD bypass	1	0805	X7R ±15%	±10	50	Murata GCM21BR71H105KA03L

## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

### 8.2 Inductor Selection

Inductors should be selected based on the following parameters:

- Rated maximum current  
Usually a coil provides two current limits:  $I_{SAT}$  specifies the maximum current at which the inductance drops by 30 % of the nominal value, and  $I_{MAX}$  is defined by the maximum power dissipation and is applied to the effective current.
- DC resistance  
Critical for the converter efficiency and should therefore be minimized.

**Table 53: Recommended Inductor Types**

Value ( $\mu\text{H}$ )	Size (mm)	$I_{MAX}$ (DC) (A)	$I_{SAT}$ (A)	Tol. (%)	DC Resistance ( $\text{m}\Omega$ )	Type
0.22	2.5 x 2.0 x 1.2	6.7	8	20	8	TDK TFM252012ALMAR22MTAA

## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

### Status Definitions

Revision	Datasheet Status	Product Status	Definition
1.<n>	Target	Development	This datasheet contains the design specifications for product development. Specifications may be changed in any manner without notice.
2.<n>	Preliminary	Qualification	This datasheet contains the specifications and preliminary characterization data for products in pre-production. Specifications may be changed at any time without notice in order to improve the design.
3.<n>	Final	Production	This datasheet contains the final specifications for products in volume production. The specifications may be changed at any time in order to improve the design, manufacturing and supply. Major specification changes are communicated via Customer Product Notifications. Datasheet changes are communicated via <a href="http://www.dialog-semiconductor.com">www.dialog-semiconductor.com</a> .
4.<n>	Obsolete	Archived	This datasheet contains the specifications for discontinued products. The information is provided for reference only.

### RoHS Compliance

Dialog Semiconductor's suppliers certify that its products are in compliance with the requirements of Directive 2011/65/EU of the European Parliament on the restriction of the use of certain hazardous substances in electrical and electronic equipment. RoHS certificates from our suppliers are available on request.

## High-Performance, 10 A, Dual-Phase DC-DC Converter for Mobile and Portable Applications

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