US069
48V Mobility Solution

August 2020

48V Mobility Solution

- **Overview**
  Electric mobility solutions are a huge focus across multiple types of applications. E-bikes, e-scooters, forklifts and hybrid electric vehicles are just a few of the applications that require a variety of solutions. In this winning combination solution, Renesas provides engineers with a design that can be configured to target specific attributes, such as low voltage and cost, functionality and efficiency, or high power and torque. This design provides the building blocks for a variety of motor solutions.

- **System Benefits**
  - Complete reference design that focuses three types of solutions: low voltage and cost, functionality and efficiency, or high power and torque
  - Fits a variety of electric motor drive solutions and voltage ranges

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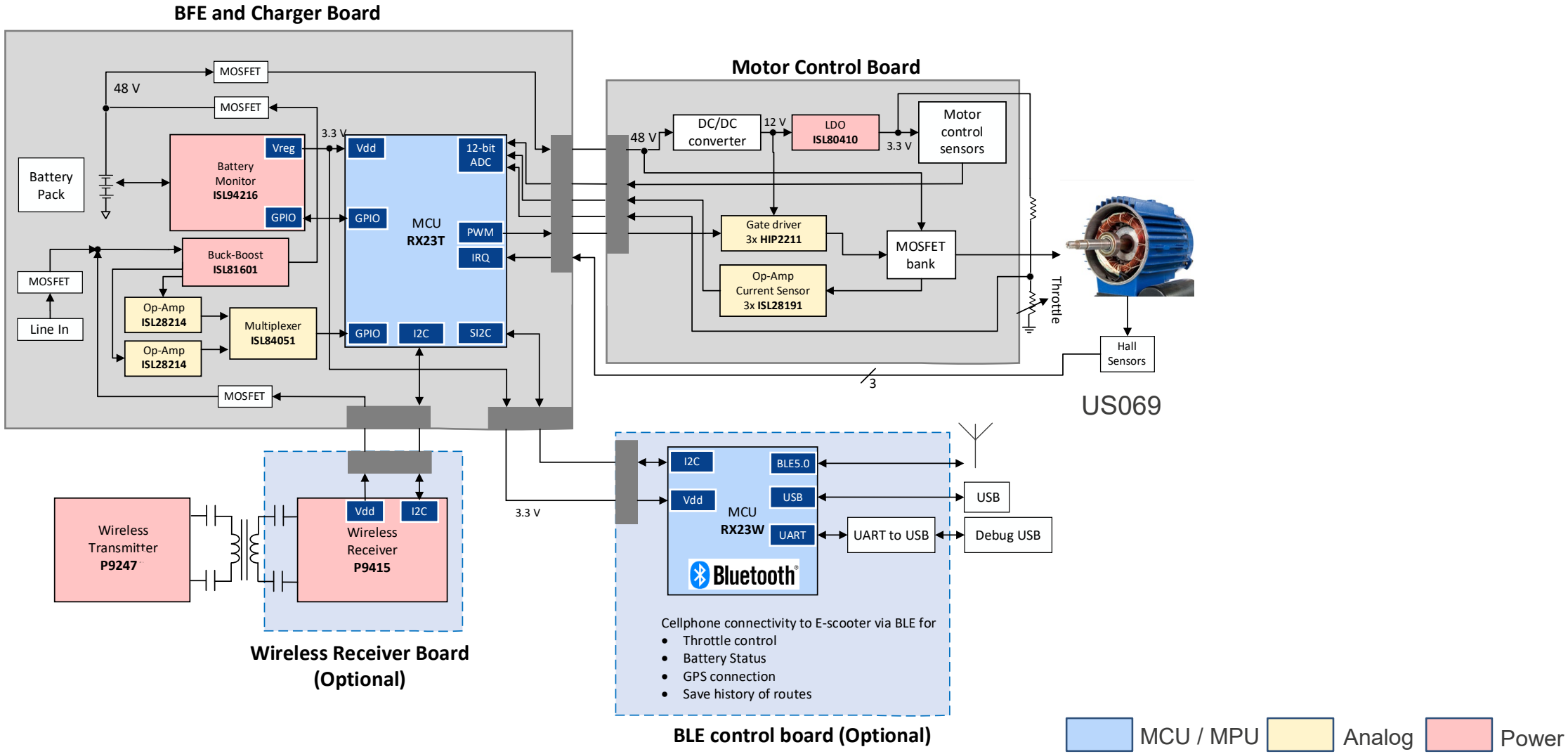

48V Mobility Solution

Device Category	P/N	Key Features
MCU	RX23T	32-bit proprietary RX core provides high efficiency, with rich peripheral functions, integrated DSP and FPU, and synchronous measurements for advanced motor control.
	RX23W	Supports Bluetooth® Low Energy 5.0 with added security functionality which is vital for secure communications, has low power consumption, and touch-key support.
Power	ISL94216	Battery front end capable of monitoring up to 16 cells, low current consumption, cell balancing features, and support for multiple interfaces (I^2C, SPI, single wire)
	ISL81601	60V bi-directional 4-switch synchronous buck-boost controller with current sensing and input/output monitoring
	ISL80410	High-voltage adjustable LDO with low quiescent current, a wide input range of 6V to 40V, and thermal shutdown/current limit protection
	P9415	30W wireless power transmitter/receiver with a highly-integrated, single-chip 32-bit Arm® core configuration

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Device Category	P/N	Key Features
Power	P9247	30W wireless power transmitter with a highly-integrated, single-chip 32-bit Arm® core configuration
Analog	HIP2211	120V, 3A/4A high-voltage bridge driver with high efficiency, small package size, and fast propagation delay
	ISL28191	Single/dual ultra-low noise RRIO op amps with high-performance 630µV maximum offset voltage and 3µA input bias current
	ISL28214	Single/dual/quad RRIO op amps with low current consumption and input bias current, and a wide supply range of 1.8 – 5.5V
	ISL84051	8 to 1 multiplexer analog switch that supports voltages as low as 2V and fast switching speeds and low power consumption

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RX23T – 32-bit FPU MCU for Controlling a Single Inverter

40 MHz RX v2 Core with FPU, 5V Power Supply and Highly Accurate 12-Bit ADC

High Performance and Low Power Design

- Max. operating frequency: 40MHz
- Enhanced DSP: 32-bit multiply-accumulate and 16-bit multiply-subtract instructions
- Built-in FPU: 32-bit single-precision floating point (compliant to IEEE754)
- Divider, fast interrupt, CISC Harvard architecture with 5-stage pipeline
- Variable-length instructions, ultra-compact code
- 3 low power consumption modes, software standby mode (with RAM retention) < 0.45 µA

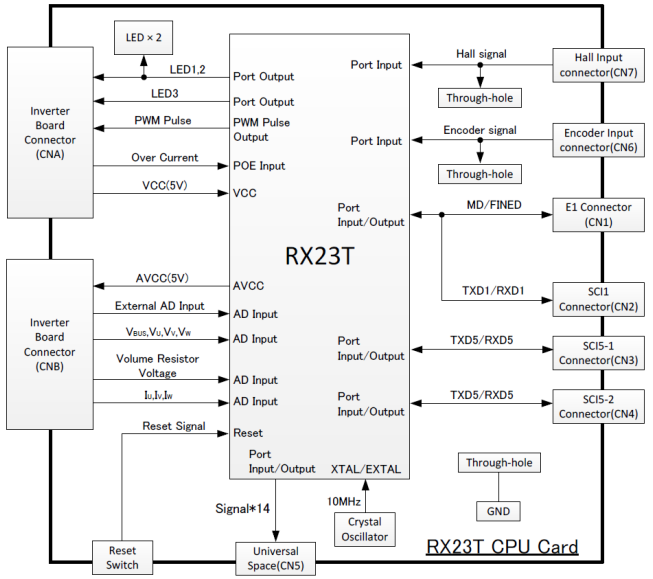
Suitable for Inverter Control

- Enhanced DSP and FPU modules
- 40MHz PWM (three-phase complementary output x 2ch)

Rich Peripheral Functions

- Up to 4 communications channels
- Up to 12 extended-function timers
- 12-bit ADC: 10ch
- Useful functions for IEC60730 compliance

Part #	ROM (Kbytes)	RAM (Kbytes)	Temp.(°C)	Package
R5F523T5ADFM	128	12	-40 to 85	LFQFP64/0.50
R5F523T3ADFD	64	12	-40 to 85	LQFP52/0.65
R5F523T5AGFM	128	12	-40 to 105	LFQFP64/0.50
R5F523T3AGFL	64	12	-40 to 105	LFQFP48/0.50



System Block

Evaluation Kits

RX23W – 32-bit MCU for Bluetooth® 5.0 Low Energy

54 MHz RXv2 Core with FPU, Low Power Design, RTC and Encryption Functions

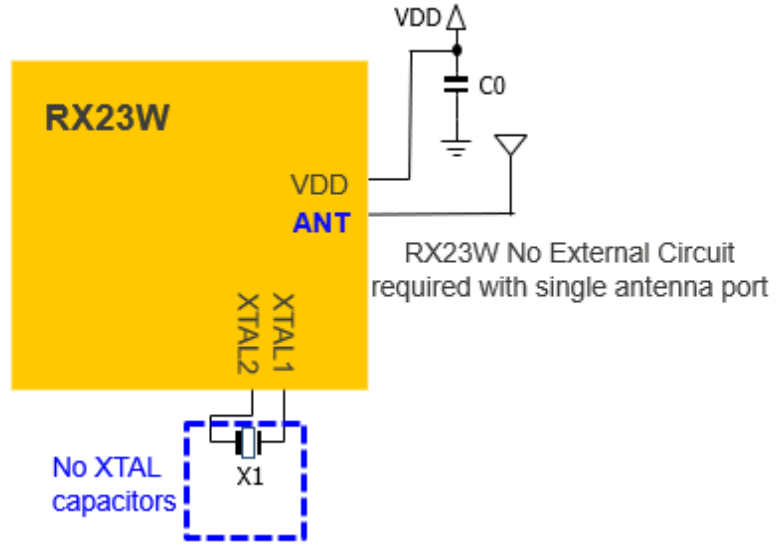
Support for Multiple Communication Functions

- Bluetooth® Low Energy (1Channel)
- An RF transceiver and link layer compliant with the Bluetooth® 5.0 Low Energy specification, also supports Bluetooth® 4.2
- LE 1M PHY, LE 2M PHY, LE Coded PHY (125 kbps and 500 kbps), and LE Advertising extension support
- On-chip Bluetooth®-dedicated AES-CCM (128-bit blocks) encryption circuit
- USB 2.0 host/function/On-The-Go (OTG) (one channel), full-speed = 12 Mbps, low-speed = 1.5 Mbps, isochronous transfer, and battery charger supported
- CAN (one channel) compliant to ISO11898-1: Transfer at up to 1 Mbps
- Including many others

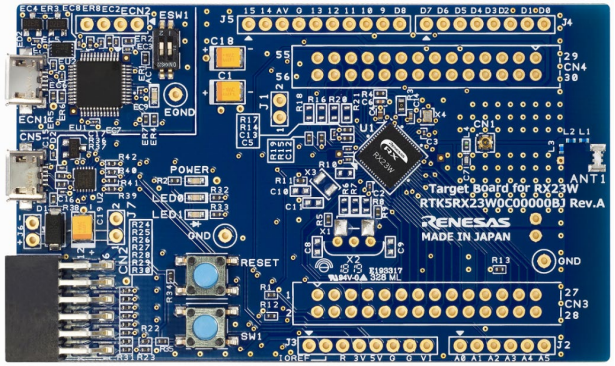
High Performance and Low Power Design

- Operation from single 1.8 to 3.6V supply
- Up to 512KB Flash and 64KB RAM
- IEC60730 Compliant
- Capacitive Touch Sensing Unit: 12Keys (Self), 36 Keys (Mutual)
- Max. operating frequency: 54 MHz, capable of 88.56 DMIPS in operation at 54 MHz
- Enhanced DSP and FPU modules
- RTC capable of operating on the battery backup power supply
- Security: 128- or 256-bit key length of AES for ECB, CBC, GCM, others. TRNG and Safe management of Keys.

Part #	ROM (Kbytes)	RAM (Kbytes)	Security Functions	Package
R5F523W8ADNG#30	512	64	N/A	QFN/56/0.4
R5F523W7ADNG#30	384	64	N/A	QFN/56/0.4
R5F523W8BDNG#30	512	64	Available	QFN/56/0.4
R5F523W7BDNG#30	384	64	Available	QFN/56/0.4



Low Cost System Block



Target Board for RX23W – RTK5RX23W0C00000B

ISL94216 – 16-Cell Battery Front End

Applications for Light Electric Vehicles, Power Tools, 24 ~48V Portable Battery Packs

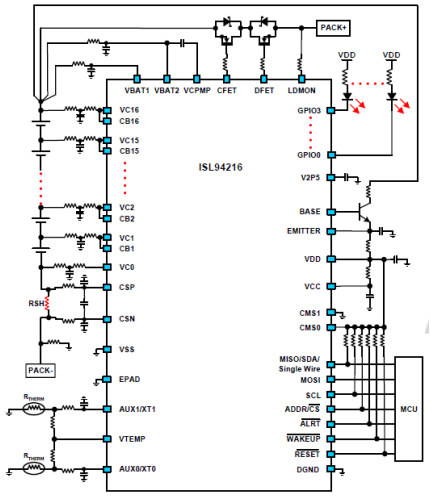
High Performance Battery Front End (BFE)

- Monitors up to 16 series connected cells
- High hot plug rating: 62V, V_{CELL} accuracy ±5mV
- I_{PACK} accuracy: ±0.2%

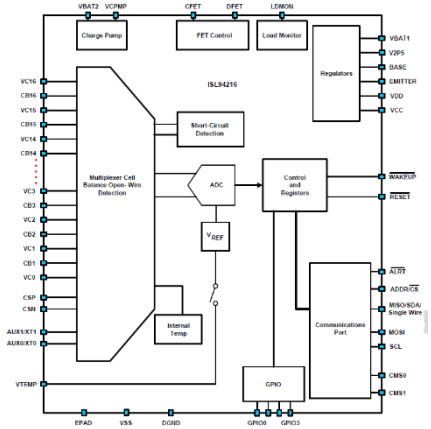
Low Power and Integrated Functions

- Low current consumption
  - ➢ Average IDLE mode : 200µA
  - ➢ SHIP mode < 18µA
- 16-bit V_{CELL} and I_{PACK} measurements
- Charge/load wakeup detection circuitry
- Integrated 3.3V regulator, supports I^2C, SPI, and single wire communications
- Supports internal and external cell balancing and periodic scanning

Part #	Cell Support (Max)	Package Voltage(Max)	Temp Range	Package
ISL94216IRZ	16	55V	-40 to 85°C	64Ld 9x9 QFN
ISL94216IRZ-T	16	55V	-40 to 85°C	64Ld 9x9 QFN



Typical Application



Block Diagram

ISL814/6/801 – High Voltage Buck Boost Controller

60V Bi-Directional 4-Switch Synchronous Buck-Boost Controller

Bi-directional Buck-Boost

- Peak & average current sensing and monitoring at input & output
- 4 independent controls for input/output voltages and currents
- 4-switch design with smooth transition between buck & boost mode

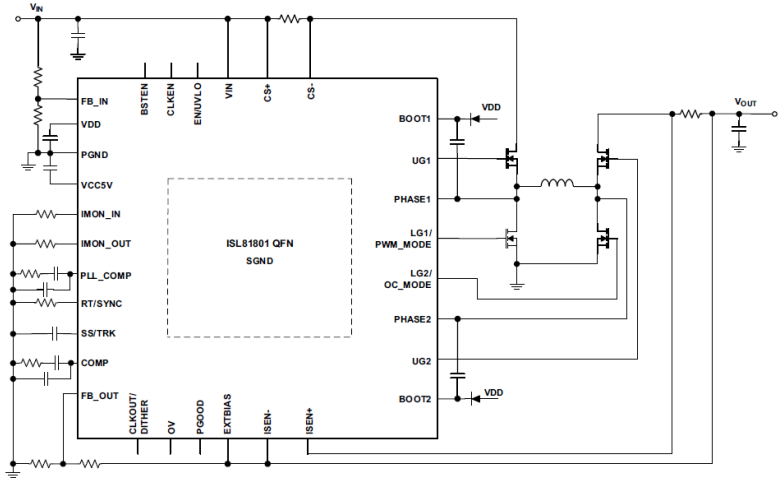
Wide Working Range

- Input voltage range: 4.5V to 60V
- Output voltage range: 0.8V to 60V
- Adjustable switching frequency from 100 to 600 kHz
- Ability to sync to external clock

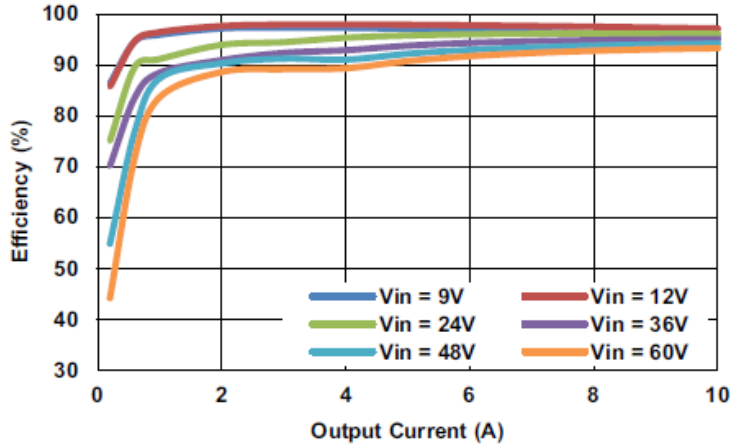
Complete Application Protection

- Multiple protection features: OVP, UVP, OTP, SCP
- Current limits on both input & output
- Adaptive shoot-through protection

Part #	Vin Range (V)	Vout Range (V)	Current Direction	Package
ISL81601FRZ-T7A	4.5-60	0.8-60	Bidirectional	32Ld 5x5 QFN
ISL81601FVEZ-T7A	4.5-60	0.8-60	Bidirectional	38Ld HTSSOP



Typical Application Circuit



Efficiency with 12V output

ISL80410 – High Voltage Adjustable V_{OUT} LDO

Low Quiescent Current and 40V/150mA Output

High Performance and Wide Input Range

- Wide V_{IN} range of 6V to 40V
- Adjustable output voltage from 2.5V to 12V
- Ensured 150mA output current
- ±1% accurate voltage reference (over temperature, load)

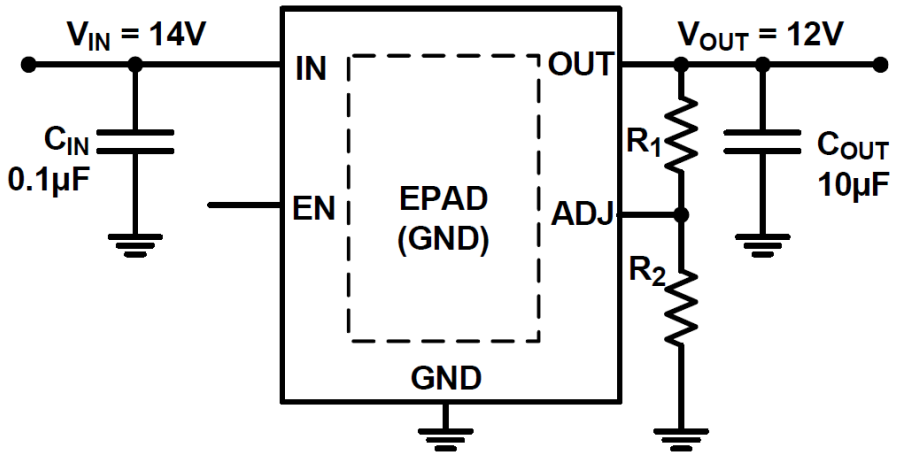
High Efficiency

- Ultra low 18µA typical quiescent current
- Low 2µA of typical shutdown current
- Low dropout voltage of 295mV at 150mA
- Low 26µVRMS noise

Excellent Safety

- 40V tolerant logic level (TTL/CMOS) enable input
- 5kV ESD HBM rated
- Thermal shutdown and current limit protection

Part #	V_{IN} Range(V)	V_{OUT} Range(V)	Enable Pin	Package
ISL80410IBEZ	6 to 40	ADJ	Yes	8 Ld EPSOIC
ISL80410IBEZ-T	6 to 40	ADJ	Yes	8 Ld EPSOIC
ISL80410IBEZ-T7A	6 to 40	ADJ	Yes	8 Ld EPSOIC



Typical Application Circuit

ISL80410EVAL1Z Evaluation Board

P9415 – Wireless Power Transceiver

30W Wireless Power Receiver with WattShare™ TRx Mode

Single-Chip Configuration

- Embedded 32-bit Arm® Cortex®-M0 processor
- Highly integrated single-chip medium power wireless solution
- Can be configured to receive or transmit an AC power signal

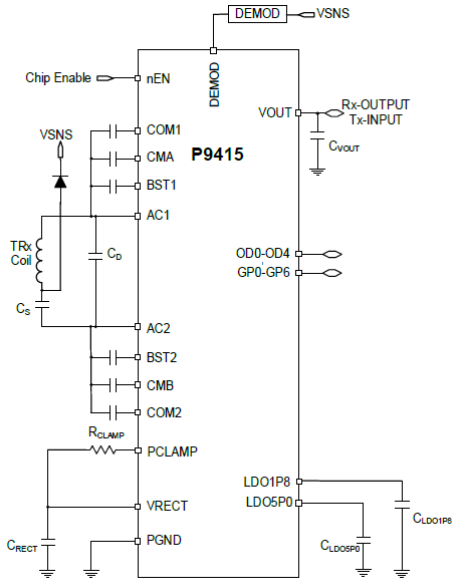
Wireless Power Transmitter and Receiver

- Includes on-chip full/half-bridge inverter, a PWM generator, and modulator/demodulator to drive tank circuit for transmitting power
- Receives AC power signals from a wireless transmitter and converts them into rectified output voltages

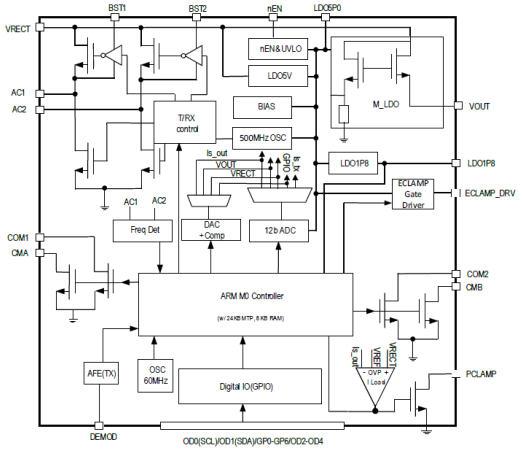
Protection and Multi-use Features

- Fault detection for over-temperature and voltage protection
- 24kB Multiple-time programmable (MTP) non-volatile memory
- Wireless Power Consortium 1.2.4 compatible

Part #	Temp Range (°C)	Package Size	Package
P9415	-55 to +150	4.22x2.82x0.50 mm	53-WLCSP



Typical Application Circuit



Block Diagram

P9247 - Highly Integrated Wireless Power Transmitter

WPC 1.2 Compliant, Wireless Charging Transmitter for 30W Applications

High Efficiency and Integration

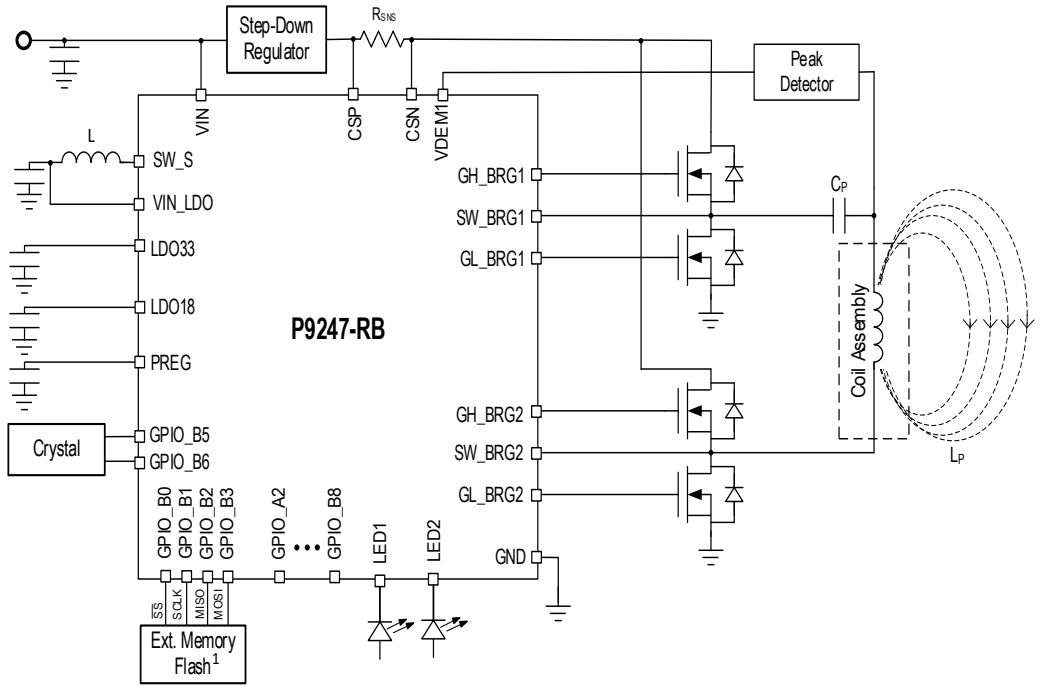
- Wireless power transmitter for up to 30W applications
- Wide input voltage range: 4.25V to 21V
- WPC-1.2 compliant, MP-A2 coil configuration
- Supports Renesas fast charging protocol for 15W+ applications

Easy and Flexible Use

- Easy configuration of design parameters through I²C interface on an external flash
- Embedded 32-bit Arm® Cortex®-M0 processor
- Reference design supports USB-PD adapters

Low Power and Protection Features

- Over-current and over-temperature protection
- Programmable current limit
- User programmable foreign objects detection (FOD)
- Low standby power <1mA



Basic Application Circuit

Part #	Temp.(°C)	Carrier	Package
P9247-RBNDGI	-40 to +85	Tray	48 Ld 6x6mm VFQFPN
P9247-RBNDGI8	-40 to +85	Reel	48 Ld 6x6mm VFQFPN

HIP221X – 120V, 3A/4A, Bridge Driver

High Voltage Drivers for Industrial Motor Control

High Robustness

- 100% production tested 115V bootstrap voltage
- 100% production tested negative 10V rating on HS pin

High Efficiency

- 3A source, 4A sink drive current
- Supports 3.3V and 5V signals

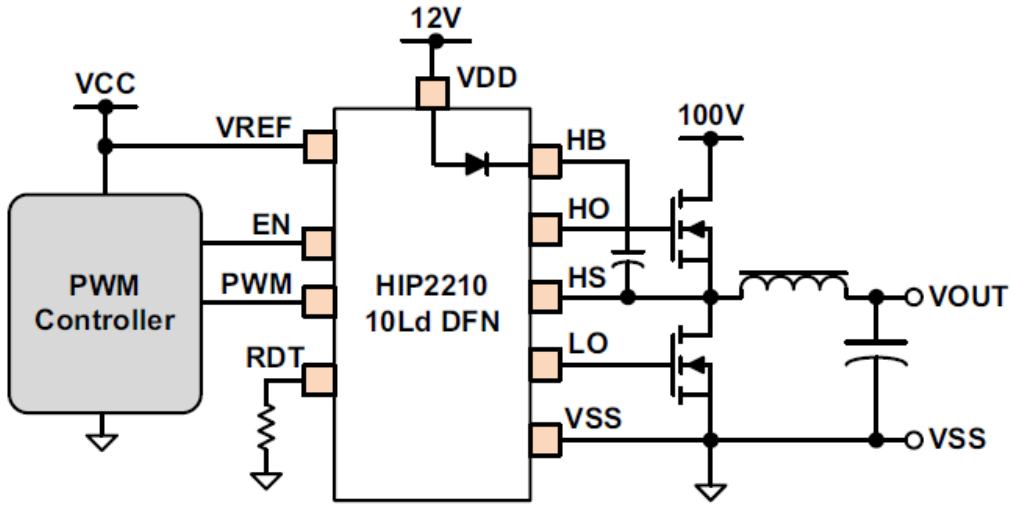
High Frequency

- 15ns fast propagation delay
- 2ns propagation delay matching

Easy Use and Small Package

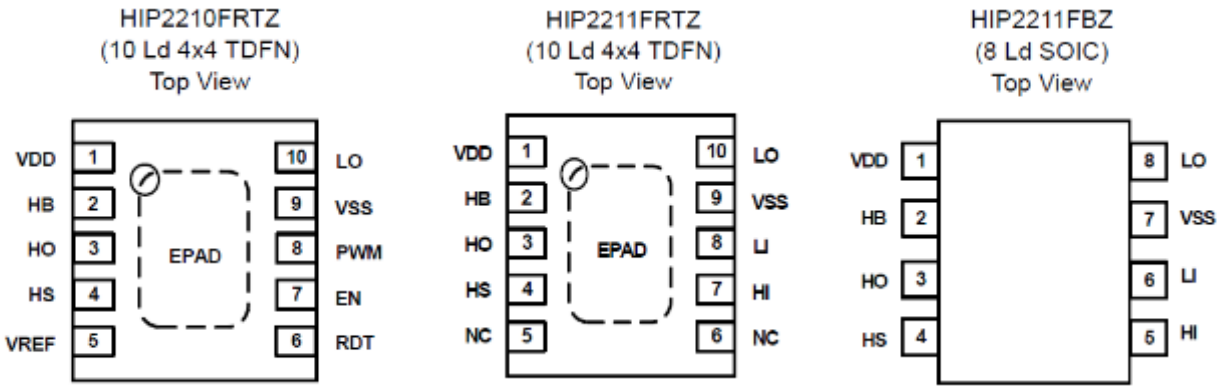
- HIP2210 with PWM input, EN and adjustable dead time
- HIP2211 with HI/LI 3.3V logic compatible
- Available in DFN4*4 and SOIC-8

Part #	Dive Current	Package
HIP2210FRTZ	3A	10Ld 4 x 4 TDFN
HIP2210FRTZ	3A	10Ld 4 x 4 TDFN
HIP2211FBZ	4A	8Ld SOIC



HIP2210 PWM Input with Programmble Dead Time

Typical Application Circuit



Pin Assignment

ISL84051 – Low Voltage 8 to 1 Multiplexer Analog Switch

Application for Portable Equipment, Communication Systems and Test Equipment

Good Compatibility

- Drop-in replacements for MAX4051/A, MAX4052/A and MAX4053/A
- Pin compatible with MAX4581~3 and with industry standard 74HC4051~3
- TTL, CMOS compatible

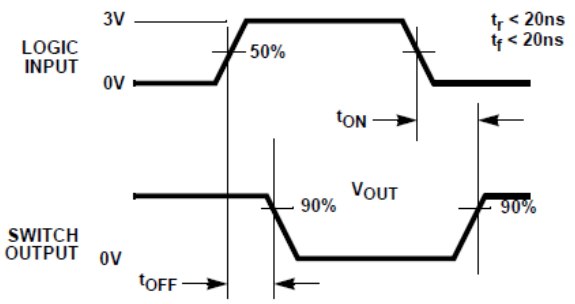
Fast Switching Speeds

- Fast switching action (V_S = +5V)
  - t_{ON}: 90ns / t_{OFF}: 60ns

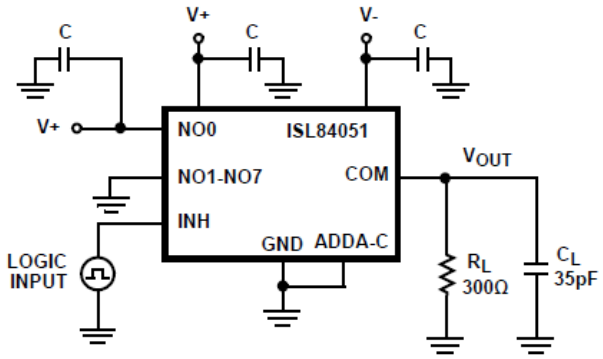
Low Power and High Reliability

- Guaranteed Max off-leakage @ VS = ±5V: 5nA
- Low charge injection: 2pC
- Break-before-make

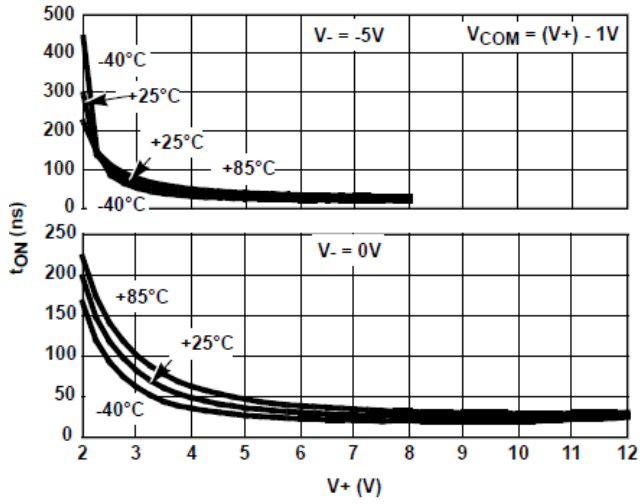
Part #	Configuration	±5V t_{ON}/t_{OFF}	5V t_{ON}/t_{OFF}	Package
ISL84051IAZ	8:1 Mux	50ns/40ns	90ns/60ns	16 Ld QSOP
ISL84051IBZ	8:1 Mux	50ns/40ns	90ns/60ns	16 Ld SOIC
ISL84051IVZ	8:1 Mux	50ns/40ns	90ns/60ns	16 Ld TSSOP



Logic input waveform is inverted for switches that have the opposite logic sense.



Test Circuits and Waveforms



Inhibit Turn-on Time vs Supply Voltage

ISL28X14 – Single/Dual/Quad RRIO Op Amps

General Purpose, Micropower, RRIO Operational Amplifiers for a Wide Range of Applications

Good Dynamic Performance

- Rail-to-rail input and output
- Gain-bandwidth: 5MHz

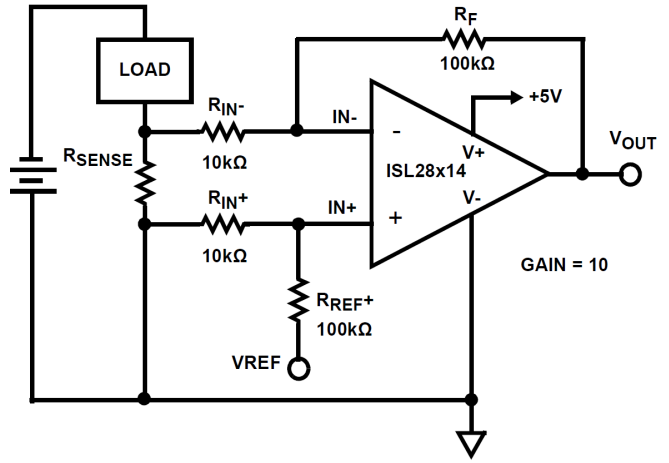
Low Power and Wide Supply Range

- Low current consumption: 390µA maximum per channel
- Input bias current: 20pA, Max
- Wide supply range: 1.8V to 5.5V

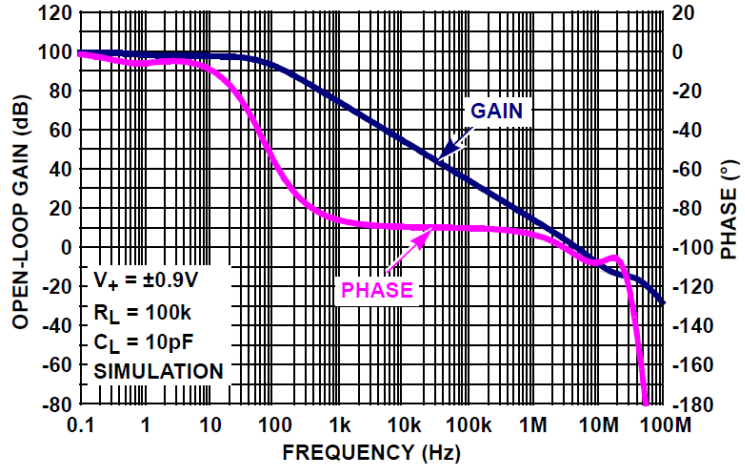
Wide Operating Temperature Range

- All devices operate across the extended temperature range of -40°C to 125°C

Part #	Channel	Package
ISL28114FEZ-T7	Single	5 Ld SC-70
ISL28114FHZ-T7	Single	5 Ld SOT-23
ISL28214FUZ	Dual	8 Ld MSOP
ISL28214FBZ	Dual	8 Ld SOIC
ISL28214FHZ-T7	Dual	8 Ld SOT-23
ISL28414FVZ	Quad	14 Ld TSSOP
ISL28414FBZ	Quad	14 Ld SOIC



Typical Application



Open-loop Gain, Phase vs Frequency, R_L = 100KΩ
C_L = 10pF, V_S = ±0.9V

ISL28X91 – Single/Dual Ultra-Low Noise RRIO Op Amps

Applications for Low Noise Signal Processing, Low Noise Microphones, ADC Buffers, etc.

Ultra-Low Noise and Ultra-Low Distortion

- 1.7nV/√Hz input voltage noise at 1kHz
- 1kHz THD+N typical 0.00018% at $2V_{P-P}$ V_{OUT}
- Harmonic distortion -76dBc, -70dBc, fo = 1MHz

Good Dynamic Performance

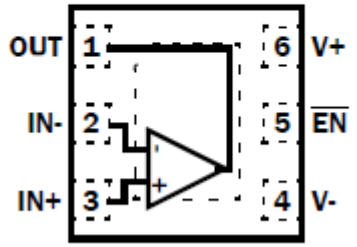
- Rail-to-rail input and output
- Gain-bandwidth: 5MHz
- 61MHz -3dB bandwidth

High Performance and Space-Saving Package

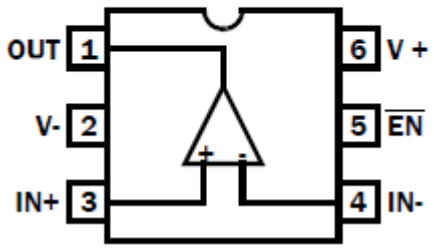
- 630µV maximum offset voltage
- 3µA input bias current
- 100dB typical CMRR
- Ground sensing and enable pin
- 6 Ld UTDFN (1.6mmx1.6mm) and 6 Ld SOT-23 packages are available in ISL28191

Part #	Channel	Supply Voltage(V)	Package
ISL28191FHZ-T7	Single	3 to 5.5	6 Ld SOT-23
ISL28191FRUZ-T7	Single	3 to 5.5	6 Ld UTDFN
ISL28291FUZ	Dual	3 to 5.5	10 Ld MSOP
ISL28291FBZ	Dual	3 to 5.5	8 Ld SOIC
ISL28291FRUZ-T7	Dual	3 to 5.5	10 Ld UTQFN

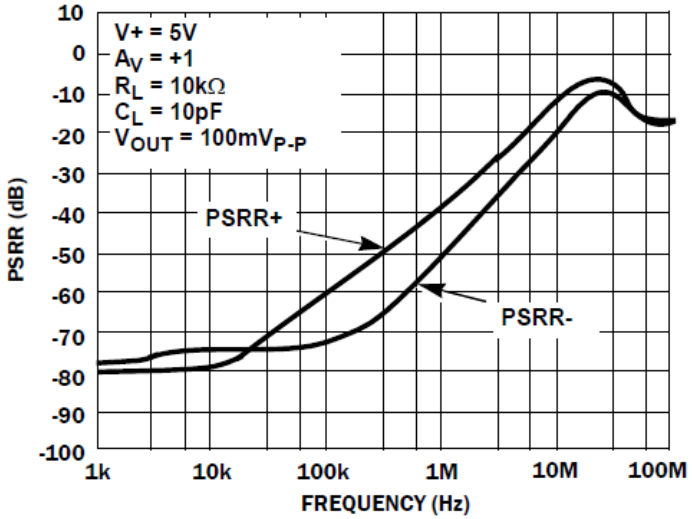
ISL28191
(6 LD 1.6X1.6X0.5 UTDFN)
TOP VIEW



ISL28191
(6 LD SOT-23)
TOP VIEW



Pin Configuration



PSRR vs Frequency

Renesas.com