

CN050 Smart Toilet

March 2020

Smart Toilet

■ Overview

Smart toilets continue to be a rapidly emerging market, with market share increasing worldwide. This system design demonstrates a high-end product with the following key features: seat/water/dry cooling and heating system, and a sterilization function, with all controls accessible via a remote.

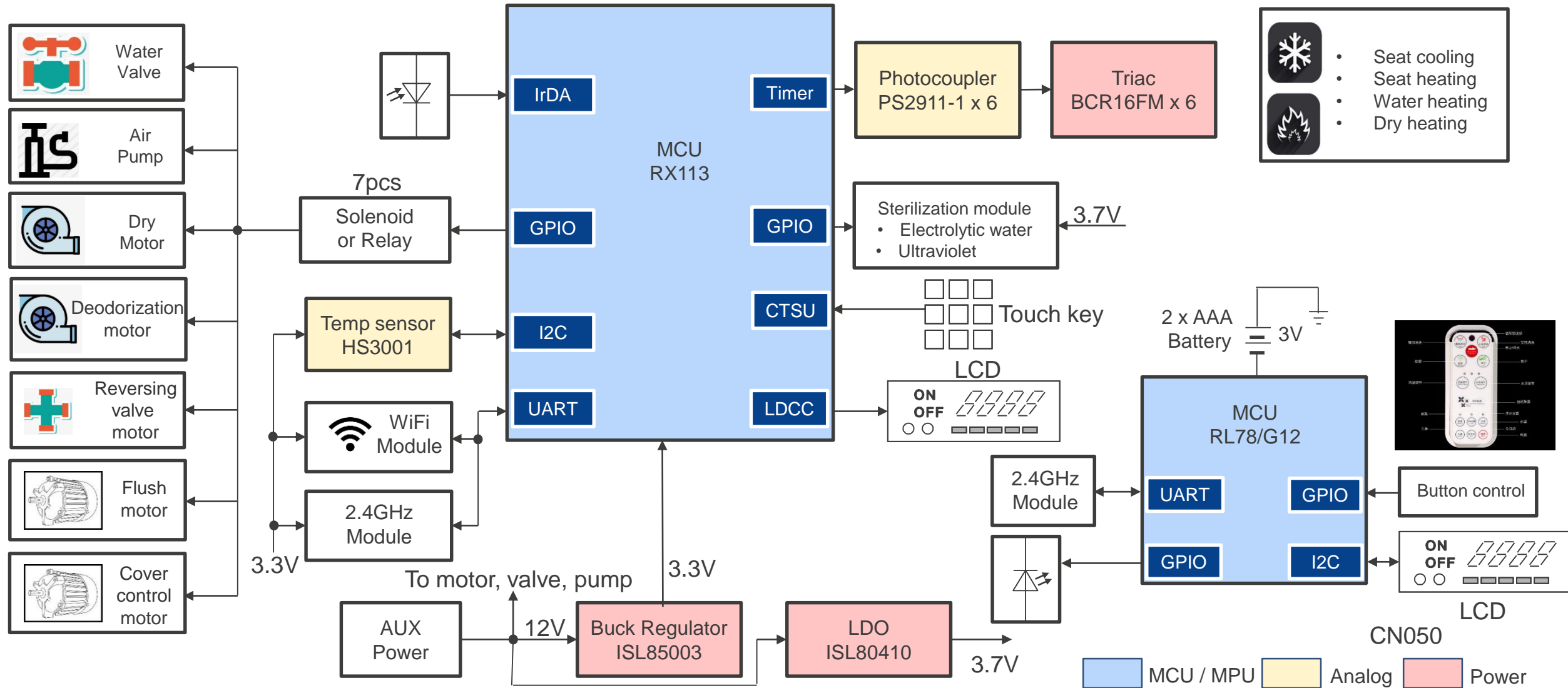
The RX113 is a 32-bit microcontroller (MCU) single-chip solution for bidirectional human machine interface (HMI) and various peripheral devices. The RL78/G12 is ideal for sub-microcontrollers like remote controllers with compact, low power and high function general purpose. This design also features DC/DC and LDO power for the MCU, motor and other peripheral modules. The triac is used for the heating function. Lastly, the humidity and temperature sensor provides leading accuracy and excellent stability, and the photocoupler provides high performance in an ultra-small package.

■ System Benefits

- Single-chip MCU, reduced BOM cost and PCB size
- Low-end MCU for remote design, widely used in various home appliances
- High performance DC/DC, LDO, photocoupler and temperature/humidity sensor for an integrated solution

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- Seat cooling
- Seat heating
- Water heating
- Dry heating

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Device Category	P/N	Key Features
MCU	RX113 R5F5113xADxx	32MHz, 32-bit MCU, up to 512 Kbytes of flash memory, USB 2.0 full-speed host/function/OTG, up to 12 comms channels, serial sound interface, LCD controller/driver, capacitive touch sensing unit, 12-bit A/D, 12-bit D/A, RTC
	RL78/G12 R5F10Rxx	24MHz, 16-bit MCU, compact, low power, high function general-purpose microcontrollers ideal for sub-microcontrollers, extreme low end to save cost
Power	ISL80410	Wide V_{IN} range of 6V to 40V, adjustable output voltage from 2.5V to 12V, ensured 150mA output current
	ISL85003	-Input voltage range 4.5V to 18V, output voltage adjustable from 0.8V, $\pm 1\%$ -Efficiency up to 95%, 3A synchronous buck regulator
	BCR16FM	IT (RMS) 16A, VDRM 600V, medium power triacs
Analog	HS3001	-RH accuracy: $\pm 1.5\%$ RH typical -Temperature sensor accuracy: $\pm 0.2^\circ\text{C}$ typical (-10 to $+80^\circ\text{C}$) -Lowest power consumption: 1.0 μA average
	PS2911-1	-Flat-lead photocoupler -Low input current -Insulation thickness: 0.4mm, Single Tr. (DC Input)

RX113 – User I/F (LCD, CTSU) and Communication (USB, IrDA)

32-bit MCU Suitable Single-chip Solution for Bidirectional HMI and Various Peripheral Devices

User Interface and Communication Functions

- 12-channel capacitive touch sensors (CTSU), improved noise immunity, sensitivity and water resistance
- Ultra-low power LCD controller: switch between internal voltage boost/capacitor split/external resistance division, segment signal output x common signal output up to 40 seg x 4 com
- Up to 12 channels for communication:
 - USB 2.0 full-speed, SCI up to 8 channels
 - IrDA interface, I²C interface, RSPI up to 16 Mbps, serial sound interface (SSI)

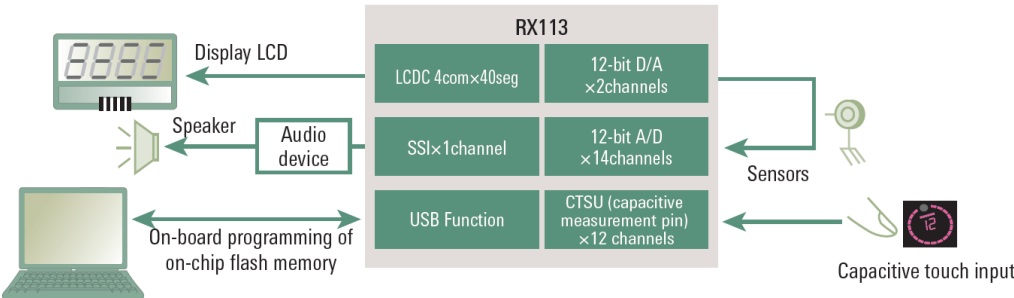
High Performance and Low Power

- Max. operating frequency: 32MHz
- Accumulator support DSP instructions
- Up to 512 Kbytes code flash and 64 Kbytes SRAM, no wait states
- 3 low power consumption modes
- Low power timer (LPT) that operates during the software standby states
- Supply current: high-speed operating mode: 0.11mA/MHz, software standby mode: 0.44 µA, recovery time from software standby mode: 4.8 µs

Rich Peripheral and Safety Functions

- Up to 14 extended-function timers, 12-bit ADC, 12-bit DAC, comparator, POR/LVD, DTC, ELC
- On-chip functions for IEC 60730 compliance: clock frequency accuracy measurement circuit, IWD, functions to assist in RAM testing, CRC Calculator (CRC), etc.

Part #	ROM (Kbytes)	RAM (Kbytes)	CTSU	Package
R5F5113xAxFP	128 ~ 512	32 ~ 64	12 channels	LFQFP100-14 x 14-0.50
R5F5113xAxLJ	128 ~ 512	32 ~ 64	12 channels	TFLGA100-7 x 7-0.50
R5F5113xAxFM	128 ~ 512	32 ~ 64	Not support	LFQFP64-10 x 10 -0.50



Application System Block



RSK and Evaluation Kits

RL78/G12 – General Purpose 16bit MCU

Compact, Low power, High Function General-purpose, Ideal for Sub-microcontrollers

High Performance Peripheral Functions

- 16bit MCU with high performance: 32.4 DMIPS (24 MHz)
- On-chip oscillator, data flash, 10-bit A/D converter, CSI/UART/IIC
- Built-in safety features enable support for the household appliance safety standard (IEC/UL 60730)

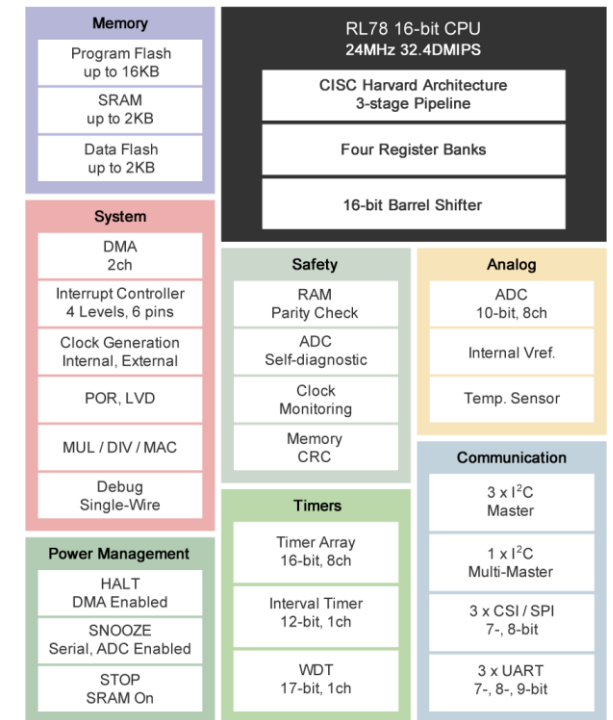
Lowest Power Consumption

- CPU: 63 μ A/MHz
- Standby (stop mode): 230 nA
- HALT, STOP, SNOOZE, 3 kind of mode to save power

Low Cost

- 20 to 30 pin compact is perfect for sub-microcontrollers of small appliances and consumer and industrial equipment

Part #	Flash ROM	RAM	Package(mm)
R5F1026x R5F1036x	2 ~ 16 KB	256B ~ 1.5 KB	20-LSSOP(4.4 x 6.5mm, 0.65mm pitch)
R5F1027x R5F1037x	4 ~ 16 KB	512B ~ 1.5 KB	24-HWQFN(4 x 4mm, 0.5mm pitch)
R5F102Ax R5F103Ax	4 ~ 16 KB	512B ~ 2 KB	30-LSSOP(7.62mm(300), 0.65mm pitch)



RL78/G12 Block Diagram



QB-R5F1026A-TB Easy Evaluation Kit

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
- $\pm 1\%$ accurate voltage reference (over temperature, load)

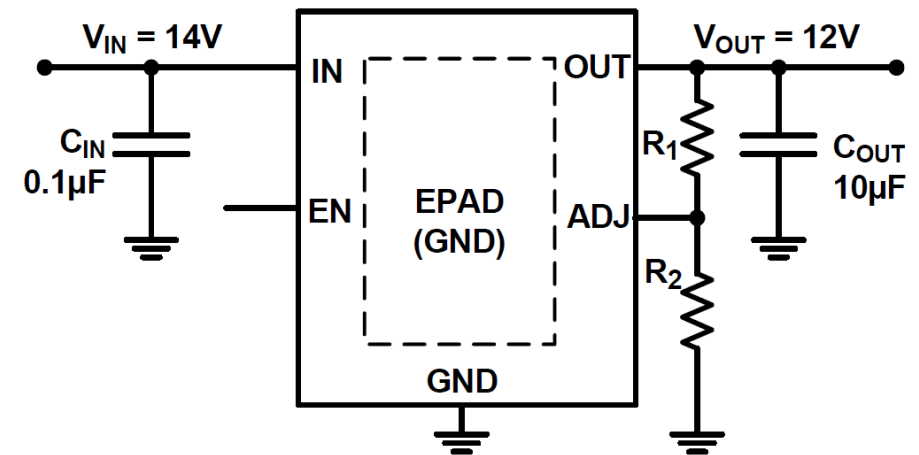
High Efficiency

- Ultra low 18 μ A typical quiescent current
- Low 2 μ A of typical shutdown current
- Low dropout voltage of 295mV at 150mA
- Low 26 μ V RMS 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

ISL85003 – Efficient 3A Synchronous Buck Regulator

Network and Communication Equipment, Industrial Control, Point-of-load Regulators

Flexible Power

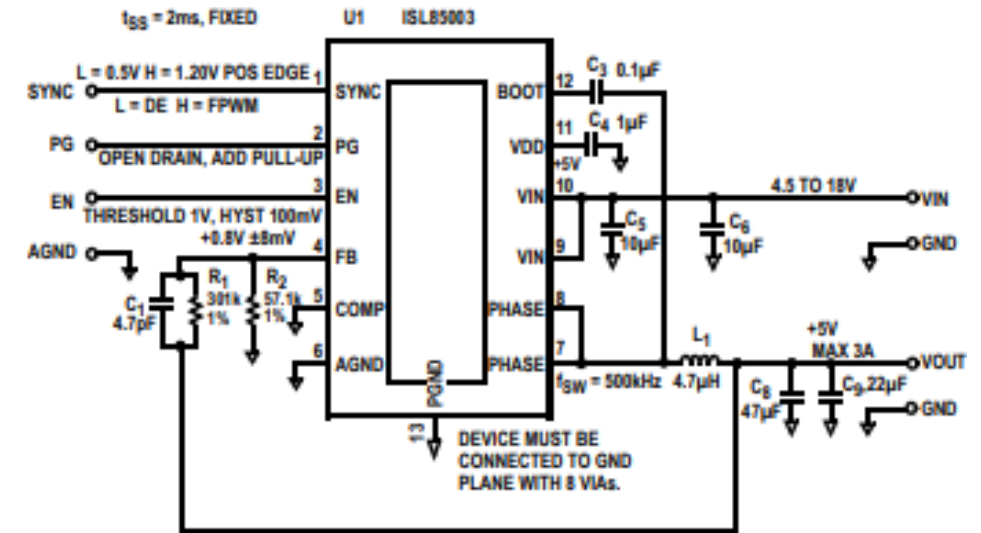
- Input voltage range 4.5V to 18V
- Adjustable output voltage as low as 0.8V
- DCM/CCM

High Efficiency and Accuracy

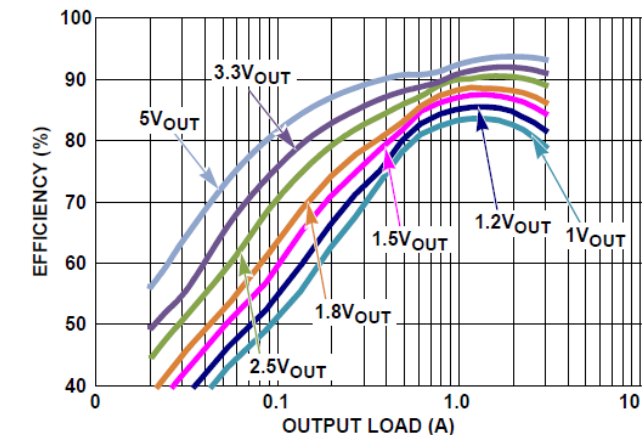
- Efficiency up to 95%
- High-side NFET $R_{ds(on)}$ of 65m Ω and low-side NFET $R_{ds(on)}$ of 45m Ω
- Precision 0.8V, $\pm 1\%$ accurate voltage reference

Built-in Protection

- Positive and negative overcurrent protection
- Overvoltage and thermal protection



Typical Operation Circuits



Efficiency vs Load, 12V_{IN} DCM

Part #	External clock synchronization	Programmable soft start	Package
ISL85003FRZ	Yes	No	12L 3x4mm DFN
ISL85003AFRZ	No	Yes	12L 3x4mm DFN

BCR16FM – 600V/16A Medium Power Triacs

Guaranteed Junction Temperature (Tj) of 150°C

High Performance

- $I_{T(RMS)}$: 16A V_{DRM} : 600V
- $I_{FGTI}, I_{RGTI}, I_{RGT III}$: 30mA
- V_{iso} : 2000V

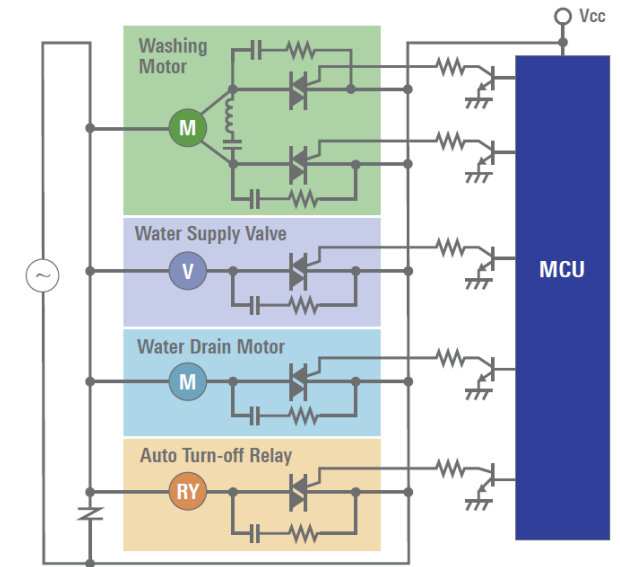
High Reliability

- Actual failure rate: 0.01ppm or less (long service life)
- Channel stopper provides stable voltage tolerance
- Guaranteed junction temperature (Tj) of 150°C

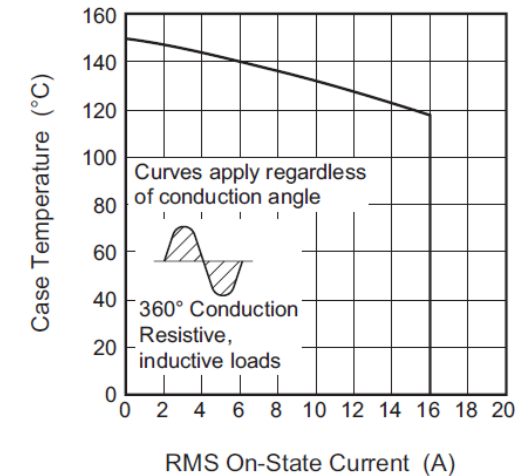
Best Fit for Applications

- Contactless AC switch
- Electric heater control
- Light dimmer, on/off and speed control of small induction motor
- On/off control of copier lamp

Part #	VDRM(V)	Peak Gate Voltage(V)	Peak Gate Current(A)	Junction Temp.(°C)	Package
BCR16FM-12LB	600	10	2	-40 to 150	TO-3PFM



Typical Application Circuit



Allowable Case Temp. vs RMS On-State Current

HS300x – Relative Humidity and Temperature Sensor

High Accuracy Humidity and Temperature Measurement for Environmental Monitoring

High Accuracy

- $\pm 1.5\%$ RH accuracy (HS3001)
- $\pm 0.2^{\circ}\text{C}$ temperature accuracy (HS3001, HS3002)

Excellent Stability

- 0.1% RH per year drift
- MEMS silicon-carbide sensor technology

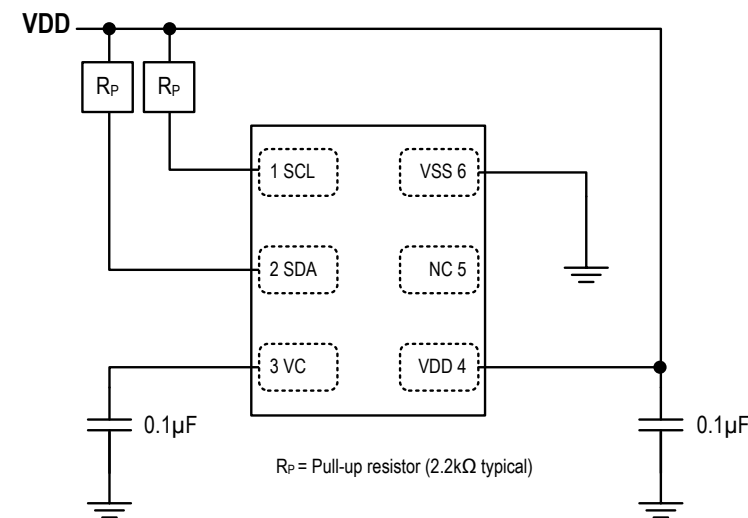
Fast Response

- Less than 6 seconds humidity response, in still air
- Less than 2 seconds temperature response

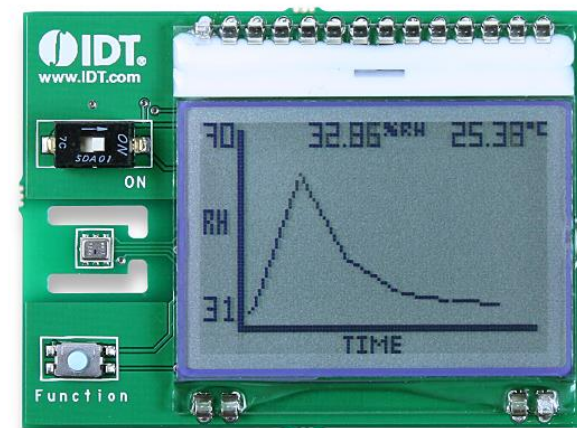
Extended Supply Voltage

- 2.3V to 5.5V, 24.4 μA at 3.3V (one RH+Temp per second)
- 1.8V custom order

Part #	Feature	Package
HS3001	$\pm 1.5\%$ RH	3 \times 2.41 \times 0.8 LGA
HS3002	$\pm 1.8\%$ RH	3 \times 2.41 \times 0.8 LGA
HS3003	$\pm 2.8\%$ RH	3 \times 2.41 \times 0.8 LGA
HS3004	$\pm 3.8\%$ RH	3 \times 2.41 \times 0.8 LGA



Typical Operating Circuit



SDAH02 Evaluation Kit

PS2911-1 – High CTR 4-Pin Photocouplers

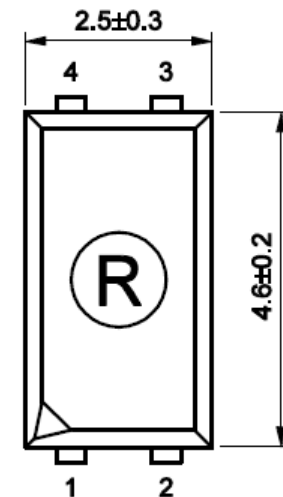
Application for DC/DC Converter, Modem/PC Card

High Performance and Small Package

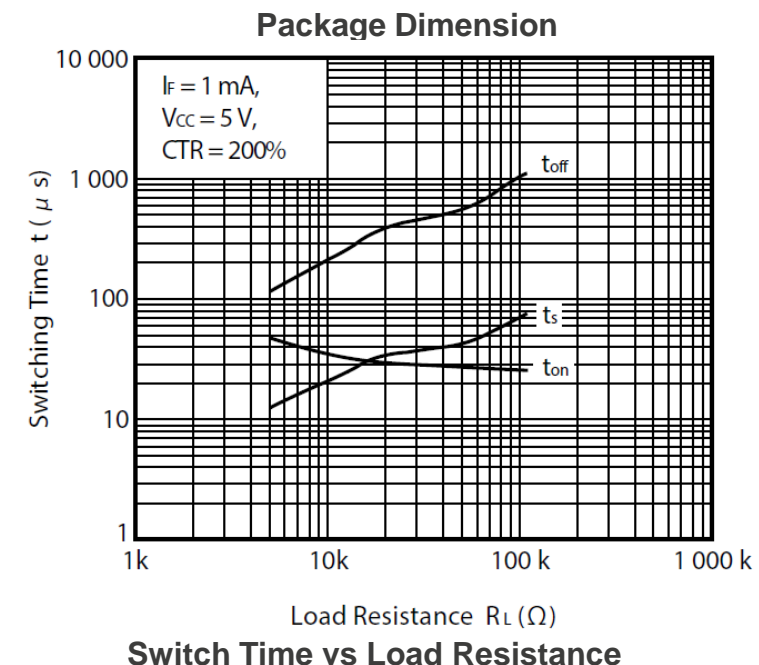
- High current transfer ratio (CTR = 200% TYP. @ $I_F = 1\text{mA}$, $V_{CE} = 5\text{V}$)
- High isolation voltage (BV = 2500 Vr.m.s.)
- Ultra small flat-lead package (4.6 (L) × 2.5 (W) × 2.1 (H) mm)

Safety Standards

- UL approved: UL1577, Single protection
- BSI approved: BS EN 62368-1, Supplementary insulation
- VDE approved: DIN EN 60747-5-5 (Option)



Part #	Forward Current(mA)	Safety Standard	Package
PS2911-1	50	UL, BSI	4 pin 4.6 x 2.5 x 2.1mm
PS2911-1-F3	50	UL, BSI	4 pin 4.6 x 2.5 x 2.1mm
PS2911-1-V	50	UL, BSI, VDE	4 pin 4.6 x 2.5 x 2.1mm
PS2911-1-V-F3	50	UL, BSI, VDE	4 pin 4.6 x 2.5 x 2.1mm



[Renesas.com](https://www.renesas.com)