REAL-TIME CLOCKS

MIXED-SIGNAL DESIGN GUIDE

Data Sheets • Application Notes • Free Samples

8th EDITION

If It's Electronic, It Needs a Clock

No matter what you design, you need your system to accurately keep time. Dallas Semiconductor has been the leader in real-time clock (RTC) design for over ten years. Our devices offer the most integration and the richest feature sets on the market. Multiple interface options, packaging variety, and integrated memory give designers ideal solutions for their applications. And did we mention that we provide the most accurate solutions in the industry? In fact, let us prove it to you. Visit www.maxim-ic.com/rtc-demo and see for yourself.

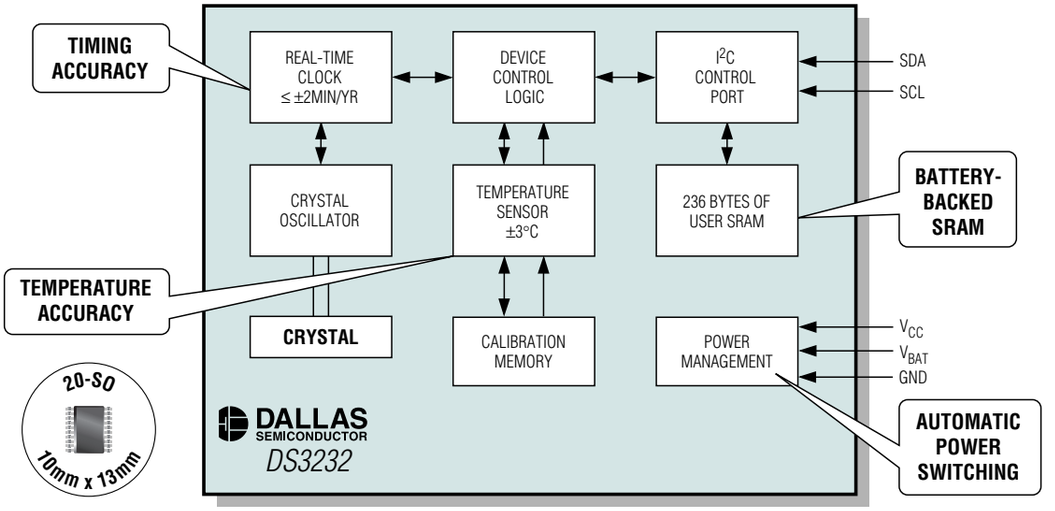
DALLAS SEMICONDUCTOR MAXIM

Extremely Accurate Timing

Dallas Semiconductor offers a unique line of RTCs with built-in temperature compensation. By automatically adjusting the crystal frequency based on temperature, these parts allow the system to keep time to within one minute per year, thereby eliminating the need to periodically reset the system time.

RTC Integrates Memory, Temp Sensor, and Crystal

±1Min/Year Accuracy Plus 236 Bytes of User SRAM



- ±1.8Min/Year Accuracy (-40°C to +85°C)
- ±1Min/Year Accuracy (0°C to +40°C)
- +2.0V to +5.5V Power Supply
- I²C Serial-Control Interface
- Low (< 4µA) Battery-Backed Current
- Automatic Power-Fail Detect and Switch Circuitry
- Digital-Temperature-Sensor Output

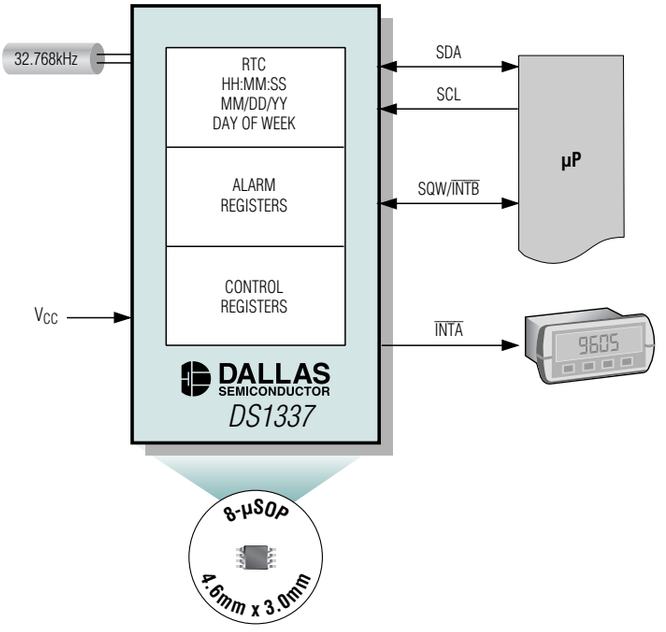
Part	Bus Type	V_{CC} (V)	Clock Format/ Resolution (s)	User RAM (bytes)	Operating Temp Range (°C)	Features	Package	Price† ($)
DS3231	I²C/400k	3.3	BCD/1	—	0 to +70, -40 to +85	Battery input, TOD alarm, square-wave output, reset input/output	16-SO with crystal	2.25
DS3232	I²C/400k			SRAM, 236				2.35
DS3234	SPI™			SRAM, 256			20-SO with crystal	2.40
DS32B35*	I²C/400k			FRAM, 2k	-40 to +85			3.42
DS32C35*	I²C/400k			FRAM, 8k	-40 to +85			3.75

SPI is a trademark of Motorola, Inc.
*Future product—contact factory for availability.
†1000-up recommended resale. Prices provided are for design guidance and are FOB USA. International prices will differ due to local duties, taxes, and exchange rates. Not all packages are offered in 1k increments, and some may require minimum order quantities.

Consumer Electronics

Dallas Semiconductor offers RTCs with different features and prices to meet the needs and budget constraints of the consumer market. Available solutions include the digital-input DS1375 with integrated crystal, the single-supply DS1337 with simple RTC functions, the dual-supply DS1338 with additional features, and the parallel-bus DS1558 with a watchdog timer and NV SRAM control.

I²C Serial RTC with Two Alarms



- **Available in Surface-Mount Package with Integrated Crystal (DS1337C)**
- **I²C Serial-Control Interface**
- **Two Time-of-Day Alarms**
- **Oscillator Stop Flag**
- **Programmable Square-Wave Output—Defaults to 32kHz on Power-Up**
- **8-Pin DIP, SO, or µSOP**

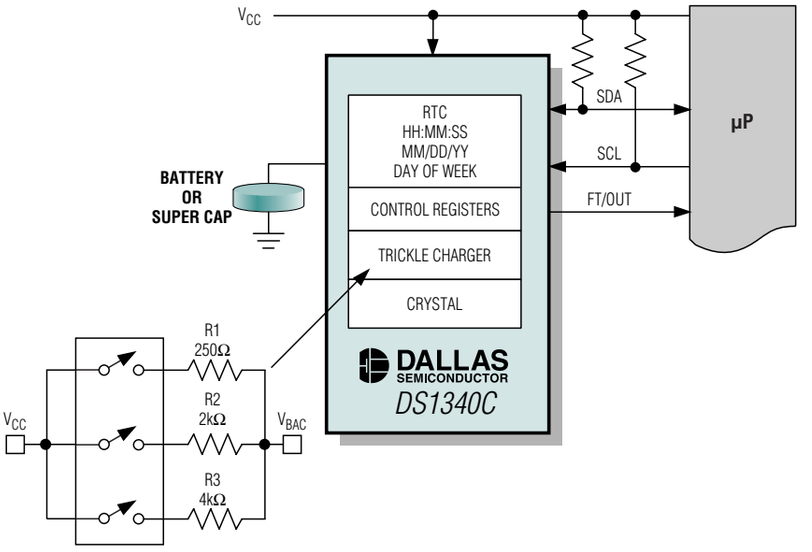
Part	Bus Type	V_{CC} (V)	Clock Format/ Resolution (s)	User RAM (bytes)	V_{OSC} (min)/ I_{CCT}	Features
DS1337	I²C/ 400k	1.8 to 4.0	BCD/1	—	1.3/600nA	TOD alarm, interrupt output, square-wave output, oscillator stop flag
DS1338		3.3	BCD/1	SRAM, 56	1.3/500nA	Battery input, square-wave output
DS1371		1.8 to 4.0	Binary/1	—	1.3/700nA	Watchdog timer, watchdog-strobe input, TOD alarm, interrupt output, square-wave output
DS1375		1.7 to 5.5	BCD/1	SRAM, 16	1.7/500nA	TOD alarm, interrupt output, square-wave output
DS1558	Parallel	3.3/5.0	STD/1	BCD/1	—	Battery input, TOD alarm, interrupt output, reset output, external RAM control

Medical Devices

Portable battery-backed medical devices require small packages to reduce overall system size and low battery-backed currents to maximize battery life. Dallas Semiconductor offers devices in small packages, such as the 8-/10-pin µSOP and 28-pin TSSOP. Many of our clock oscillators keep time down to +1.3V with a typical current drain of less than 1µA.

RTC Integrates Crystal and Programmable Trickle Charger

Keeps Time Down to +1.3V



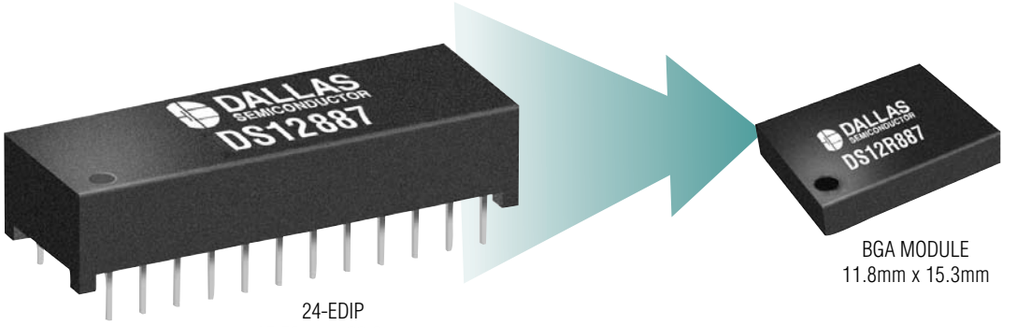
- Fast (400kHz) I^2C Interface
- Software Clock Calibration
- Automatic Power-Fail Detect and Switch Circuitry
- Oscillator Stop Flag
- Timekeeping-Voltage Ranges Down to +1.3V
- Three Operating-Voltage Ranges (+1.8V, +3V, and +3.3V)
- Available in Surface-Mount Package with Integrated Crystal (DS1340C)

Part	V_{OSC} (min)/ I_{CCT}	XTAL (pF)	Operating Temp Range (°C)	Features
DS1337	1.3/600nA	6	-40 to +85	TOD alarm, interrupt output, square-wave output, oscillator stop flag
DS1338	1.3/500nA	6		Battery input, square-wave output
DS1339	1.3/700nA	6		Battery input, trickle charger, TOD alarm, interrupt output, square-wave output, oscillator stop flag
DS1340	1.3/800nA	12.5		Battery input, clock calibration, frequency-test output, square-wave output, trickle charger
DS1374	1.3/600nA	6		Battery input, trickle charger, watchdog timer, TOD alarm, interrupt output, square-wave output, reset input/output, oscillator stop flag
DS1388	—	—		Battery input, trickle charger, watchdog timer, reset input/output
DS1501	—	—	0 to +70, -40 to +85	Battery input, watchdog timer, TOD alarm, periodic alarm, interrupt output, square-wave output, reset input/output, kick-start input
DS3231	—	—	0 to +70, -40 to +85	Battery input, TOD alarm, square-wave output, reset input/output

Industrial Controls

Industrial controls often function in hostile environments, making module products that isolate the battery and crystal from the outside particularly desirable. Dallas Semiconductor offers modules with the crystal and/or battery included. Devices are available in I^2C, SPI, mux-bus, or bytewide interfaces.

Surface-Mountable RTC Module Contains Integrated Crystal and Battery



24-EDIP
17.78mm x 33.9mm

BGA MODULE
11.8mm x 15.3mm

- **Functionally Compatible with DS12887**
- **Capable of IR Reflow**
- **+5.0V or +3.3V Operation**
- **Automatic Power Switching**
- **-40°C to +85°C Temp Range**

Part	Bus Type	V_{CC} (V)	Clock Format/ Resolution (s)	User RAM (bytes)	Features
DS12CR887	Motorola®/ Intel® mux	3.3/5	STD/1	SRAM, 114	TOD alarm, periodic alarm, interrupt output, square-wave output, reset input
DS12R887	Motorola/ Intel mux	3.3/5	STD/1	SRAM, 114	TOD alarm, periodic alarm, interrupt output, square-wave output, reset input, RAM-clear input
DS1339	I^2C/400k	2.0/3.0/3.3	BCD/1	—	Battery input, trickle charger, TOD alarm, interrupt output, square-wave output, oscillator stop flag
DS1553	Parallel	3.3/5.0	Y2K/1	SRAM, 8k	Watchdog timer, TOD alarm, interrupt output, reset output
DS1557	Parallel	3.3/5.0	Y2K/1	SRAM, 512k	
DS3232	I^2C/400k	3.3	BCD/1	SRAM, 236	Battery input, TOD alarm, square-wave output, reset input/output
DS3234	SPI			SRAM, 256	
DS32B35*	I^2C/400k			FRAM, 2k	
DS32C35*	I^2C/400k			FRAM, 8k	

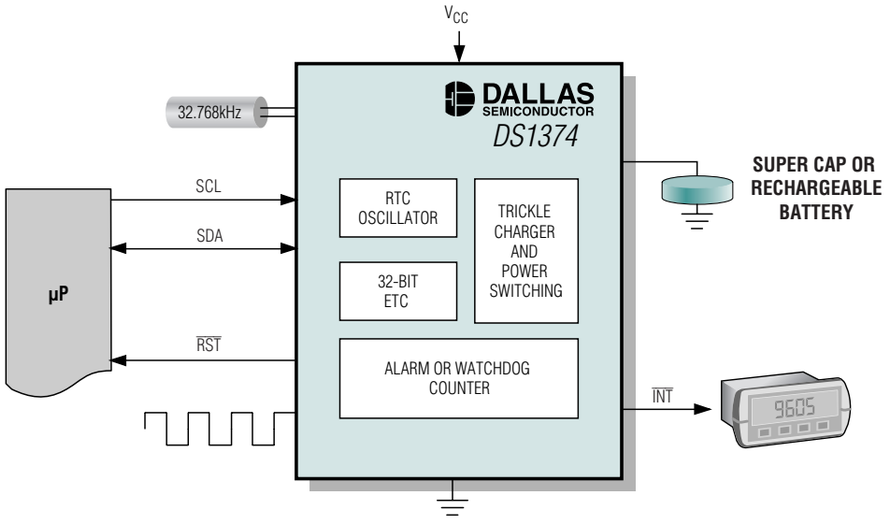
Motorola is a registered trademark of Motorola, Inc.
Intel is a registered trademark of Intel Corp.
*Future product—contact factory for availability.

Global Positioning Systems

In order to reduce the time required for initial satellite acquisition, a global positioning system (GPS) requires a backup real-time clock. Because this clock is only read during system boot, low cost and a low battery-backup current are the main considerations for this RTC. Dallas Semiconductor offers a variety of parts that operate down to +1.3V with current draws less than 1µA.

I²C Real-Time Clock in Binary-Coded-Decimal Format

Keeps Time Down to +1.3V



- 32-Bit Elapsed-Time Counter
- 24-Bit Alarm or Watchdog Counter
- Programmable Square-Wave Output
- Power-on-Reset Output
- Programmable Trickle Charger
- Oscillator Operates Down to +1.3V
- I²C Serial-Control Interface
- Oscillator Stop Flag

Part	Bus Type	V_{CC} (V)	Features	Package	Price† ($)
DS1318	Parallel	3.3	Battery input, periodic alarm, interrupt output, square-wave output, elapsed-time counter	24-TSSOP	1.32
DS1337	I²C/400k	1.8 to 4.0	TOD alarm, interrupt output, square-wave output, oscillator stop flag	8-SO/µSOP, 16-SO with crystal	0.88
DS1338		3.3	Battery input, square-wave output		1.12
DS1339		2.0/3.0/3.3	Battery input, trickle charger, TOD alarm, interrupt output, square-wave output, oscillator stop flag		1.12
DS1371		1.8 to 4.0	Watchdog timer, watchdog-strobe input, TOD alarm, interrupt output, square-wave output	8-µSOP	0.88
DS1374		1.8/3.0/3.3	Battery input, watchdog timer, TOD alarm, interrupt output, square-wave output, reset input/output, oscillator stop flag	10-µSOP	1.25
DS1670	3-wire/ 500k to 2M	3.3	Battery input, watchdog timer, watchdog-strobe input, TOD alarm, interrupt output, reset output, ADC	20-TSSOP	3.44
DS1672	I²C/400k	2.0/3.0/3.3	Battery input, trickle charger, reset output	8-SO/µSOP	1.12

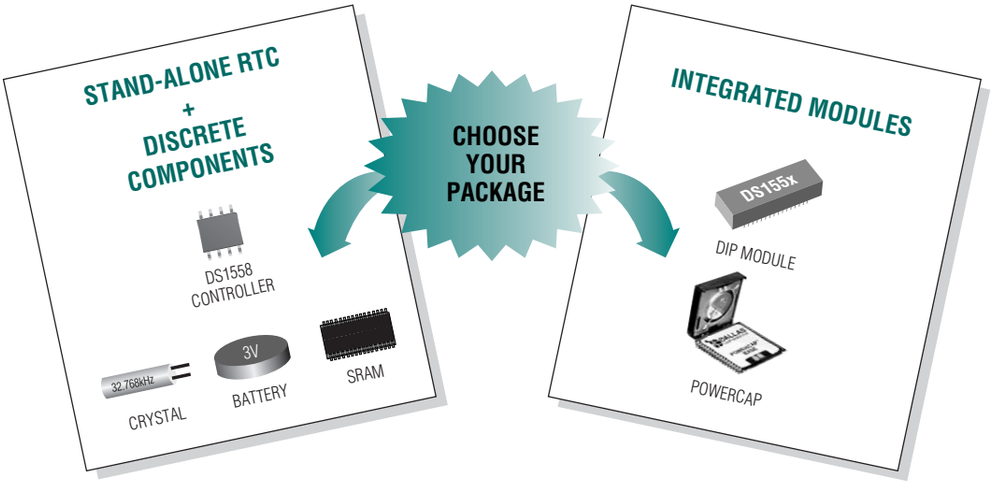
†1000-up recommended resale. Prices provided are for design guidance and are FOB USA. International prices will differ due to local duties, taxes, and exchange rates. Not all packages are offered in 1k increments, and some may require minimum order quantities.

Telecommunications

There is a widespread need for the local time stamping of events in telecommunication systems. This need can be supported by either a stand-alone RTC that includes control of external SRAM or by an RTC module that includes nonvolatile (NV) memory. Dallas Semiconductor offers stand-alone RTCs with NV SRAM control in phantom (DS1315), 3-wire (DS1670, DS1673, DS1680), or parallel (DS1500, DS1558) interfaces. Module devices such as the DS1251 integrate SRAM, battery, and crystal in a single package.

Watchdog RTC Offers Nonvolatile SRAM Control

Choose Between a Stand-Alone RTC or Integrated-Module Solution



AVAILABLE SRAM DENSITIES

8k x 8 128k x 8
32k x 8 512k x 8

- **Integrated RTC, Power-Fail Control Circuit, and NV SRAM Controller**
- **Clock Registers Are Accessed Identically to the SRAM**
- **Century Register**
- **Precision Power-On Reset**
- **Programmable Watchdog Timer and RTC Alarm**
- **Battery-Voltage-Level Indicator Flag**
- **Power-Fail Write Protection Allows ±10% V_{CC} Power-Supply Tolerance**
- **UL Recognized Component**

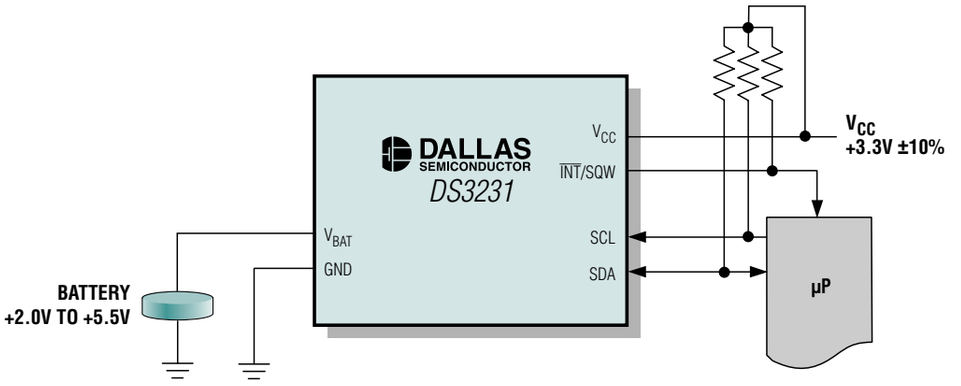
Part	Bus Type	V_{CC} (V)	Clock Format/ Resolution (s)	User RAM (bytes)	Operating Temp Range (°C)	Features
DS1251	Parallel	5.0	STD/(1/100)	SRAM, 512k	0 to +70	Reset input
DS1315	Phantom	3.3/5.0	Y2K/(1/100)	—	-40 to +85	Battery input, external RAM control
DS1500	Parallel	5.0	Y2K/1	SRAM, 256	0 to +70, -40 to +85	Battery input, watchdog timer, TOD alarm, periodic alarm, interrupt output, square-wave output, reset output, external RAM control, wake-up, kick-start input
DS1501		3.3/5.0	Y2K/1	SRAM, 256	0 to +70, -40 to +85	Battery input, watchdog timer, TOD alarm, periodic alarm, interrupt output, square-wave output, reset output, wake-up, kick-start input
DS1557		3.3/5.0	Y2K/1	SRAM, 512k	0 to +70	Watchdog timer, TOD alarm, interrupt output, reset output
DS1558		3.3/5.0	BCD/1	—	-40 to +85	Battery input, watchdog timer, TOD alarm, interrupt output, reset output, external RAM control
DS1670	3-wire/ 500k to 2M	3.3	BCD/1	—	0 to +70	Battery input, watchdog timer, watchdog-strobe input, TOD alarm, interrupt output, reset output, external RAM control, ADC

Utility Metering

Dallas Semiconductor offers a unique line of RTCs with built-in temperature compensation. By automatically adjusting the crystal frequency based on temperature, these parts allow the system to keep time to within one minute per year, thereby eliminating the need to periodically reset the system time.

Industry's Most Accurate RTC

The DS3231 provides better than ±2min/year accuracy (< ±3.5ppm) over the entire industrial temperature range (-40°C to +85°C) and better than ±1min/year (< ±2.0ppm) in the 0°C to +40°C temperature range. Designed for low-power applications, it supports supply voltages from +2.3V to +5.5V. An I^2C serial-control interface provides access to time and temperature.



- **Low (< 3µA) Battery-Backed Current**
- **Fast (400kHz) I^2C Interface**
- **Programmable Square-Wave Output**
- **Automatic Power-Fail Detect and Switch Circuitry**
- **±2°C Accurate Digital Temperature-Sensor Output**
- **16-Pin SO with Integrated Crystal**

Part	User RAM (bytes)	Operating Temp Range (°C)	Features
DS1318	—	-40 to +85	Battery input, periodic alarm, interrupt output, square-wave output, elapsed-time counter
DS1338	SRAM, 56		Battery input, square-wave output
DS1339	—		Battery input, trickle charger, TOD alarm, interrupt output, square-wave output, oscillator stop flag
DS1340	—		Battery input, clock calibration, frequency-test output
DS1374	—		Battery input, trickle charger, watchdog timer, TOD alarm, interrupt output, square-wave output, reset input/output, oscillator stop flag
DS1390	—		Battery input, trickle charger, TOD alarm, square-wave output
DS1391	—		Battery input, trickle charger, TOD alarm, reset input/output
DS3231	—	0 to +70, -40 to +85	Battery input, TOD alarm, square-wave output, reset input/output
DS3232	SRAM, 236	0 to +70, -40 to +85	
DS32C35*	FRAM, 8k	-40 to +85	

For a Live Demo of the Industry's Most Accurate RTC, Visit: www.maxim-ic.com/rtc-demo

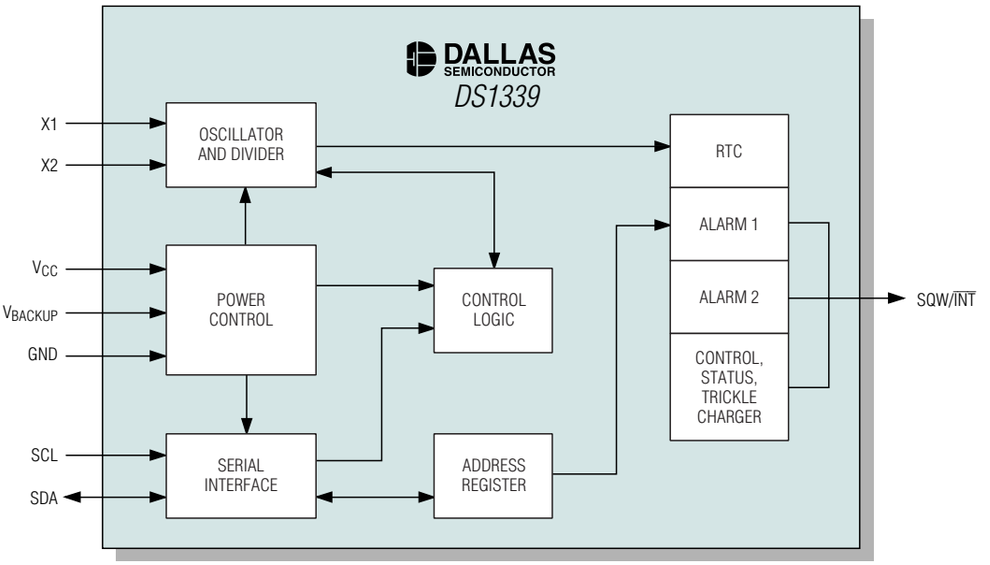
*Future product—contact factory for availability.

Office Automation

A variety of processors and chipsets are used in office equipment designs, and designers typically want to reduce the number of peripheral ICs. Our integrated solutions offer features that help reduce system chip count, including a trickle charger to maintain a backup capacitor, scratch-pad memory for system configuration, and a watchdog timer. A variety of interfaces are available to meet system needs.

I²C Serial RTC Provides System Flexibility with Multiple Programmable Features

Available in 8-Pin µSOP or 16-Pin SO with Crystal



- I²C Serial-Control Interface
- Two Time-of-Day Alarms
- Programmable Square-Wave Output
- Oscillator Stop Flag
- Automatic Power-Fail Detect and Switch Circuitry
- Trickle-Charge Capability
- UL Recognized Component

Part	Bus Type	V_{CC} (V)	Features
DS1339	I²C/400k	2.0/3.0/3.3	Trickle charger, TOD alarm, interrupt output, square-wave output, oscillator stop flag
DS1340		1.8/3.0/3.3	Battery input
DS1374		1.8/3.0/3.3	Trickle charger, watchdog timer, TOD alarm, interrupt output, square-wave output, reset input/output, oscillator stop flag
DS1388		3.0/3.3/5.0	Trickle charger, watchdog timer, reset input/output
DS1390	SPI/1M to 4M	1.8/3.0/3.3/5.0	Trickle charger, TOD alarm, square-wave output
DS1391	SPI/1M to 4M		Trickle charger, TOD alarm, reset input/output
DS1392	3-wire		Trickle charger, TOD alarm, interrupt output, square-wave output
DS1393	3-wire		Trickle charger, TOD alarm, square-wave output, reset input/output
DS1501	Parallel	3.3/5.0	Watchdog timer, TOD alarm, periodic alarm, interrupt output, square-wave output, reset output, wake-up, kick-start input
DS1553	Parallel	3.3/5.0	Watchdog timer, TOD alarm, interrupt output, reset output

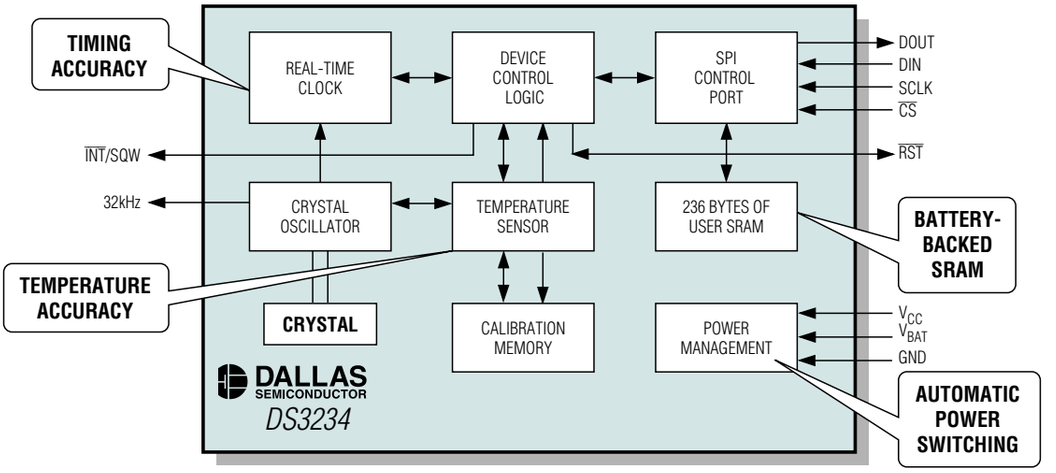
Automotive

As the electronics in automobiles become more complex and varied, the need for time-stamping events and local data storage is growing rapidly. Dallas Semiconductor offers a variety of data-storage mediums for various local data-storage functions. Our accurate RTCs can be used as a central time-base reference by automotive processors.

Extremely Accurate RTC Supports µPs Using SPI-Compatible Interface

±1Min/Year Accuracy at 0°C to +40°C

The DS3234 provides accuracies of better than ±1.8min/year (< ±3.5ppm) over the -40°C to +85°C industrial temperature range and ±1min/year (< ±2.0ppm) over the 0°C to +40°C temperature range. The DS3234 supports embedded system applications that control and communicate with peripheral devices through an SPI-compatible interface, which also provides access to time, temperature, and memory.



- **SPI Interface Enables Compatibility with Motorola Processors**
- **Integrated Crystal Eliminates User Calibration**
- **Automatic Power-Fail Detect and Switch Circuitry**
- **300-mil, 20-Pin SO Package**

Part	V_{CC} (V)	Clock Format/ Resolution (s)	User RAM (bytes)	V_{OSC} (min)/ I_{CCT}	Operating Temp Range (°C)	Features	Package	Price† ($)
DS1337	1.8 to 4.0	BCD/1	—	1.3/600nA	-40 to +85	TOD alarm, square-wave output	8-SO/µSOP, 16-SO with crystal	0.88
DS1338	3.3		SRAM, 56	1.3/500nA	-40 to +85	Battery input, square-wave output		1.12
DS3231			—	—	0 to +70, -40 to +85	Battery input, square-wave output, reset input/output	16-SO with crystal	2.25
DS3232			SRAM, 236	—	0 to +70, -40 to +85			2.35
DS3234			SRAM, 256	—	0 to +70, -40 to +85		20-SO with crystal	2.40
DS32B35*			FRAM, 2k	—	-40 to +85			3.42
DS32C35*			FRAM, 8k	—	-40 to +85			3.75

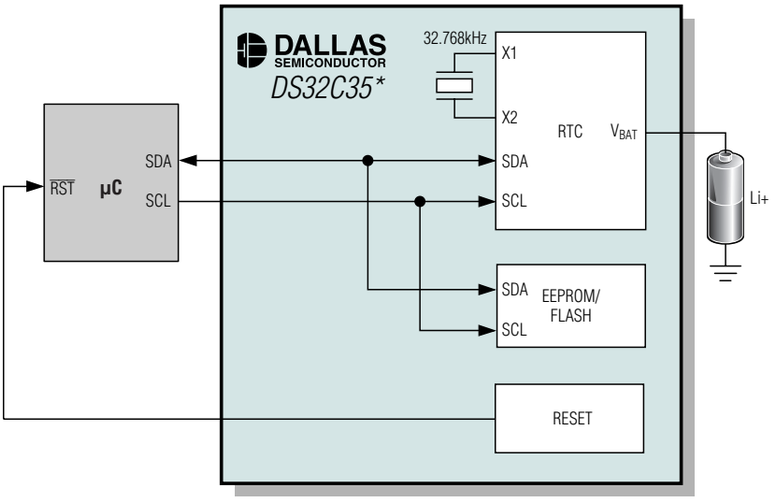
*Future product—contact factory for availability.
†1000-up recommended resale. Prices provided are for design guidance and are FOB USA. International prices will differ due to local duties, taxes, and exchange rates. Not all packages are offered in 1k increments, and some may require minimum order quantities.

Test and Measurement

System-configuration data for test and measurement equipment needs to be stored in nonvolatile memory. This need is heightened by the push to smaller system sizes, which limit the space available for backup batteries. Our RTCs are available: with onboard SRAM, EEPROM, or FRAM; with control of external SRAM; or in module packages with battery and SRAM.

Reduce PCB Requirements by 80% Compared to Battery-Backed SRAM

Memory with SRAM Speed and No Write-Cycle Limits



Part	Bus Type	V_{CC} (V)	Clock Format/ Resolution (s)	User RAM (bytes)	Features
DS1315	Phantom	3.3/5.0	Y2K/(1/100)	—	Battery input, external RAM control
DS1318	Parallel	3.3	Binary/244µ	—	Battery input, periodic alarm, interrupt output, square-wave output, elapsed-time counter
DS1338	I^2C/400k	3.3	BCD/1	SRAM, 56	Battery input, square-wave output
DS1500	Parallel	5.0	Y2K/1	SRAM, 256	Battery input, watchdog timer, TOD alarm, periodic alarm, interrupt output, square-wave output, reset output, external RAM control, wake-up, kick-start input
DS1682	I^2C/400k	2.5/5.5	Binary/1	EEPROM, 10	TOD alarm, interrupt output
DS1743	Parallel	3.3/5.0	Y2K/1	SRAM, 8k	Reset output, battery-voltage-level indicator flag, power-fail write protection
DS1744				SRAM, 32k	
DS1746				SRAM, 128k	
DS1747				SRAM, 512k	
DS32C35	I^2C/400k	3.3	BCD/1	FRAM, 8k	Battery input, TOD alarm, square-wave output, reset input/output

*Future product—contact factory for availability.