



# DS1501/DS1511

## Y2KC Watchdog Real Time Clock

### FEATURES

- BCD coded century, year, month, date, day, hours, minutes, and seconds with automatic leap year compensation valid up to the year 2100
- Programmable Watchdog Timer and RTC Alarm
- Century register; Y2K Compliant RTC
- +3.3 or +5 volt operation
- Precision Power-On Reset
- Power control circuitry supports system power on from date/day/time alarm or key closure/modem detect signal
- 256 bytes user NV SRAM
- Burst Mode for reading/writing successive addresses in NV SRAM
- Auxiliary battery input
- Accuracy of DS1511 is better than  $\pm 1$  min./month @ 25°C
- Day of week/Date alarm register
- Crystal select bit allows RTC to operate with 6 pF or 12.5 pF crystal
- Battery voltage level indicator flags
- Available as chip (DS1501) or standalone module with embedded battery and crystal (DS1511)

### ORDERING INFORMATION

PART #	DESCRIPTION
DS1501Y	5 Volt, 28-pin DIP
DS1501YE	5 Volt, 28-pin TSOP
DS1501YS	5 Volt, 28-pin SOIC
DS1511Y	5 Volt, 28-pin DIP Module
DS1501W	3.3 Volt, 28-pin DIP
DS1501WE	3.3 Volt, 28-pin TSOP
DS1501WS	3.3 Volt, 28-pin SOIC
DS1511W	3.3 Volt, 28-pin DIP Module

### DESCRIPTION

The DS1501/DS1511 is a full function, year 2000 compliant (Y2KC), real-time clock/calendar (RTC) with a RTC alarm, watchdog timer, power-on reset, battery

### PIN ASSIGNMENT

PWR	1	28	V <sub>CC</sub>
X1	2	27	WE
X2	3	26	V <sub>BAUX</sub>
RST	4	25	V <sub>BAT</sub>
IRQ	5	24	KS
A4	6	23	SQW
A3	7	22	OE
A2	8	21	GND
A1	9	20	CE
A0	10	19	DQ7
DQ0	11	18	DQ6
DQ1	12	17	DQ5
DQ2	13	16	DQ4
GND	14	15	DQ3

28-PIN DIP, 28-PIN SOIC

PWR	1	28	V <sub>CC</sub>
X1	2	27	WE
X2	3	26	V <sub>BAUX</sub>
RST	4	25	NC
IRQ	5	24	KS
A4	6	23	SQW
A3	7	22	OE
A2	8	21	NC
A1	9	20	CE
A0	10	19	DQ7
DQ0	11	18	DQ6
DQ1	12	17	DQ5
DQ2	13	16	DQ4
GND	14	15	DQ3

28-PIN ENCAPSULATED PACKAGE (720 MIL FLUSH)

PWR	1	28	V <sub>CC</sub>
X1	2	27	WE
X2	3	26	V <sub>BAUX</sub>
RST	4	25	V <sub>BAT</sub>
IRQ	5	24	KS
A4	6	23	SQW
A3	7	22	OE
A2	8	21	GND
A1	9	20	CE
A0	10	19	DQ7
DQ0	11	18	DQ6
DQ1	12	17	DQ5
DQ2	13	16	DQ4
GND	14	15	DQ3

28-PIN TSOP

monitors, and 256 bytes non-volatile static RAM in a monolithic chip. User access to all registers within the DS1501 is accomplished with a bytewide interface as

shown in Figure 1. The RTC registers contain century, year, month, date, day, hours, minutes, and seconds data in 24-hour BCD format. Corrections for day of month and leap year are made automatically.

## SIGNAL DESCRIPTION

V <sub>CC</sub>	— Supply Voltage
A0–A4	— Address Inputs
DQ0–DQ8	— Data I/O
CE	— Chip Enable Input
OE	— Output Enable Input
WE	— Write Enable Input
IRQ	— Interrupt Output (open drain)
PWR	— Power-On Output (open drain)
RST	— Reset Output (open drain)
KS	— Kickstart Input
SQW	— Square wave output
V <sub>BAT</sub>	— Backup Battery Supply
V <sub>B_AUX</sub>	— Auxiliary battery supply
X1	— Oscillator Input
X2	— Oscillator Output
GND	— Ground
NC	— No Connection

The RTC registers are double buffered into an internal and external set. The user has direct access to the external set. Clock/calendar updates to the external set of registers can be disabled and enabled to allow the user to access static data. Assuming the internal oscillator is turned on, the internal set of registers are continuously updated; this occurs regardless of external registers settings to guarantee that accurate RTC information is always maintained.

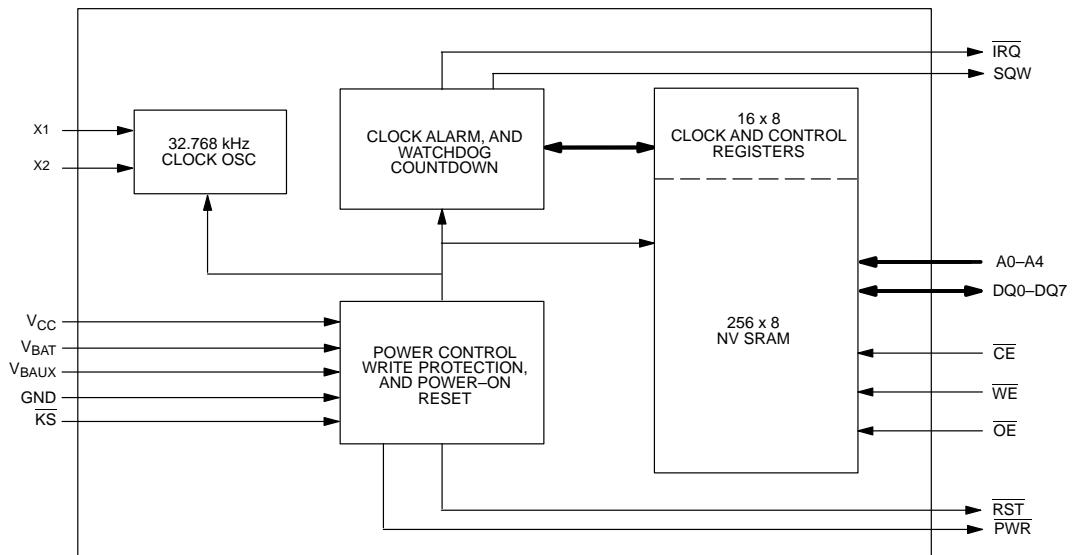
The DS1501/DS1511 contains its own power fail circuitry which automatically deselects the device when

the V<sub>CC</sub> supply enters an out of tolerance condition. This feature provides a high degree of data security during unpredictable system operation brought on by low V<sub>CC</sub> levels.

The DS1501/DS1511 has interrupt (IRQ), wakeup (PWR), and reset (RST) outputs which can be used to control CPU activity. The IRQ interrupt output can be used to generate an external interrupt under several conditions. A Wakeup interrupt will be generated when the RTC register values match user programmed alarm values and Time of day/date Power Enable bit (TPE) (Bit 4), in register 0Fh is set to a logic 1. A Kickstart interrupt will be generated when a high to low transition occurs on the Kickstart (KS) pin while the Kickstart Interrupt Enable bit (KIE) (Bit 2), in register 0Fh is set to a logic 1. The interrupt is always available while the device is powered from the system supply. The PWR output can be programmed to occur when in the battery backed state to serve as a system wake-up. The PWR pin is under software control, so that when a task is complete, the system power can then be shut down. Either the IRQ or RST outputs can also be used as a CPU watchdog timer, CPU activity is monitored and an interrupt or reset output will be activated if the correct activity is not detected within programmed limits. The DS1501/DS1511 power-on reset can be used to detect a system power down or failure and hold the CPU in a safe reset state until normal power returns and stabilizes; the RST output is used for this function.

The DS1501/DS1511 also incorporates a 32.768 kHz output for sustaining power management activities.

DS1501/DS1511 BLOCK DIAGRAM Figure 1



DS1501/DS1511 OPERATING MODES Table 1

$V_{CC}$	$\overline{CE}$	$\overline{OE}$	$\overline{WE}$	DQ0-DQ7	A0-A4	MODE	POWER
IN TOLERANCE	$V_{IH}$	X	$V_{IL}$	HIGH-Z	X	DESELECT	STANDBY
	$V_{IL}$	X	$V_{IL}$	$D_{IN}$	$A_{IN}$	WRITE	ACTIVE
	$V_{IL}$	$V_{IL}$	$V_{IH}$	$D_{OUT}$	$A_{IN}$	READ	ACTIVE
	$V_{IL}$	$V_{IH}$	$V_{IH}$	HIGH-Z	$A_{IN}$	READ	ACTIVE
$V_{BAT} < V_{CC} < \text{TOLERANCE}$	X	X	X	HIGH-Z	X	DESELECT	CMOS STANDBY
$V_{CC} < V_{BAT}$	X	X	X	HIGH-Z	X	DATA RETENTION	BATTERY CURRENT

### DATA READ MODE

The DS1501/DS1511 is in the read mode whenever  $\overline{CE}$  (chip enable) is low and  $\overline{WE}$  (write enable) is high. The device architecture allows ripple through access to any valid address location. Valid data will be available at the DQ pins within  $t_{AA}$  (address access) after the last address input is stable, providing that  $\overline{CE}$  and  $\overline{OE}$  access times are satisfied. If  $CE$  or  $OE$  access times are not met, valid data will be available at the latter of chip enable access ( $t_{CEA}$ ) or at output enable access time ( $t_{OEA}$ ). The state of the data input/output pins (DQ) is controlled by  $\overline{CE}$  and  $\overline{OE}$ . If the outputs are activated before  $t_{AA}$ , the data lines are driven to an intermediate state until  $t_{AA}$ . If the address inputs are changed while  $\overline{CE}$  and  $\overline{OE}$  remain valid, output data will remain valid for

output data hold time ( $t_{OH}$ ) but will then go indeterminate until the next address access. (See Table 1.)

### DATA WRITE MODE

The DS1501/DS1511 is in the write mode whenever  $\overline{WE}$  and  $\overline{CE}$  are in their active state. The start of a write is referenced to the latter occurring transition of  $\overline{WE}$  or  $\overline{CE}$ . The addresses must be held valid throughout the cycle.  $\overline{CE}$  and  $\overline{WE}$  must return inactive for a minimum of  $t_{WR}$  prior to the initiation of a subsequent read or write cycle. Data in must be valid  $t_{DS}$  (data setup) prior to the end of the write and remain valid for  $t_{DH}$  (data hold) afterward. In a typical application, the  $\overline{OE}$  signal will be high during a write cycle. However,  $\overline{OE}$  can be active provided that

care is taken with the data bus to avoid bus contention. If  $\overline{OE}$  is low prior to a high to low transition on  $\overline{WE}$ , the data bus can become active with read data defined by the address inputs. A low transition on  $\overline{WE}$  will then disable the outputs  $t_{WEZ}$  ( $\overline{WE}$  data off time) after  $\overline{WE}$  goes active. (See Table 1.)

## DATA RETENTION MODE

The 5-volt device is fully accessible and data can be written and read only when  $V_{CC}$  is greater than  $V_{PF}$ . However, when  $V_{CC}$  falls below the power fail point  $V_{PF}$  (point at which write protection occurs) the internal clock registers and SRAM are blocked from any access. While in the data retention mode, all inputs are dont cares and outputs go to a high-Z state. When  $V_{CC}$  falls below the greater of  $V_{BAT}$  and  $V_{BAUX}$ , device power is switched from the  $V_{CC}$  pin to either the  $V_{BAT}$  or  $V_{BAUX}$  pin. RTC operation and SRAM data are maintained from the battery until  $V_{CC}$  is returned to nominal levels.

The 3.3-volt device is fully accessible and data can be written and read only when  $V_{CC}$  is greater than  $V_{PF}$ . However, when  $V_{CC}$  falls below  $V_{PF}$ , access to the device is inhibited. If  $V_{PF}$  is less than  $V_{BAT}$  and  $V_{BAUX}$ , the device power is switched from  $V_{CC}$  to the greater of  $V_{BAT}$  and  $V_{BAUX}$  when  $V_{CC}$  drops below  $V_{PF}$ . If  $V_{PF}$  is greater than  $V_{BAT}$  and  $V_{BAUX}$ , the device power is switched from  $V_{CC}$  to the larger of  $V_{BAT}$  and  $V_{BAUX}$  when  $V_{CC}$  drops below the larger of  $V_{BAT}$  and  $V_{BAUX}$ . RTC operation and SRAM data are maintained from the battery until  $V_{CC}$  is returned to nominal levels. (See Table 1.)

All control, data, and address signals must be powered down when  $V_{CC}$  is absent.

## AUXILIARY BATTERY

The  $V_{BAUX}$  input is provided to supply power from an auxiliary battery for the DS1501/DS1511 kickstart and SQW output features in the absence of  $V_{CC}$ . This power source must be available in order to use these auxiliary features when  $V_{CC}$  is not applied to the device.

This auxiliary battery may be used as the primary backup power source for maintaining the clock/calender and extended user RAM. This occurs if the  $V_{BAT}$  pin is at a lower voltage than  $V_{BAUX}$ . If the DS1501/DS1511 is to be backed-up using a single battery with the auxiliary features enabled, then  $V_{BAUX}$  should be used and  $V_{BAT}$  should be grounded. If  $V_{BAUX}$  is not to be used, it should be grounded.

## POWER ON RESET

A temperature compensated comparator circuit monitors the level of  $V_{CC}$ . When  $V_{CC}$  falls to the write protection voltage, the RST signal (open drain) is pulled low. When  $V_{CC}$  returns to nominal levels, the RST signal continues to be pulled low for a period of 40 ms to 200 ms. The power on reset function is independent of the RTC oscillator and thus is operational whether or not the oscillator is enabled.

DS1501/DS1511 REGISTER MAP Table 2

Address	DATA								FUNCTION	BCD			
	B7	B6	B5	B4	B3	B2	B1	B0					
00H	0	10 SECONDS				SECONDS			SECONDS	00-59			
01H	0	10 MINUTES				MINUTES			MINUTES	00-59			
02H	0	0	10 HOURS			HOUR			HOURS	00-23			
03H	0	0	0	0	0	DAY			DAY	1-7			
04H	0	0	10 DATE			DATE			DATE	00-31			
05H	EOSC	E32K	BB32	10 MO	MONTH				MONTH	01-12			
06H	10 YEAR				YEAR			YEAR	YEAR	00-99			
07H	0	0	10 CENTURY			CENTURY			CENTURY	00-39			
08H	AM1	10 SECONDS				SECONDS			ALARM SECONDS	00-59			
09H	AM2	10 MINUTES				MINUTES			ALARM MINUTES	00-59			
0AH	AM3	0	10 HOURS			HOUR			ALARM HOURS	00-23			
0BH	AM4	DY/DT	10 DAY/DATE			DAY/DATE			ALARM DAY/DATE	1-7/01-31			
0CH	0.1 SECOND				0.01 SECOND				WATCHDOG	00-99			
0DH	10 SECOND				SECOND				WATCHDOG	00-99			
0EH	VRT1	VRT2	PRS	PAB	TDF	KSF	WDF	IRQF	CONTROL A				
0FH	TE	CS	BME	TPE	TIE	KIE	WDE	WDS	CONTROL B				
10H	EXTENDED RAM ADDRESS								RAM ADDR LSB	00-FF			
11H	RESERVED												
12H	RESERVED												
13H	EXTENDED RAM DATA								RAM DATA	00-FF			
14H	RESERVED												
15H	RESERVED												
16H	RESERVED												
17H	RESERVED												
18H	RESERVED												
19H	RESERVED												
1AH	RESERVED												
1BH	RESERVED												
1CH	RESERVED												
1DH	RESERVED												
1EH	RESERVED												
1FH	RESERVED												

**TABLE 2 LEGEND (DS1501/DS1511 REGISTER MAP):**

0="0" and are read only	AM1–AM4=Alarm Mask bits
PRS=PAB Reset Select bit	WDF=Watchdog Flag
BME=Burst Mode Enable bit	KIE=Kickstart Interrupt Enable bit
EOSC=Oscillator start/stop bit	DY/DT=Day/Date bit
PAB=Power Active Bar control bit	IRQF=Interrupt Request Flag
TPE=Time of day/date alarm Power Enable bit	WDE=Watchdog Enable bit
E32K=Enable 32.768 KHz output bit	VRT1=Valid RAM and Time bit
TDF=Time of Day/Date alarm Flag	TE=Transfer Enable bit
TIE=Time of Day/Date alarm Interrupt Enable bit	WDS=Watchdog Steering bit
BB32=Battery Backup 32 kHz enable bit	VRT2=Auxiliary battery low bit
KSF=Kickstart Flag	CS=Crystal Select bit

**NOTE:** Unless otherwise specified, the state of the control/RTC/SRAM bits in the DS1501/DS1511 is not defined upon initial power application; the DS1501/DS1511 should be properly configured/defined during initial configuration.

**CLOCK OSCILLATOR CONTROL**

The Clock oscillator may be stopped at any time. To increase the shelf life of a backup lithium battery source, the oscillator can be turned off to minimize current drain from the battery. The EOSC bit is the MSB of the month register (B7 of 05h). Setting it to a "1" stops the oscillator, setting to a "0" starts the oscillator.

**READING THE CLOCK**

When reading the RTC data, it is recommended to halt updates to the external set of double buffered RTC registers. This puts the external registers into a static state allowing data to be read without register values changing during the read process. Normal updates to the internal registers continue while in this state. External updates are halted when a "0" is written into the read (TE) bit, B7, of Control register B (0Fh). As long as a "0" remains in the Control register B (TE) bit, updating is halted. After a halt is issued, the registers reflect the RTC count (day, date, and time) that was current at the moment the halt command was issued. Normal updates to the external set of registers will resume within 1 second after the (TE) bit is set to a "1".

**SETTING THE CLOCK**

It is also recommended to halt updates to the external set of double buffered RTC registers when writing to the clock. The (TE) bit should be used as described above before loading the RTC registers with the desired RTC count (day, date, and time) in 24-hour BCD format. Setting the (TE) bit to a "1" then transfers the values written to the internal RTC registers and allows normal operation to resume.

**CLOCK ACCURACY**

A standard 32.768 kHz quartz crystal should be directly connected to the DS1501 X1 and X2 oscillator pins. The crystal selected for use should have a specified load capacitance (CL) of either 6 pF or 12.5 pF depending on crystal capacitance setting selected with the Crystal Select (CS) bit. For more information on crystal selection and crystal layout considerations, please consult Application Note 58, "Crystal Considerations with Dallas Real Time Clocks". The DS1501 can also be driven by an external 32.768 kHz oscillator. In this configuration, the X1 pin is connected to the external oscillator signal and the X2 pin is floated. Accuracy of DS1511 is better than  $\pm 1$  min./month @ 25°C.

**USING THE CLOCK ALARM**

The alarm settings and control for the DS1501/DS1511 reside within registers 08h – 0Bh. Bit 7 of registers 08h to 0Bh contains an alarm mask bit: AM1 thru AM4. The TIE (Time of Day/Date alarm Interrupt Enable bit, B3 of 0Fh) and alarm mask bits AM1–AM4 must be set as described below for the  $\overline{\text{IRQ}}$  output to be activated for a matched alarm condition.

The alarm can be programmed to activate on a specific day of the month, day of the week, or repeat every day, hour, minute, or second. It can also be programmed to go off while the DS1501/DS1511 is in the battery backed state of operation to serve as a system wake-up. Alarm mask bits AM1–AM4 control the alarm mode. Table 3 shows the possible settings. Configurations not listed in the table default to the once per second mode to notify the user of an incorrect alarm setting. When the RTC

register values match alarm register settings, the Time of Day/Date alarm Flag 'TDF' bit is set to logic 1. If TIE is also set to logic 1, the alarm condition activates the  $\overline{\text{IRQ}}$ .

NOTE: Please refer to Table 2 as required for the following functional descriptions.

**ALARM MASK BITS** Table 3

DY/DT	AM4	AM3	AM2	AM1	ALARM RATE
X	1	1	1	1	ONCE PER SECOND
X	1	1	1	0	WHEN SECONDS MATCH
X	1	1	0	0	WHEN MINUTES AND SECONDS MATCH
X	1	0	0	0	WHEN HOURS, MINUTES, AND SECONDS MATCH
0	0	0	0	0	WHEN DATE, HOURS, MINUTES, AND SECONDS MATCH
1	0	0	0	0	WHEN DAY, HOURS, MINUTES, AND SECONDS MATCH

### USING THE WATCHDOG TIMER

The watchdog timer can be used to detect an out-of-control processor. The user programs the watchdog timer by setting the desired amount of time-out into the two BCD Watchdog Registers (Address 0Ch and 0Dh). (For example: writing 06h in the watchdog register 0Ch and 00h to watchdog register 0Dh will set the watchdog time-out to 60 milli-seconds). If the processor does not access the timer, with a read or write, within the specified period, the Watchdog Flag 'WDF' is set and a processor interrupt is generated at the  $\overline{\text{IRQ}}$  pin or the  $\overline{\text{RST}}$  pin depending on the status of the Watchdog Steering bit.

Bit 0 of register 0Fh is the Watchdog Steering Bit 'WDS'. When set to a 0, the watchdog will activate the  $\overline{\text{IRQ}}$  output when the watchdog times out. The WDF bit will be set to a logic 1 to serve as an indication to the processor that a watchdog reset has occurred.

When WDS is set to a 1, the watchdog will output a logic low (0) pulse on the  $\overline{\text{RST}}$  output for a duration of 40 ms to

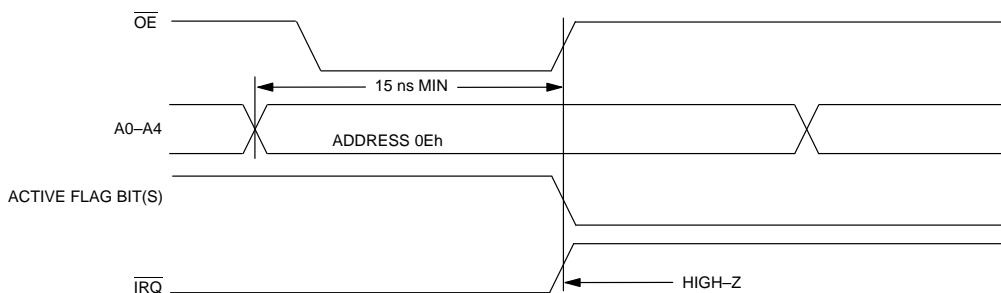
200 ms. The Watchdog time-out will be restarted and WDE (the Watchdog Enable) bit will reset to a logic 0 at the beginning of a watchdog time-out when the WDS bit is set to a logic 1. The WDF bit will remain set to a logic 1 to serve as an indication to the processor that a watchdog reset has occurred.

The watchdog timer resets when the processor performs a read or write of the Watchdog register. The time-out period then starts over. The watchdog timer is disabled by writing a value of 00h to both watchdog registers. The watchdog functions are automatically disabled upon power-up.

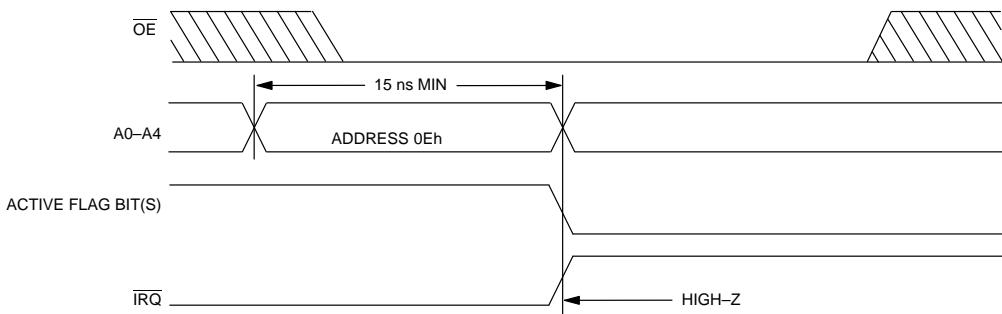
### CLEARING IRQ AND FLAGS

The alarm flag(s), watchdog flag, and the  $\overline{\text{IRQ}}$  output are cleared by reading the Flags register (0Eh, bits 0-3) or writing "0" to the corresponding Flag as shown in Figures 2a and 2b.

**IRQ AND FLAG WAVEFORMS** Figure 2a



## IRQ AND FLAG WAVEFORMS Figure 2b



## WAKE UP/KICKSTART

The DS1501/DS1511 incorporates a wake up feature which can power on at a pre-determined date through activation of the  $\overline{\text{PWR}}$  output pin. In addition, the kickstart feature can allow the system to be powered up in response to a low going transition on the  $\overline{\text{KS}}$  pin, without operating voltage applied to the  $\text{V}_{\text{CC}}$  pin. As a result, system power may be applied upon such events as key closure, or modem ring detect signal. In order to use either the wake up or the kickstart features, the DS1501/DS1511 must have a battery connected to the  $\text{V}_{\text{BAUX}}$  pin and the oscillator must be running.

The wake up feature is controlled through the Time of Day/Date Alarm Power Enable bit 'TPE' in Control B register (B4 of 0Fh). Setting TPE to "1" enables the wake up feature, clearing TPE to "0" disables it. Similarly, the kickstart feature is controlled through the Kickstart Interrupt Enable bit 'KIE' in Control B register (B2 of 0Fh).

A wake up sequence will occur as follows: When wake up is enabled via TPE = "1" while the system is powered down (no  $\text{V}_{\text{CC}}$  voltage), the clock/calendar will monitor the current day or date for a match condition with Day/Date Alarm register (0Bh). In conjunction with the Day/Date Alarm register, the hours, minutes, and seconds alarm bytes in the clock calendar register map (02h, 01h, and 00h) are also monitored. As a result, a wake up will occur at the day or date and time specified by the day/date, hours, minutes, and seconds alarm register values. This additional alarm will occur regardless of the programming of the TIE bit (Time of Day/Date alarm Interrupt Enable bit) (B3 of 0Fh). When the match condition occurs, the  $\overline{\text{PWR}}$  pin will automatically be driven low. This output can be used to turn on the main system power supply which provides  $\text{V}_{\text{CC}}$  voltage to the

DS1501/DS1511 as well as the other major components in the system. Also, at this time, the Time of Day/Date alarm Flag will be set, indicating that a wake up condition has occurred.

While the system is powered down, the  $\overline{\text{KS}}$  input pin will be monitored for a low going transition of minimum pulse width  $t_{\text{KSPW}}$ . When such a transition is detected, the  $\overline{\text{PWR}}$  line will be pulled low, as it is for a wake up condition. Also at this time, the Kickstart Flag (KSF, register 0Eh) will be set, indicating that a kickstart condition has occurred.

The timing associated with both the wake up and kick-starting sequences is illustrated in the Wake Up/Kickstart Timing Diagram, Figure 8, in the Electrical Specifications section of this datasheet. The timing associated with these functions is divided into 5 intervals, labeled 1–5 on the diagram.

The occurrence of either a kickstart or wake up condition will cause the  $\overline{\text{PWR}}$  pin to be driven low, as described above. During interval 1, if the supply voltage on the DS1501/DS1511  $\text{V}_{\text{CC}}$  pin rises above the battery switch voltage ( $\text{V}_{\text{SW}}$ ) before the power on timeout period ( $t_{\text{POTO}}$ ) expires, then  $\overline{\text{PWR}}$  will remain at the active low level. If  $\text{V}_{\text{CC}}$  does not rise above the battery switch voltage ( $\text{V}_{\text{SW}}$ ) in time, then the  $\overline{\text{PWR}}$  output pin will be turned off and will return to its high impedance level. In this event, the  $\overline{\text{IRQ}}$  pin will also remain tri-stated. The interrupt flag bit (either TDF or KSF) associated with the attempted power on sequence will remain set until cleared by software during a subsequent power on.

If  $V_{CC}$  is applied within the time-out period, then the system power on sequence will continue as shown in intervals 2–5 in the timing diagram. During interval 2,  $\overline{PWR}$  will remain active and  $\overline{IRQ}$  will be driven to its active low level, indicating that either TDF or KSF was set in initiating the power on. In the diagram  $\overline{KS}$  is assumed to be pulled up to the  $V_{BAUX}$  supply (logic high). Also at this time, the PAB bit will be automatically cleared to “0” in response to a successful power on. The  $\overline{PWR}$  line will remain active as long as the PAB remains cleared to “0”.

At the beginning of interval 3, the system processor has begun code execution and clears the interrupt condition of TDF and/or KSF by writing zeroes to both of these control bits. As long as no other interrupt within the DS1501 is pending, the  $\overline{IRQ}$  line will be taken inactive once these bits are reset, and execution of the application software may proceed. During this time, both the wakeup and kickstart functions may be used to generate status and interrupts. TDF will be set in response to a day/date, hours, minutes, and seconds match condition. KSF will be set in response to a low going transition on  $\overline{KS}$ . If the associated interrupt enable bit is set (TDE and/or KIE) then the  $\overline{IRQ}$  line will be driven low in response to enabled event. In addition, the other possible interrupt sources within the DS1501/DS1511 may cause  $\overline{IRQ}$  to be driven low. While system power is applied, the on chip logic will always attempt to drive the  $\overline{PWR}$  pin active in response to the enabled kickstart or wake up condition. This is true even if  $\overline{PWR}$  was previously inactive as the result of power being applied by some means other than wake up or kickstart.

The system may be powered down under software control by setting the PAB bit to a “1”. This causes the open-drain  $\overline{PWR}$  pin to be placed in a high impedance state, as shown at the beginning of interval 4 in the timing diagram. As  $V_{CC}$  voltage decays, the  $\overline{IRQ}$  output pin will be placed in a high impedance state when  $V_{CC}$  goes below  $V_{PF}$ . If the system is to be again powered on in response to a wake up or kickstart, then both the TDF and KSF flags should be cleared and TPE and/or KIE should be enabled prior to setting the PAB bit.

During interval 5, the system is fully powered down. Battery backup of the clock calendar and nonvolatile RAM is in effect and  $\overline{IRQ}$  is tri-stated, and monitoring of wake up and kickstart takes place. If PRS=“1”,  $\overline{PWR}$  stays active, otherwise if PRS=“0”,  $\overline{PWR}$  is tri-stated.

## SQUARE WAVE OUTPUT

The square wave output is enabled and disabled via the ‘E32K’ bit in the month register (B6 of 05h). If the square wave is enabled ( $\overline{E32K} = '1'$ ) and the oscillator is enabled, then a 32.768 kHz square wave will be output on the SQW pin. If  $\overline{E32K} = '1'$  and the Battery Backup 32 kHz enable bit ‘BB32’ is enabled (B5 of 05h) and voltage is applied to  $V_{BAUX}$ , then the 32 kHz square wave signal will be output on the SQW pin in the absence of  $V_{CC}$ .

## BATTERY MONITOR

Upon power-up, the DS1501/DS1511 checks the battery voltage of the back-up battery sources ( $V_{BAT}$  and  $V_{BAUX}$ ). The Battery Low Flag ‘VRT1’ and ‘VRT2’ bits of control A register (B7 and B6 of 0Eh) will be set to a logic 1 at power-up if the battery voltage on  $V_{BAT}$  and  $V_{BAUX}$  are less than 2.5V (typical), otherwise VRT1 and VRT2 bits will be logic 0. VRT1 monitors  $V_{BAT}$  with VRT2 monitoring  $V_{BAUX}$ .

## POWER-UP DEFAULT STATES

These bits are set upon power-up:  $\overline{EOSC}=1$ ,  $\overline{E32K}=0$ ,  $TIE=0$ ,  $KIE=0$ ,  $WDE=0$ , and  $WDS=0$ .

## 256 X 8 EXTENDED RAM

The DS1501/DS1511 provides 256 x 8 of on-chip SRAM which is controlled as nonvolatile data storage sustained from a lithium battery. On power-up, the RAM is taken out of write protect status by an internal signal.

Access to the SRAM is controlled by two on-chip latch registers. One register is used to hold the SRAM address, and the other is used to hold read/write data. The SRAM address space is from 00h to FFh. The 8-bit address of the RAM location to be accessed must be loaded into the extended RAM address register located at 10h. Data in the addressed location may be read by performing a read operation from location 13h, or written to by performing a write operation to location 13h.

When the Burst Mode Enable bit (B5 of control B register 0Fh) is enabled (BME = ‘1’), the address pointer in the extended RAM will automatically increment following each read/write operation. In this mode, the RAM can be consecutively read or written without changing the address in location 10h.

With burst mode disabled (BME = ‘0’), data in any addressed location may be read or written repeatedly without changing the address in location 10h.

**ABSOLUTE MAXIMUM RATINGS\***

Voltage on Any Pin Relative to Ground	–0.5V to +6.0V
Operating Temperature	0°C to 70°C
Storage Temperature	–55°C to +125°C
Soldering Temperature	260°C for 10 seconds (See Note 8)

\* This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operation sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods of time may affect reliability.

**RECOMMENDED DC OPERATING CONDITIONS**

(0°C to 70°C)

PARAMETER	SYMBOL	MIN	TYP	MAX	UNITS	NOTES
Logic 1 Voltage All Inputs $V_{CC} = 5V \pm 10\%$ $V_{CC} = 3.3V \pm 10\%$	$V_{IH}$	2.2		$V_{CC} + 0.3$	V	1
	$V_{IH}$	2.0		$V_{CC} + 0.3$	V	1
Logic 0 Voltage All Inputs $V_{CC} = 5V \pm 10\%$ $V_{CC} = 3.3V \pm 10\%$	$V_{IL}$	–0.3		0.8	V	1
	$V_{IL}$	–0.3		0.6	V	1
Battery Voltage	$V_{BAT}$	2.5		3.7	V	1
Auxiliary Battery Voltage	$V_{BAUX}$	2.5		3.7	V	1

**DC ELECTRICAL CHARACTERISTICS**(0°C to 70°C;  $V_{CC} = 5.0V \pm 10\%$ )

PARAMETER	SYMBOL	MIN	TYP	MAX	UNITS	NOTES
Active Supply Current	$I_{CC}$		X	15	mA	2
TTL Standby Current ( $\bar{CE} = V_{IH}$ )	$I_{CC1}$		X	3	mA	2
CMOS Standby Current ( $\bar{CE} \geq V_{CC} - 0.2V$ )	$I_{CC2}$		X	3	mA	2
Battery Current, Oscillator On	$I_{BAT1}$			1.0	$\mu A$	
Battery Current, Oscillator Off	$I_{BAT2}$			0.1	$\mu A$	
Input Leakage Current (any input)	$I_{IL}$	–1		+1	$\mu A$	
Output Leakage Current (any output)	$I_{OL}$	–1		+1	$\mu A$	
Output Logic 1 Voltage ( $I_{OUT} = -1.0\text{ mA}$ )	$V_{OH}$	2.4			V	1
Output Logic 0 Voltage $I_{OUT} = 2.1\text{ mA}$ , DQ0–7 Outputs $I_{OUT} = 10.0\text{ mA}$ , $\overline{IRQ}$ , $\overline{PWR}$ , and $\overline{RST}$ Outputs	$V_{OL1}$			0.4	V	1
	$V_{OL2}$			0.4	V	1, 3
Power Fail Voltage	$V_{PF}$	4.25	4.37	4.50	V	1
Battery Switch Over Voltage	$V_{SO}$		$V_{BAT}$ , $V_{BAUX}$		V	1, 4

## DC ELECTRICAL CHARACTERISTICS

(0°C to 70°C;  $V_{CC} = 3.3V \pm 10\%$ )

PARAMETER	SYMBOL	MIN	TYP	MAX	UNITS	NOTES
Active Supply Current	$I_{CC}$		X	10	mA	2
TTL Standby Current ( $\overline{CE} = V_{IH}$ )	$I_{CC1}$		X	2	mA	2
CMOS Standby Current ( $\overline{CE} \geq V_{CC} - 0.2V$ )	$I_{CC2}$		X	2	mA	2
Battery Current, Oscillator On	$I_{BAT1}$			1.0	$\mu A$	
Battery Current, Oscillator Off	$I_{BAT2}$			0.1	$\mu A$	
Input Leakage Current (any input)	$I_{IL}$	-1		+1	$\mu A$	
Output Leakage Current (any output)	$I_{OL}$	-1		+1	$\mu A$	
Output Logic 1 Voltage ( $I_{OUT} = -1.0 \text{ mA}$ )	$V_{OH}$	2.4			V	1
Output Logic 0 Voltage $I_{OUT} = -2.1 \text{ mA}$ , DQ0–7 Outputs $I_{OUT} = 10.0 \text{ mA}$ , IRQ, PWR, and RST Outputs	$V_{OL1}$			0.4	V	1
	$V_{OL2}$			0.4	V	1, 3
Power Fail Voltage	$V_{PF}$	2.80	2.88	2.97	V	1
Battery Switch Over Voltage	$V_{SO}$		$V_{BAT}$ , $V_{BAUX}$ , or $V_{PF}$		V	1, 7

## READ CYCLE, AC CHARACTERISTICS

(0°C to 70°C;  $V_{CC} = 5.0V \pm 10\%$ )

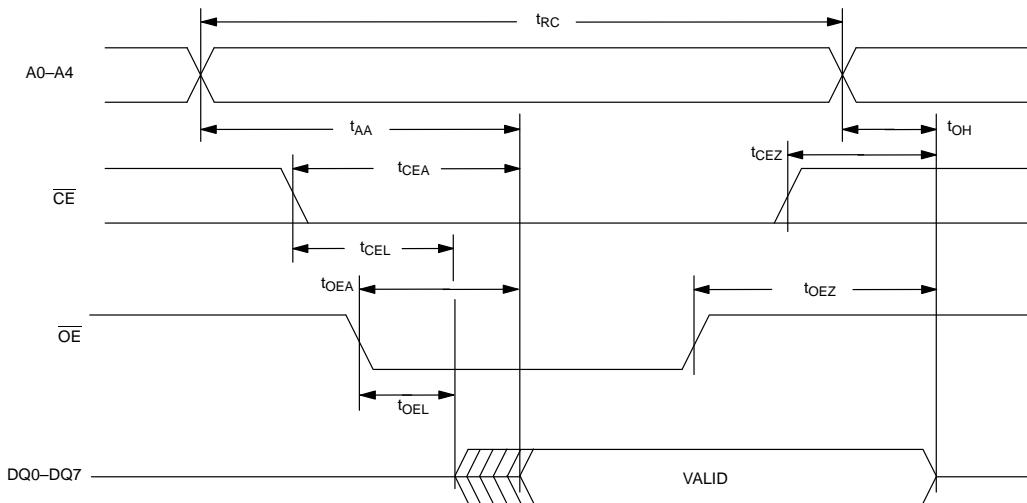
PARAMETER	SYMBOL	MIN	TYPE	MAX	UNITS	NOTES
Read Cycle Time	$t_{RC}$	70			ns	
Address Access Time	$t_{AA}$			70	ns	
$\overline{CE}$ to DQ Low-Z	$t_{CEL}$	5			ns	
$\overline{CE}$ Access Time	$t_{CEA}$			70	ns	
$\overline{CE}$ Data Off Time	$t_{CEZ}$			25	ns	
$\overline{OE}$ to DQ Low-Z	$t_{OEL}$	5			ns	
$\overline{OE}$ Access Time	$t_{OEA}$			35	ns	
$\overline{OE}$ Data Off Time	$t_{OEZ}$			25	ns	
Output Hold from Address	$t_{OH}$	5			ns	

## READ CYCLE, AC CHARACTERISTICS

(0°C to 70°C;  $V_{CC} = 3.3V \pm 10\%$ )

PARAMETER	SYMBOL	MIN	TYPE	MAX	UNITS	NOTES
Read Cycle Time	$t_{RC}$	120			ns	
Address Access Time	$t_{AA}$			120	ns	
$\overline{CE}$ to DQ Low-Z	$t_{CEL}$	5			ns	
$\overline{CE}$ Access Time	$t_{CEA}$			120	ns	
$\overline{CE}$ Data Off Time	$t_{CEZ}$			40	ns	
$\overline{OE}$ to DQ Low-Z	$t_{OEL}$	5			ns	
$\overline{OE}$ Access Time	$t_{OEA}$			100	ns	
$\overline{OE}$ Data Off Time	$t_{OEZ}$			35	ns	
Output Hold from Address	$t_{OH}$	5			ns	

## READ CYCLE TIMING Figure 3

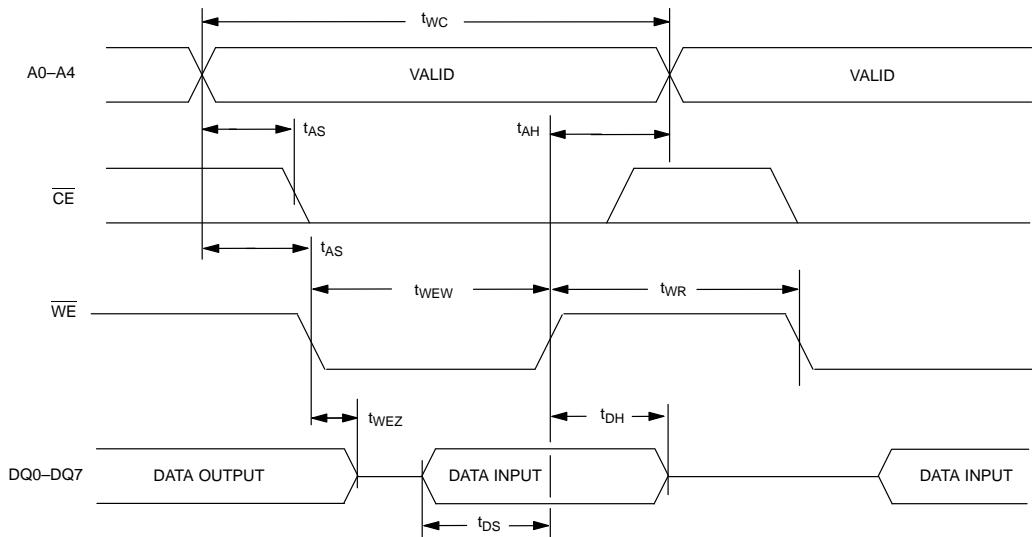
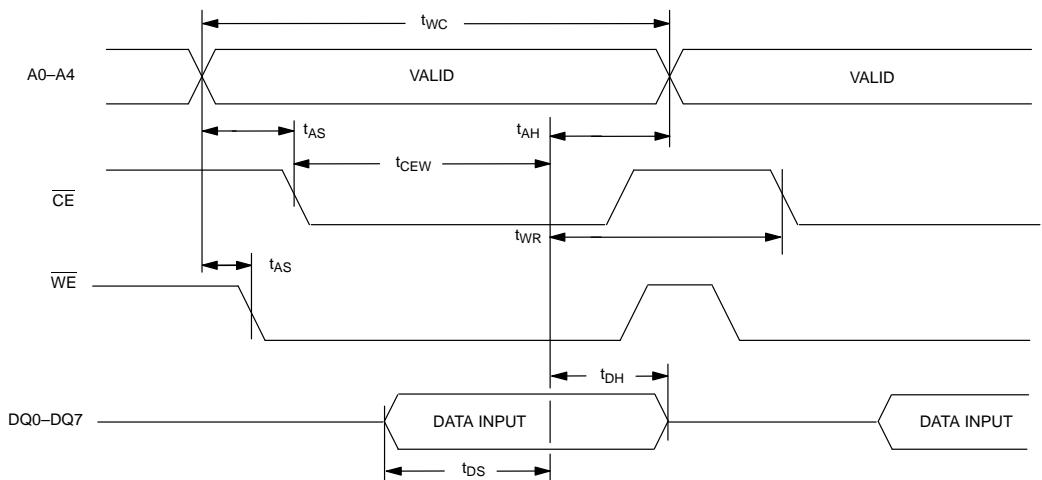


**WRITE CYCLE, AC CHARACTERISTICS**(0°C to 70°C;  $V_{CC} = 5.0V \pm 10\%$ )

PARAMETER	SYMBOL	MIN	TYPE	MAX	UNITS	NOTES
Write Cycle Time	$t_{WC}$	70			ns	
Address Stepup Time	$t_{AS}$	0			ns	
$\bar{WE}$ Pulse Width	$t_{WEW}$	50			ns	
$\bar{CE}$ Pulse Width	$t_{CEW}$	55			ns	
Data Setup Time	$t_{DS}$	30			ns	
Data Hold Time	$t_{DH}$	0			ns	
Address Hold Time	$t_{AH}$	0			ns	
$\bar{WE}$ Data Off Time	$t_{WEZ}$			25	ns	
Write Recovery Time	$t_{WR}$	5			ns	

**WRITE CYCLE, AC CHARACTERISTICS**(0°C to 70°C;  $V_{CC} = 3.3V \pm 10\%$ )

PARAMETER	SYMBOL	MIN	TYPE	MAX	UNITS	NOTES
Write Cycle Time	$t_{WC}$	120			ns	
Address Step-up Time	$t_{AS}$	0			ns	
$\bar{WE}$ Pulse Width	$t_{WEW}$	100			ns	
$\bar{CE}$ Pulse Width	$t_{CEW}$	110			ns	
Data Setup Time	$t_{DS}$	80			ns	
Data Hold Time	$t_{DH}$	0			ns	
Address Hold Time	$t_{AH}$	0			ns	
$\bar{WE}$ Data Off Time	$t_{WEZ}$			40	ns	
Write Recovery Time	$t_{WR}$	10			ns	

**WRITE CYCLE TIMING, WRITE ENABLE CONTROLLED** Figure 4**WRITE CYCLE TIMING, CHIP ENABLE CONTROLLED** Figure 5

## POWER UP/DOWN CHARACTERISTICS

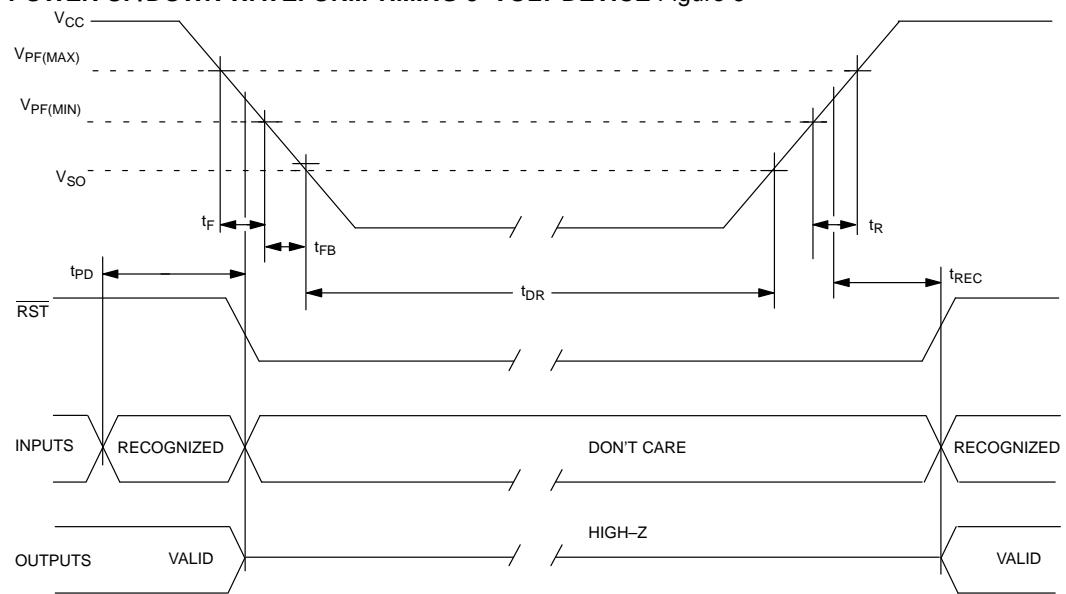
(0°C to 70°C;  $V_{CC} = 5.0V \pm 10\%$ )

PARAMETER	SYMBOL	MIN	TYP	MAX	UNITS	NOTES
$\overline{CE}$ or $\overline{WE}$ at $V_{IH}$ Before Power-Down	$t_{PD}$	0			$\mu s$	
$V_{CC}$ Fall Time: $V_{PF(max)}$ to $V_{PF(min)}$	$t_F$	300			$\mu s$	
$V_{CC}$ Fall Time: $V_{PF(min)}$ to $V_{SO}$	$t_{FB}$	10			$\mu s$	
$V_{CC}$ Rise Time: $V_{PF(min)}$ to $V_{PF(max)}$	$t_R$	0			$\mu s$	
VPF to $\overline{RST}$ High	$t_{REC}$	40		200	ms	

 $(t_A = 25^\circ C)$ 

PARAMETER	SYMBOL	MIN	TYP	MAX	UNITS	NOTES
$\overline{CE}$ or $\overline{WE}$ at $V_{IH}$ Before Power-Down	$t_{DR}$	10			years	5,6

## POWER UP/DOWN WAVEFORM TIMING 5-VOLT DEVICE Figure 6

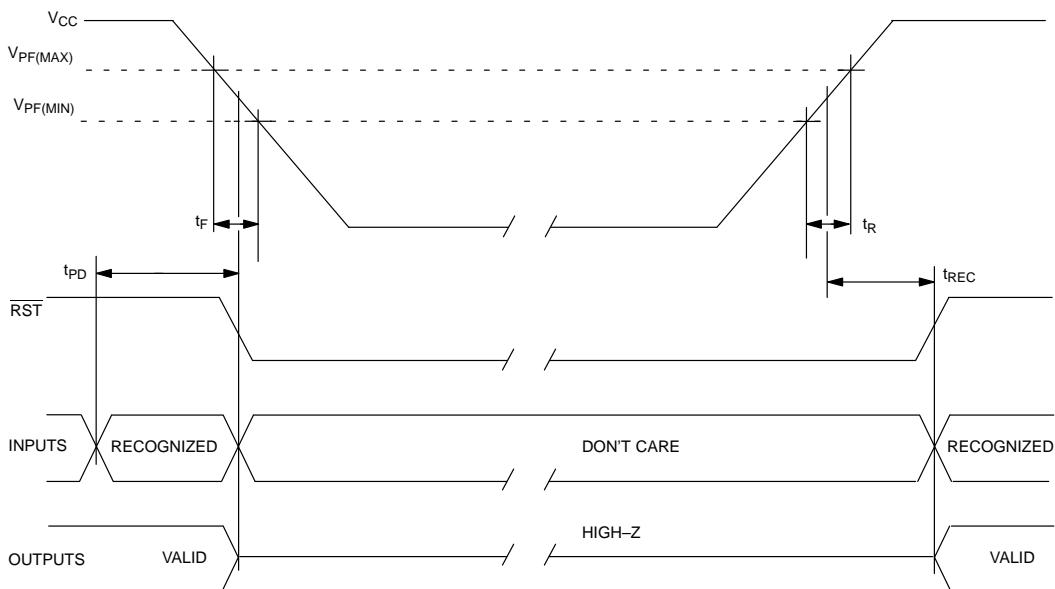


## POWER UP/DOWN CHARACTERISTICS

(0°C to 70°C;  $V_{CC} = 3.3V \pm 10\%$ )

PARAMETER	SYMBOL	MIN	TYP	MAX	UNITS	NOTES
$\overline{CE}$ or $\overline{WE}$ at $V_{IH}$ Before Power-Down	$t_{PD}$	0			$\mu s$	
$V_{CC}$ Fall Time: $V_{PF(max)}$ to $V_{PF(min)}$	$t_F$	300			$\mu s$	
$V_{CC}$ Rise Time: $V_{PF(min)}$ to $V_{PF(max)}$	$t_R$	0			$\mu s$	
$V_{PF}$ to $\overline{RST}$ High	$t_{REC}$	40		200	ms	

## POWER UP/DOWN WAVEFORM TIMING 3.3-VOLT DEVICE Figure 7



## CAPACITANCE

 $(t_A = 25^\circ C)$ 

PARAMETER	SYMBOL	MIN	TYP	MAX	UNITS	NOTES
Capacitance on all input pins	$C_{IN}$			10	pF	
Capacitance on $\overline{IRQ}$ , $\overline{PWR}$ , $\overline{RST}$ , and $DQ$ pins	$C_{IO}$			10	pF	

## AC TEST CONDITIONS

Output Load: 100 pF + 1 TTL Gate

Input Pulse Levels: 0.0 to 3.0 Volts

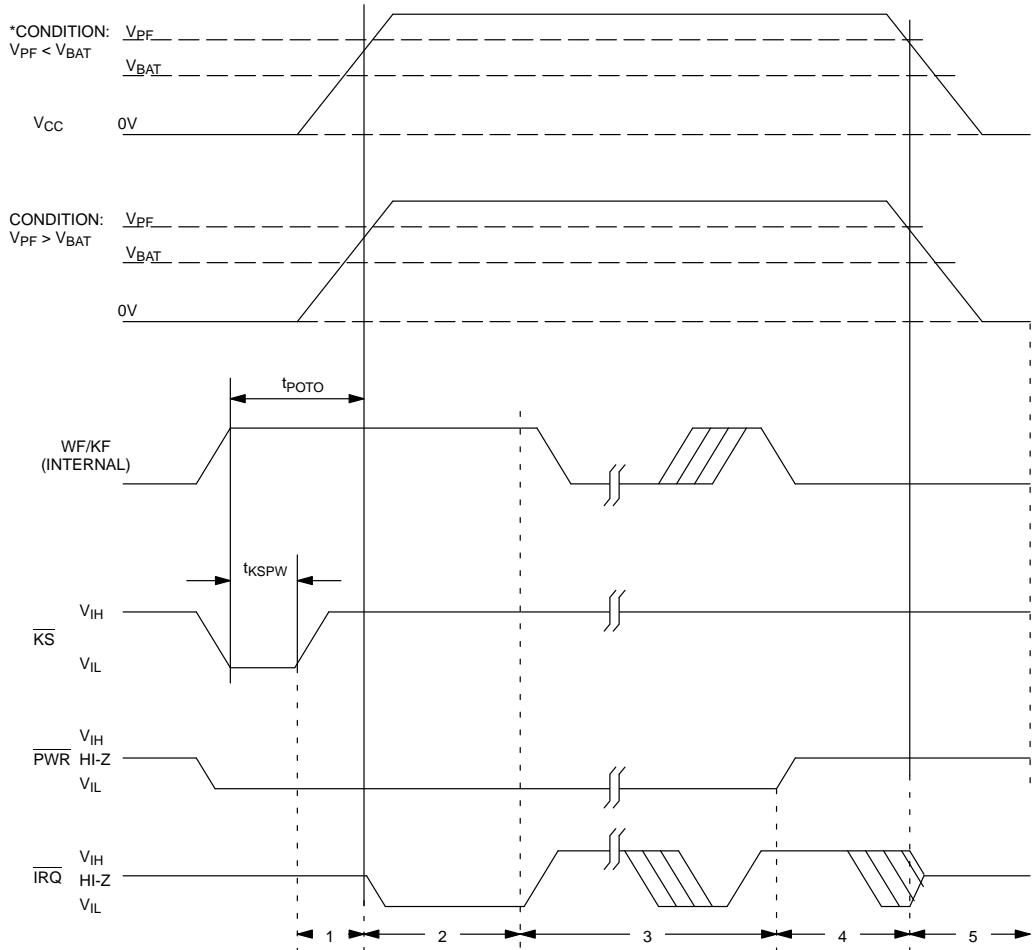
Timing Measurement Reference Levels:

Input: 1.5V

Output: 1.5V

Input Pulse Rise and Fall Times: 5 ns

## WAKE UP/KICKSTART TIMING Figure 8

**NOTE:**

Time intervals shown above are referenced in Wake-up/Kickstart section.

\*This condition can occur with the 3.3V device.

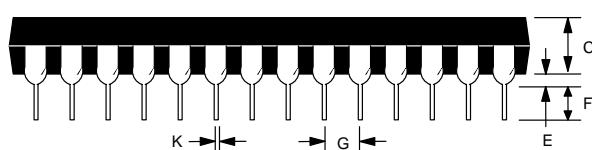
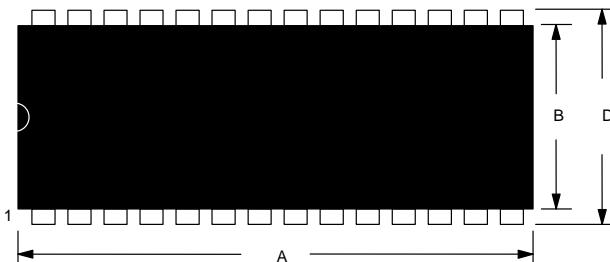
**WAKE UP/KICKSTART TIMING**(t<sub>A</sub> = 25°C)

PARAMETER	SYMBOL	MIN	TYP	MAX	UNITS	NOTES
Kickstart Input Pulse Width	t <sub>KSPW</sub>	2			μs	
Wake-up/Kickstart Power On Timeout	t <sub>POTO</sub>	2			seconds	8

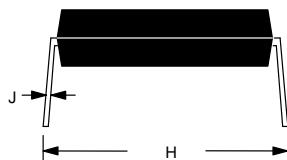
**NOTE**

1. Voltage referenced to ground.
2. Outputs are open.
3. The  $\overline{IRQ}$ ,  $\overline{PWR}$ , and  $\overline{RST}$  outputs are open drain.
4. Battery switch over occurs at the battery terminal voltage level.
5. The DS1511 will keep time to an accuracy of  $\pm 1$  min./month during data retention time for the period of t<sub>DR</sub>.
6. t<sub>DR</sub> is the amount of time that the internal battery can power the internal oscillator and internal registers of the DS1511.
7. If V<sub>PF</sub> is less than V<sub>BAT</sub> and V<sub>BAUX</sub>, the device power is switched from V<sub>CC</sub> to the greater of V<sub>BAT</sub> and V<sub>BAUX</sub> when V<sub>CC</sub> drops below V<sub>PF</sub>. If V<sub>PF</sub> is greater than V<sub>BAT</sub> and V<sub>BAUX</sub>, the device power is switched from V<sub>CC</sub> to the larger of V<sub>BAT</sub> and V<sub>BAUX</sub> when V<sub>CC</sub> drops below the larger of V<sub>BAT</sub> and V<sub>BAUX</sub>.
8. Real-Time Clock Modules can be successfully processed through conventional wave-soldering techniques as long as temperature exposure to the lithium energy source contained within does not exceed +85°C. Post solder cleaning with water washing techniques is acceptable, provided that ultrasonic vibration is not used.

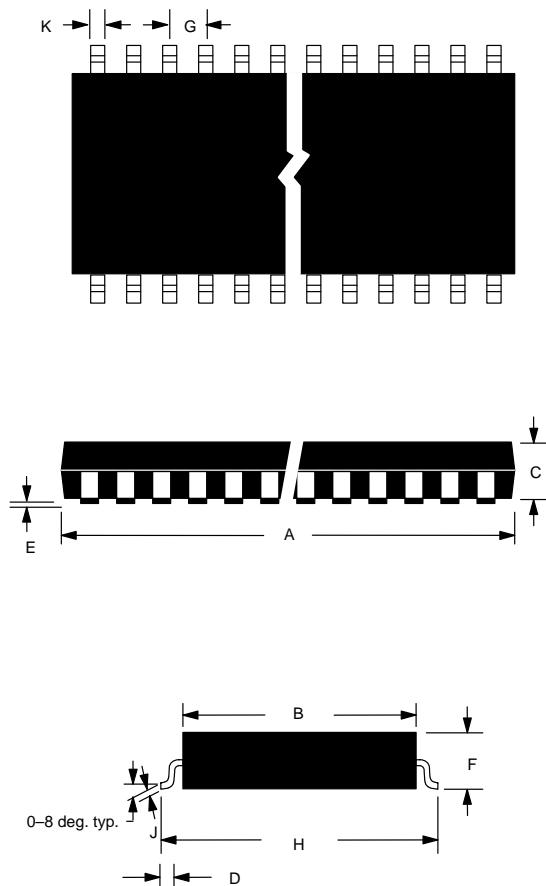
## DS1501 28-PIN DIP



PKG	28-PIN		
	DIM	MIN	MAX
A IN. MM	1.445 36.70	1.470 37.34	
B IN. MM	0.530 13.46	0.550 13.97	
C IN. MM	0.140 3.56	0.160 4.06	
D IN. MM	0.600 15.24	0.625 15.88	
E IN. MM	0.015 0.38	0.040 1.02	
F IN. MM	0.120 3.05	0.145 3.68	
G IN. MM	0.090 2.29	0.110 2.79	
H IN. MM	0.625 15.88	0.675 17.15	
J IN. MM	0.008 0.20	0.012 0.30	
K IN. MM	0.015 0.38	0.022 0.56	

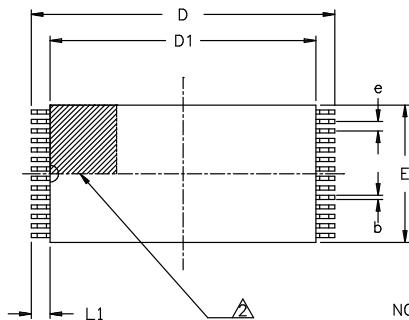


## DS1501S 28-PIN SOIC



PKG	28-PIN		
	DIM	MIN	MAX
A IN. MM	0.706 17.93	0.728 18.49	
B IN. MM	0.338 8.58	0.350 8.89	
C IN. MM	0.086 2.18	0.110 2.79	
D IN. MM	0.020 0.58	0.050 1.27	
E IN. MM	0.002 0.05	0.014 0.36	
F IN. MM	0.090 2.29	0.124 3.15	
G IN. MM	0.050 1.27	BSC	
H IN. MM	0.460 11.68	0.480 12.19	
J IN. MM	0.006 0.15	0.013 0.33	
K IN. MM	0.014 0.36	0.020 0.51	

## DS1501E 28-PIN TSOP

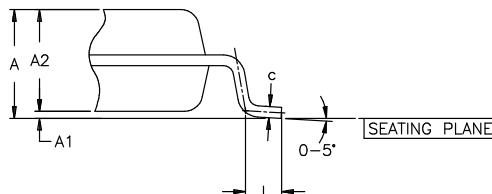


## NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS

DETAILS OF PIN 1 IDENTIFIER ARE OPTIONAL BUT ONE HALF OF ITS AREA MUST BE LOCATED WITHIN THE ZONE INDICATED.

SEE DETAIL A

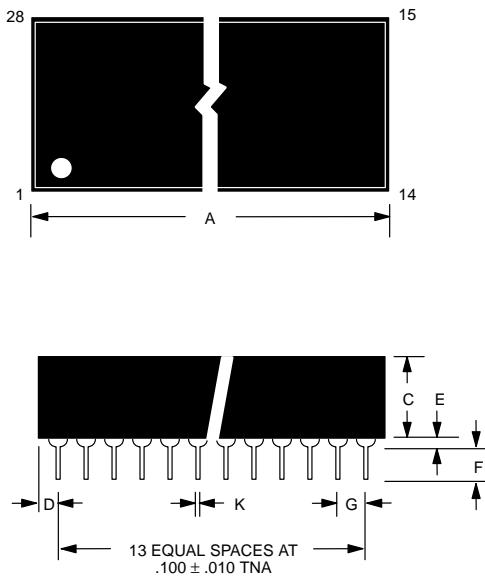


DETAIL A

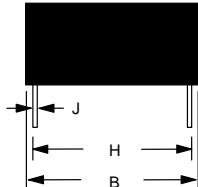
PKG	28-PIN	
DIM	MIN	MAX
A	—	1.20
A1	0.05	—
A2	0.91	1.02
b	0.18	0.27
c	0.15	0.20
D	13.20	13.60
D1	11.70	11.90
E	7.90	8.10
e	0.55 BSC	
L	0.30	0.70
L1	0.80 BSC	

56-G5003-000

## DS1511



PKG	28-PIN		
	DIM	MIN	MAX
A IN. MM	1.520 38.61	1.540 39.12	
B IN. MM	0.695 17.65	0.720 18.29	
C IN. MM	0.350 8.89	0.375 9.52	
D IN. MM	0.100 2.54	0.130 3.30	
E IN. MM	0.015 0.38	0.030 0.76	
F IN. MM	0.110 2.79	0.140 3.56	
G IN. MM	0.090 2.29	0.110 2.79	
H IN. MM	0.590 14.99	0.630 16.00	
J IN. MM	0.008 0.20	0.012 0.30	
K IN. MM	0.015 0.38	0.021 0.53	



NOTE: PINS 2, 3, 21, AND 25 ARE MISSING BY DESIGN.