
REAL-TIME CLOCK

S-3531A

S-3531A is a CMOS real-time clock IC supporting an I²C-BUS, which is designed to transfer or set each data of a clock and calender as requested by a CPU. It provides connection with a CPU via two wires and has two systems of interrupt/alarm and clock output features, allowing the alleviation of software treatment on the side of a host. It also works on lower power with the oscillating circuit operated at a constant voltage.

■ Features

- Low power consumption: 0.7 μ A typ. ($V_{DD}=3.0$ V)
- Wide area of operating voltage: 1.7 to 5.5 V
- BCD input/output of year, month, day, day of a week, hour, minute and second
- CPU interface via two wires (I²C-BUS)
- Auto calender till the year of 2,099
(automatic leap year arithmetic feature included)
- Built-in power voltage detecting circuit
- Built-in constant voltage circuit
- Built-in flag generating circuit on power on/off
- Built-in alarm interrupter (two systems)
- Steady-state interrupt frequency/duty setting feature
- Built-in 32 kHz crystal oscillating circuit (Internal Cd, External Cg)

■ Applications

- Cellular phone
- PHS
- A variety of pagers
- TV set and VCR
- Camera

■ Package

- 8-Pin SSOP (pin pitch : 0.65 mm) (Package drawing code : FS008-A)
- Die

■ **Block Diagram**

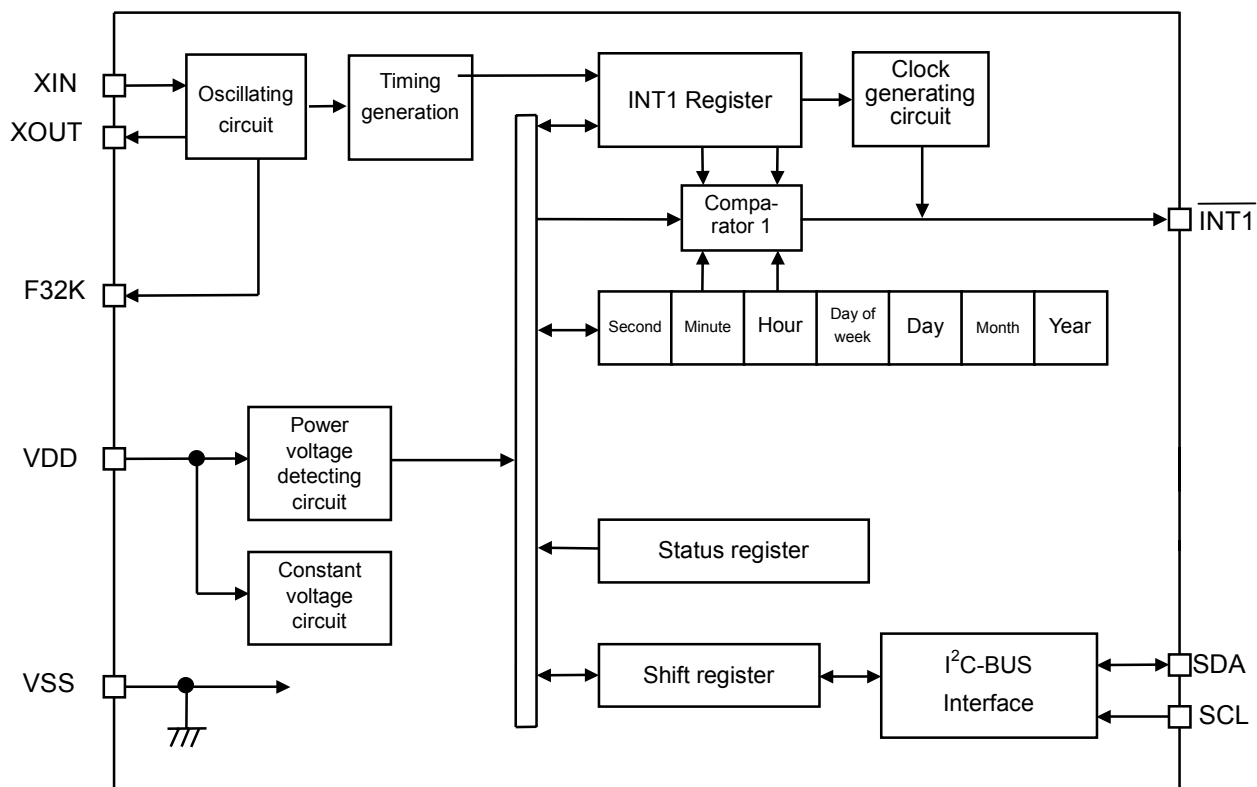
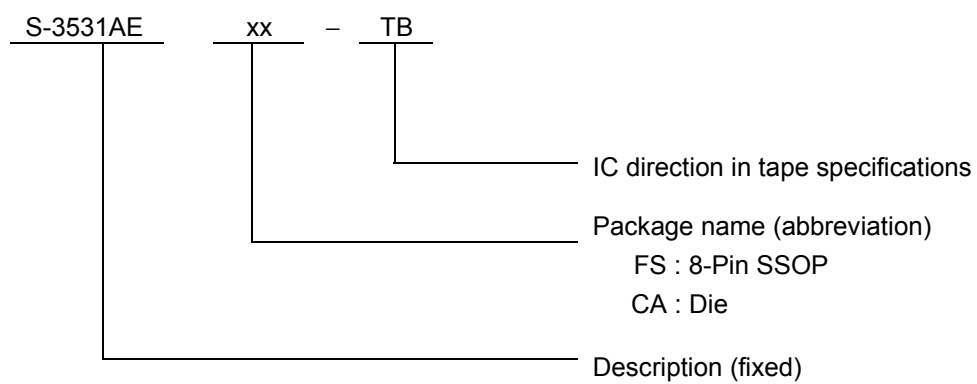


Figure 1

■ Product Code Structure



■ Pin Assignment

(1) Package: S-3531AEFS

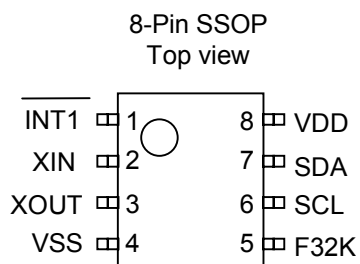
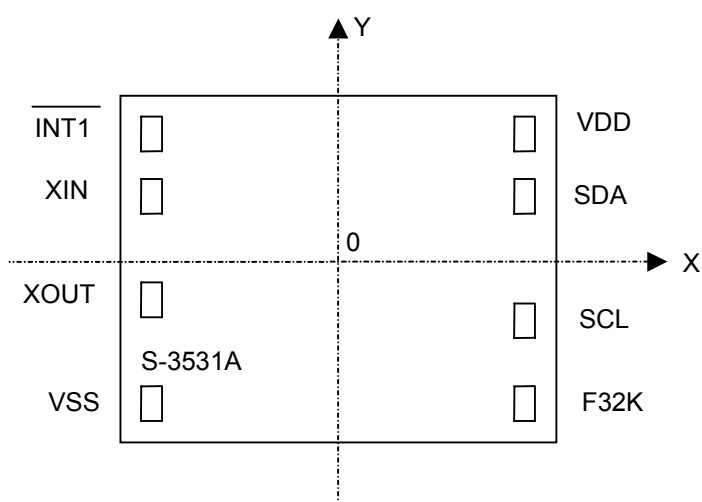


Figure 2

(2) Die : S-3531AECA



Remark Die size : 2.10 × 1.60 mm
 Sizes shown are for design purposes only.
 The corners of the die shrink by approximately 30 μm after dicing.
 Pad size : 100 × 100 μm

Pad Coordinates

Symbol	X	Y	Symbol	X	Y
INT1	-890	641	VDD	890	641
XIN	-890	351	SDA	890	356
XOUT	-890	-114	SCL	890	-240
VSS	-890	-641	F32K	890	-641

Figure 3

■ Description of Pins

Table 1

Pin No.	Symbol	Description	Configuration
1	$\overline{\text{INT1}}$	Alarm interrupt 1 output pin. Depending on the mode set by the $\overline{\text{INT1}}$ register and status register, it outputs low or Clock when time is reached. It is disabled by rewriting the status register.	Nch open drain output (No protective diode on the side of VDD)
2	XIN	Crystal oscillator connect pin (32,768 Hz)	—
3	XOUT	(Internal Cd, External Cg)	
4	VSS	Negative power supply pin (GND)	—
5	F32K	32,768 Hz clock output pin. This clock is always being output and cannot be controlled by command.	Nch open drain output (No protective diode on the side of VDD)
6	SCL	Serial clock input pin. Follow the specification with great care to the rising/falling time of the SCL signal because the signal is treated at its rising/falling edge.	CMOS input (No protective diode on the side of VDD)
7	SDA	Serial data input/output pin. This pin is usually pulled up to VDD via a resistor, and connected to other open-drain or open-collector output devices in wired OR configuration.	Nch open drain output (No protective diode on the side of VDD) CMOS input
8	VDD	Positive power supply pin.	—

■ Absolute Maximum Ratings

Table 2

Item	Symbol	Applicable pin, conditions	Rating	Unit
Power voltage	V_{DD}	—	$V_{SS}-0.3$ to $V_{SS}+6.5$	V
Input voltage	V_{IN}	Applied to SCL, SDA	$V_{SS}-0.3$ to $V_{DD}+0.3$	V
Output voltage	V_{OUT}	Applied to SDA, $\overline{INT1}$, F32K	$V_{SS}-0.3$ to $V_{DD}+0.3$	V
Operating temperature	T_{opr}	$V_{DD}=3.0$ V	-40 to +85	°C
Storage temperature	T_{stg}	—	-55 to +125	°C

Caution The absolute maximum ratings are rated values exceeding which the product could suffer physical damage. These values must therefore not be exceeded under any conditions.

■ Recommended Operating Conditions

Table 3

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Power voltage	V_{DD}	—	1.7	3.0	5.5	V
Operating temperature	T_{opr}	—	-20	+25	+70	°C

■ Oscillation Characteristics

Table 4

(Unless otherwise specified : $T_a=25^\circ\text{C}$, $V_{DD}=3$ V, DS-VT-200 (crystal oscillator, $C_L=6$ pF, 32,768 Hz) manufactured by SII Quartz Techno Ltd.)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Oscillation start voltage	V_{STA}	Within 10 seconds	1.7	—	5.5	V
Oscillation start time	T_{STA}	—	—	—	1	s
IC-to-IC frequency diversity	δIC	—	-10	—	+10	ppm
Frequency voltage diversity	δV	$V_{DD}=1.7$ to 5.5 V	-3	—	+3	ppm/V
Input capacity	C_g	Applied to the XIN pin	3	—	35	pF
Output capacity	C_d	Applied to the XOUT pin	—	12	—	pF

■ DC Electrical Characteristics

Table 5 DC characteristics (3 V)

 (Unless otherwise specified ; Ta=25°C, V_{DD}=3 V, DS-VT-200 (crystal oscillator, C_L=6 pF, 32,768 Hz) manufactured by SII Quartz Techno Ltd.)

Item	Symbol	Applicable pin	Condition	Min.	Typ	Max.	Unit
Operating voltage range	V _{DD}	—	Ta= -20 to +70°C	1.7	3.0	5.5	V
Current consumption 1	I _{DD1}	—	During no communications	—	0.7	1.5	μA
Current consumption 2	I _{DD2}	—	During communications (SCL=100 kHz)	—	12	20	μA
Input leak current 1	I _{IZH}	SCL, SDA	V _{IN} =V _{DD}	-0.5	—	0.5	μA
Input leak current 2	I _{IZL}	SCL, SDA	V _{IN} =V _{SS}	-0.5	—	0.5	μA
Output leak current1	I _{OZH}	$\overline{\text{INT1}}$, F32K, SDA	V _{OUT} =V _{DD}	-0.5	—	0.5	μA
Output leak current2	I _{OZL}	INT1, F32K, SDA	V _{OUT} =V _{SS}	-0.5	—	0.5	μA
Input voltage 1	V _{IH}	SDA, SCL	—	0.8×V _{DD}	—	—	V
Input voltage 2	V _{IL}	SDA, SCL	—	—	—	0.2×V _{DD}	V
Output current 1	I _{OL1}	$\overline{\text{INT1}}$, F32K	V _{OUT} =0.4 V	1.5	2.5	—	mA
Output current 2	I _{OL2}	SDA	V _{OUT} =0.4 V	5	10	—	mA
Power voltage detection voltage 1	V _{DET1}	—	Ta=+25°C	1.8	2.0	2.2	V
Power voltage detection voltage 2	V _{DET2}	—	Ta= -20 to +70°C	1.72	—	2.3	V

Table 6 DC characteristics (5 V)

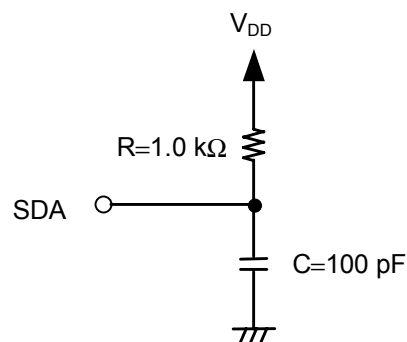
 (Unless otherwise specified : Ta=25°C, V_{DD}=3 V, DS-VT-200 (crystal oscillator, C_L=6 pF, 32,768 Hz) manufactured by SII Quartz Techno Ltd.)

Item	Symbol	Applicable pin	Condition	Min.	Typ	Max.	Unit
Operating voltage range	V _{DD}	—	Ta= -20 to +70°C	1.7	3.0	5.5	V
Current consumption 1	I _{DD1}	—	During no communications	—	1.6	3.0	μA
Current consumption 2	I _{DD2}	—	During communications (SCL=100 kHz)	—	26	40	μA
Input leak current 1	I _{IZH}	SCL, SDA	V _{IN} =V _{DD}	-0.5	—	0.5	μA
Input leak current 2	I _{IZL}	SCL, SDA	V _{IN} =V _{SS}	-0.5	—	0.5	μA
Output leak current1	I _{OZH}	$\overline{\text{INT1}}$, F32K, SDA	V _{OUT} =V _{DD}	-0.5	—	0.5	μA
Output leak current2	I _{OZL}	INT1, F32K, SDA	V _{OUT} =V _{SS}	-0.5	—	0.5	μA
Input voltage 1	V _{IH}	SDA, SCL	—	0.8×V _{DD}	—	—	V
Input voltage 2	V _{IL}	SDA, SCL	—	—	—	0.2×V _{DD}	V
Output current 1	I _{OL1}	$\overline{\text{INT1}}$, F32K	V _{OUT} =0.4 V	2.0	3.5	—	mA
Output current 2	I _{OL2}	SDA	V _{OUT} =0.4 V	6	12	—	mA
Power voltage detection voltage 1	V _{DET1}	—	Ta=+25°C	1.8	2.0	2.2	V
Power voltage detection voltage 2	V _{DET2}	—	Ta= -20 to +70°C	1.72	—	2.3	V

■ AC Electrical Characteristics

Table 7 Measurement conditions

Input pulse voltage	$0.1 \times V_{DD}$ to $0.9 \times V_{DD}$
Input pulse rising/falling time	20 ns
Output judgement voltage	$0.5 \times V_{DD}$
Output load	100 pF+1.0 kΩ



Caution Both IC and load powers are the same V_{DD}

Figure 4 Output load circuit

Table 8 AC properties

Item	Symbol	$V_{DD}=1.7 \text{ V to } 5.5 \text{ V}$			Unit
		Min.	Typ.	Max.	
SCL clock frequency	f_{SCL}	0	—	100	kHz
SCL clock "L" time	t_{LOW}	4.7	—	—	μs
SCL clock "H" time	t_{HIGH}	4.0	—	—	μs
SDA output delay time	t_{PD}	—	—	3.5	μs
Start condition setup time	t_{SU}, t_{STA}	4.7	—	—	μs
Start condition holding time	t_{HD}, t_{STA}	4.0	—	—	μs
Data input setup time	t_{SU}, t_{DAT}	250	—	—	ns
Data input holding time	t_{HD}, t_{DAT}	150	—	—	ns
Stop condition setup time	t_{SU}, t_{STO}	4.7	—	—	μs
SCL, SDA rising time	t_R	—	—	1.0	μs
SCL, SDA falling time	t_F	—	—	0.3	μs
Bus release time	t_{BUF}	4.7	—	—	μs
Noise suppression time	t_I	—	—	100	ns

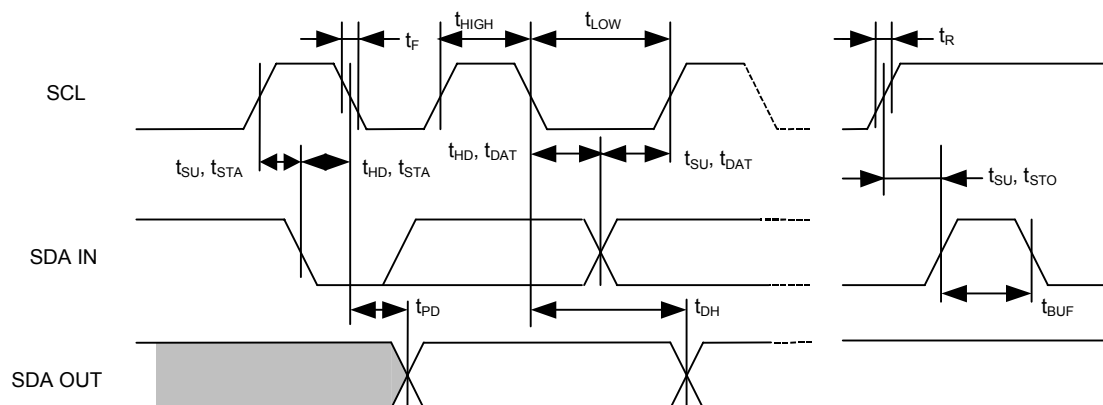


Figure 5 Bus timing

■ Description of Operation

1. Serial interface

S-3531A receives various commands through the I²C-BUS-based serial interface to read/write data. The method of I²C-BUS-based transfer is described here.

1.1 Start condition

Changing the SDA line from “H” to “L” when the SCL line is “H” activates the start condition. All the operations begin at the start condition.

1.2 Stop condition

Changing the SDA line from “L” to “H” when the SCL line is “H” activates the stop condition. During a read sequence, any read operation is stopped and a device enters its stand-by mode when a stop condition is received.

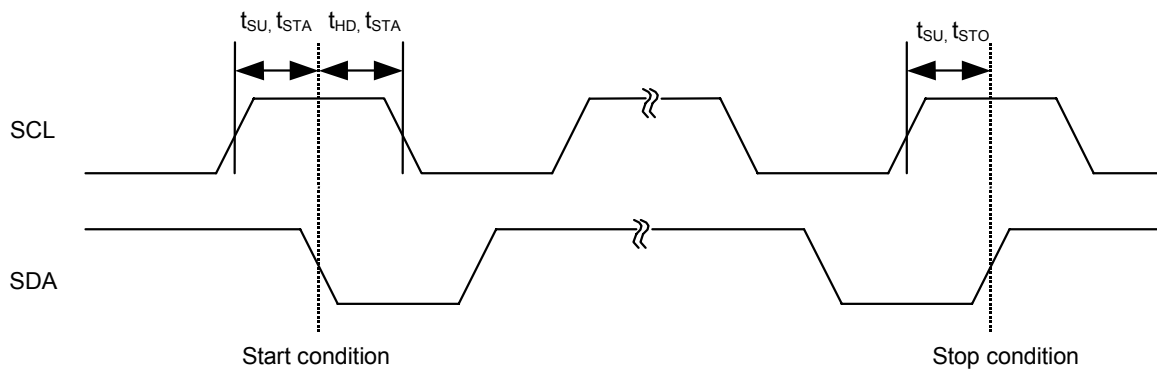


Figure 6 Start/Stop condition

1.3 Data transfer

When the SDA line is changed while the SCL line is on “L”, data transfer is performed. When the SDA line is changed while the SCL line is on “H”, a start or stop condition is recognized.

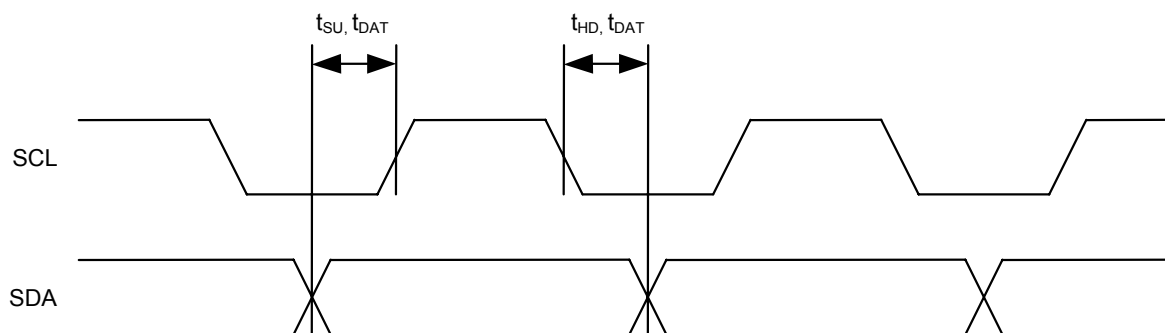


Figure 7 Data transfer timing

1.4 Acknowledge

Data transfer is performed in 8-bit sequence. A device on the system bus, which successfully receives data during a period of a ninth clock cycle, puts the SDA line on "L" and returns an acknowledge signal meaning that the data has been received.

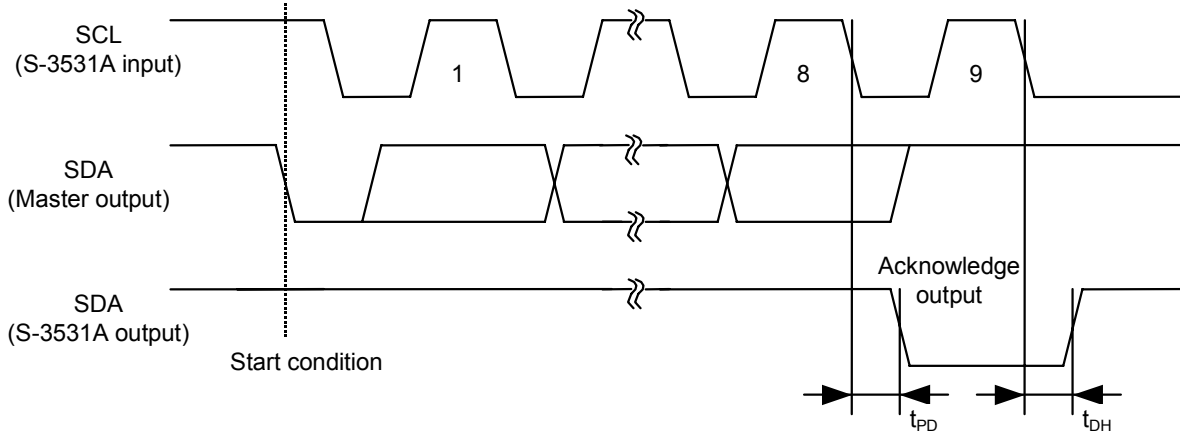


Figure 8 Acknowledge output timing

1.5 Device addressing

The master device on the system generates a start condition to its slave device to make communication. It continuously issues the device address of a 4-bit length, the command of a 3-bit length and the read/write command of a 1-bit length over the SDA bus.

The upper four bits, called a device code, represent a device address and are fixed at "0110."

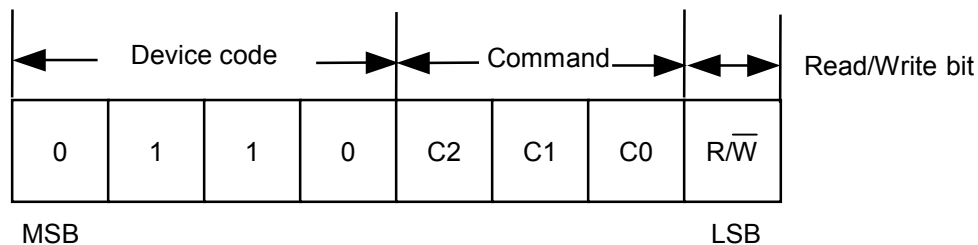


Figure 9 Communication data

1.6 Command configuration

There are seven kinds of commands by which the read/write operation of various registers is performed. The table below lists them. If you send any code other than the listed codes, the command is ignored.

Table 9 Command list

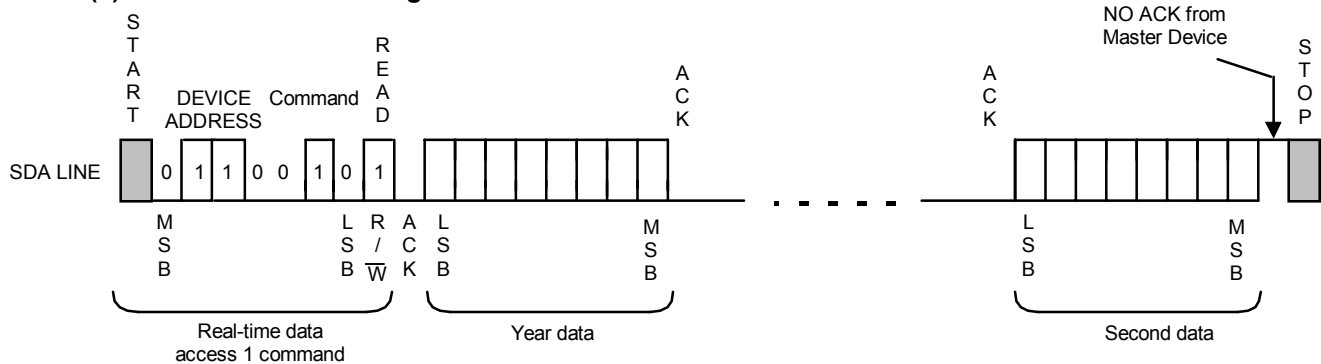
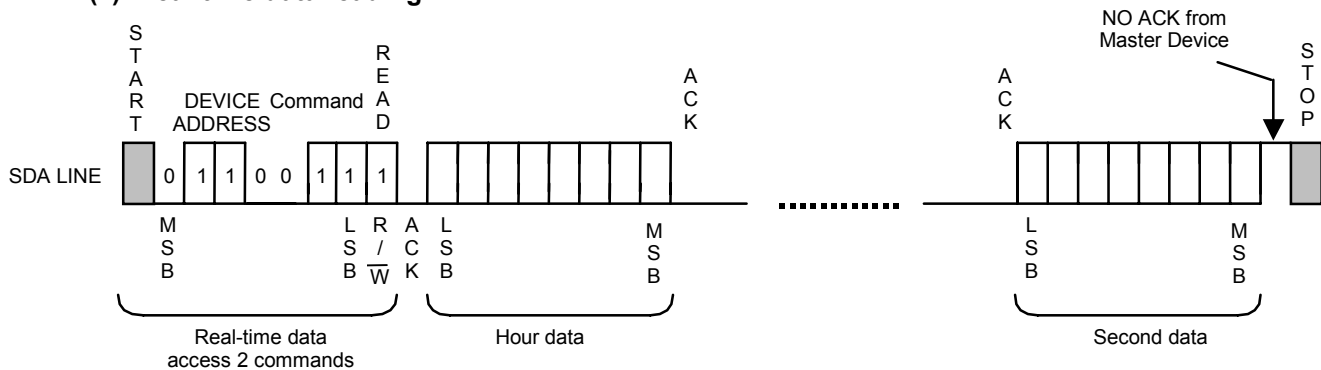
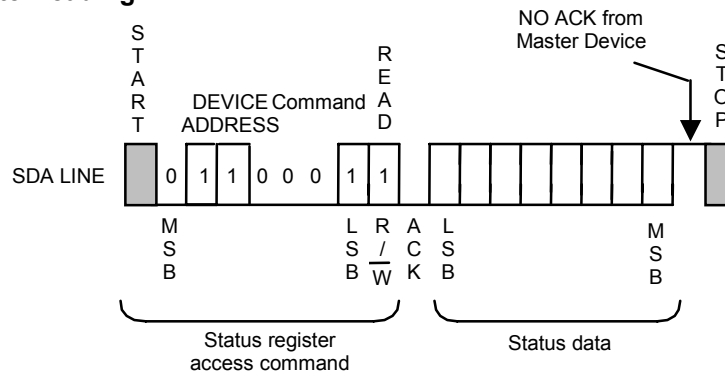
C2	C1	C0	Description	Number of ACK
0	0	0	Reset (00 (year), 01 (month), 01 (day), 0 (day of week), 00 (minute), 00 (second)) ^{*1}	1
0	0	1	Status register access	2
0	1	0	Real-time data access 1 (year data to)	8
0	1	1	Real-time data access 2 (hour data to)	4
1	0	0	Alarm time/frequency duty setting 1 (for INT1 pin)	3
1	1	0	Test mode start ^{*2}	1
1	1	1	Test mode end ^{*2}	1

^{*1}. Don't care the R/W bit of this command.

^{*2}. This command is access-disabled due to specific use for the IC test.

1.7 Data reading

After a start condition is detected from the outside, the device code and command are received. At this point, the real-time reading mode or status register reading mode is entered when the read/write bit is "1". In either the real-time reading mode or status register reading mode, data are output in the order from LSB.

(1) Real-time data reading 1**(2) Real-time data reading 2****(3) Status register reading****Figure 10 Read communication**

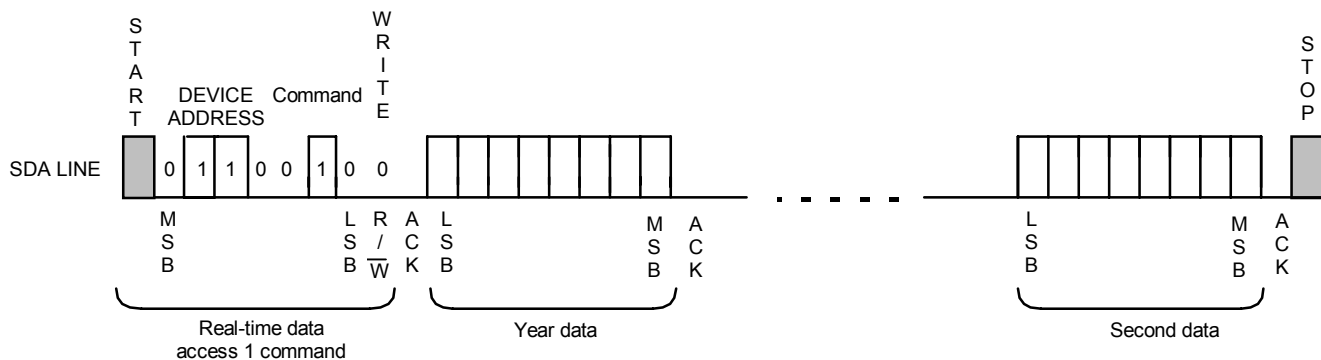
Caution **ACK Upside:** **Generate from the master device**
 ACK Downside: **Generate from the S-3531A**

1.8 Data writing

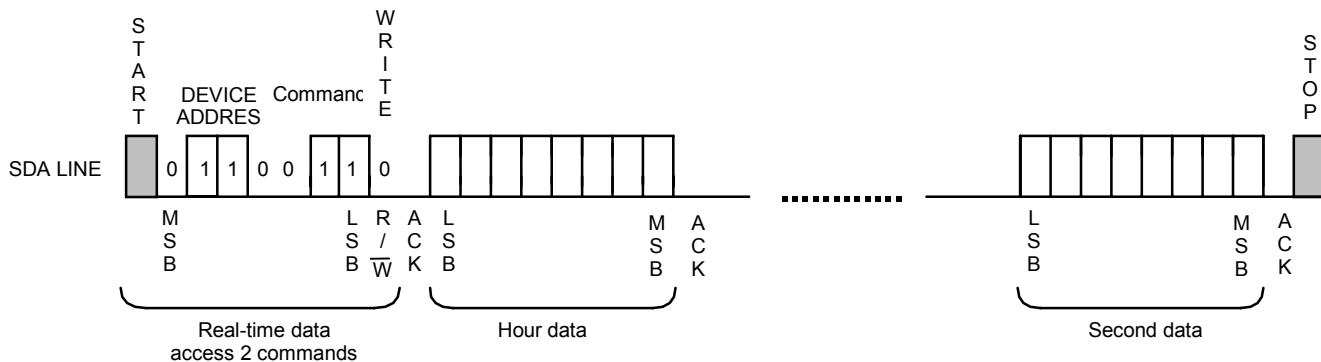
After a start condition is detected from the outside, the device code and command are received. At this point, the real-time data writing mode or other register writing mode is entered when the read/write bit is "0". Data must be entered in the order from LSB of the real-time data writing mode or status register writing mode.

In real-time data writing, the counter of a calendar and time is reset when the ACK signal rises following the real-time writing command, and any update operation is disabled. After a minute data is received, the end of a month is corrected while a second data is imported. Then, the count-up is started when the ACK signal rises after the second data is received.

(1) Real-time data writing 1



(2) Real-time data writing 2



(3) Status register writing

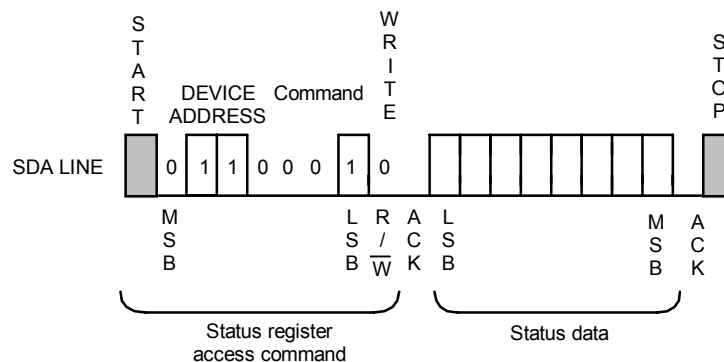


Figure 11 Write communication

2. Register configuration

2.1 Real-time data register

The real-time data register is a 56-bit register which stores the BCD code of the data of year, month, day, day of week, hour, minute and second. Any read/write operation performed by the real-time data access command sends or receives the data from LSB on the first digit of the year data.

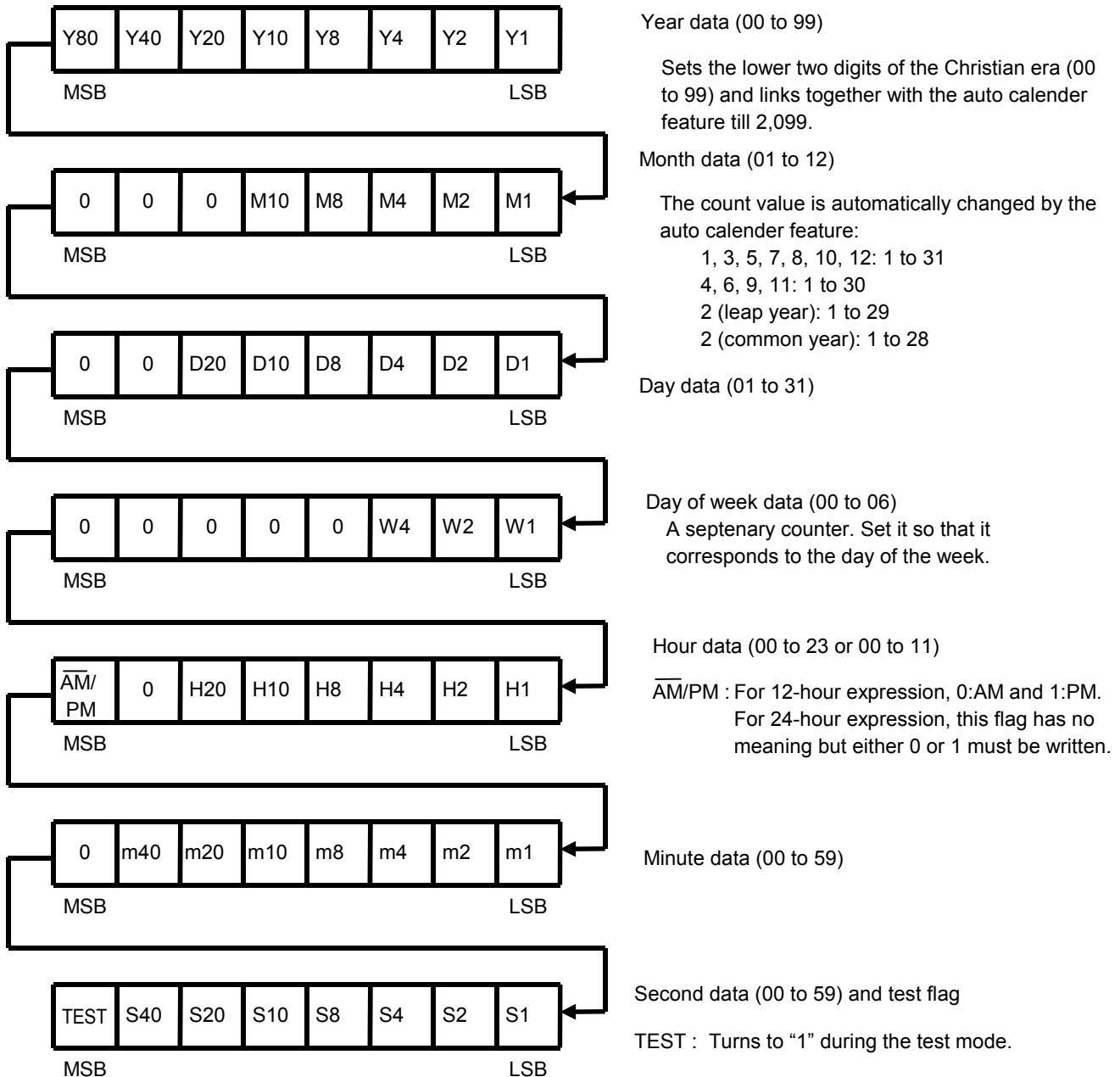


Figure 12

2.2 Status register

The status register is an 8-bit register which allows you to display and set various modes. The POWER flag is read-only and others are read/write-enabled.

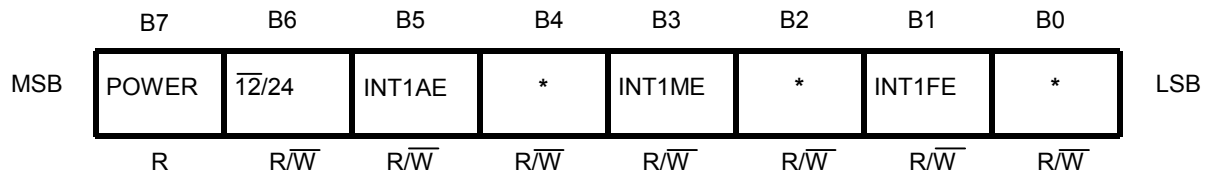


Figure 13

- B7:POWER** This flag turns to "1" if the power voltage detecting circuit operates during power-on or changes in power voltage (below V_{DET}). Once turning to "1", this flag does not turn back to "0" even when the power voltage reaches or exceeds the detection voltage. When the flag is "1", you must send the reset command (or the status register read command) and turn it to "0". It is a read-only flag.
- B6: $\overline{12}/24$** This flag is used to set 12-hour or 24-hour expression.
0 : 12-hour expression
1 : 24-hour expression
- B5:INT1AE** This flag is used to choose the state of $\overline{INT1}$ pin output with alarm interrupt output set. Enable this flag after setting alarm time that forms a meeting condition in the INT1 register:
0 : Alarm interrupt output is disabled.
1 : Alarm interrupt output is enabled.
- B3:INT1ME** This flag is used to make the output of the $\overline{INT1}$ pin per-minute edge interrupt or per-minute steady interrupt. To make the output per-minute steady interrupt, set "1" at INT1ME and INT1FE .
0 : Alarm interrupt or selected frequency steady interrupt output
1 : Per-minute edge interrupt or per-minute steady interrupt output
- B1:INT1FE** This flag is used to make the output of the $\overline{INT1}$ pin per-minute steady interrupt output (a period of one minute, 50% of duty) or selected frequency steady interrupt. Note that the INT1 register is considered as the data of frequency/duty if selected frequency steady interrupt is chosen.
0 : Alarm interrupt or per-minute edge interrupt output
1 : Per-minute steady interrupt or selected frequency steady interrupt output
- B4,B2,B0:** * Non-used bits; They are ignored during the data writing. Indefinite data ("0" or "1") is read during the data reading.

2.3 Alarm time/Frequency duty setting register

There are two types of alarm time/frequency duty setting registers, 16-bit registers, which set alarm time or frequency duty. They are switched by INT1AE or INT1FE register. $\overline{\text{AM/PM}}$ flag to be set must be in accordance with 12-hour or 24-hour expression. If $\overline{\text{AM/PM}}$ flag is not rightly then set hour data is not met to alarm data. The alarm time/frequency duty setting register is a write-only register.

(1) When INT1AE = 1

INT1 register

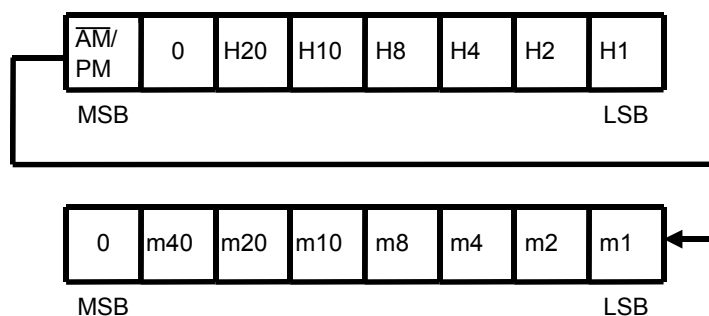


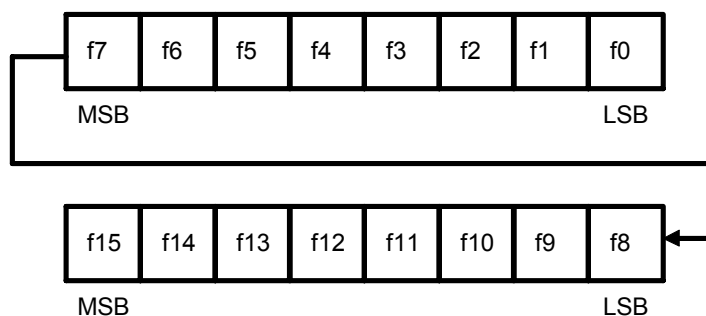
Figure 14 INT1 register (alarm)

INT1 register is considered as alarm time data. Having the same configuration as the time and minutes registers of real-time data register configuration, it represents hours and minutes with BCD codes. When setting them, do not set any none-existent day. Data to be set must be in accordance with 12-hour or 24-hour expression that is set at the status register.

(2) When INT1FE = 1

INT1 register is considered as frequency duty data. By turning each bit of the registers to "1", a frequency corresponding to each bit is chosen in an ANDed form.

INT1 register



f0	32768 Hz	f4	2048 Hz	f8	128 Hz	f12	8 Hz
f1	16384 Hz	f5	1024 Hz	f9	64 Hz	f13	4 Hz
f2	8192 Hz	f6	512 Hz	f10	32 Hz	f14	2 Hz
f3	4096 Hz	f7	256 Hz	f11	16 Hz	f15	1 Hz

Figure 15 INT1 register (frequency duty)

Example

If f15 to f0 = 000A H

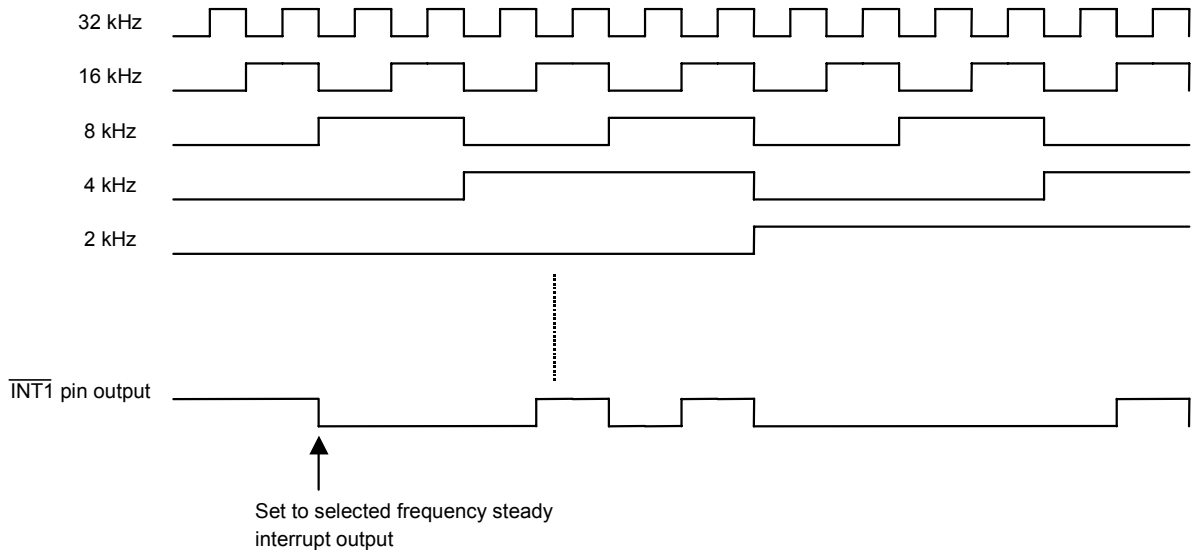


Figure 16 Clock output

2.4 Test flag

The test flag is a 1-bit register which is assigned to MSB of the second data of the real-time data register. If transferred data is considered as the test mode starting command due to the receiving of the test mode starting command or noises, "1" is set. When "1" is set, you must send the test mode ending command or reset command.

3. Initialization

Note that S-3531A has different initializing operations, depending on states.

3.1 When power is turned on

When power is turned on, the status register is set to "82h" and the INT1 register to "8000h" by the power-on detecting circuit. In other words, "1" is set at the bit 7 (POWER flag) of the status register and the clock of 1 Hz is output from the INT1 pin. This is provided to adjust oscillating frequencies. In normal use, the reset command must be sent when power is turned on.

Real-time data register	: 00 (year), 01 (month), 01 (day), 0 (day of week), 00 (hour), 00 (minute), 00 (second)
Status register	: "82h"
INT1 register	: "8000h"

3.2 When the power voltage detecting circuits operates

The power voltage detecting circuit included in S-3531A operates and sets "1" at the bit 7 (POWER flag) of the internal status register when power is turned on or power voltage is reduced. Once "1" is set, it is held even after the power voltage gets equal to or higher than the detection voltage, i.e., the power voltage detector threshold. When the flag has "1", you must send the reset command from CPU and initialize the flag. At this point, other registers do not change, however, if the POWER flag has "0" during the power-on reset of CPU (S-3531A does not reach any indefinite area during backup), you do not have to send the reset command.

3.3 When the reset command is received

When the reset command is received, each register turns as follows:

Real-time data register : 00 (year), 01 (month), 01 (day), 0 (day of week), 00 (hour), 00 (minute), 00 (second)

Status register : "00h"

INT1 register : "0000h"

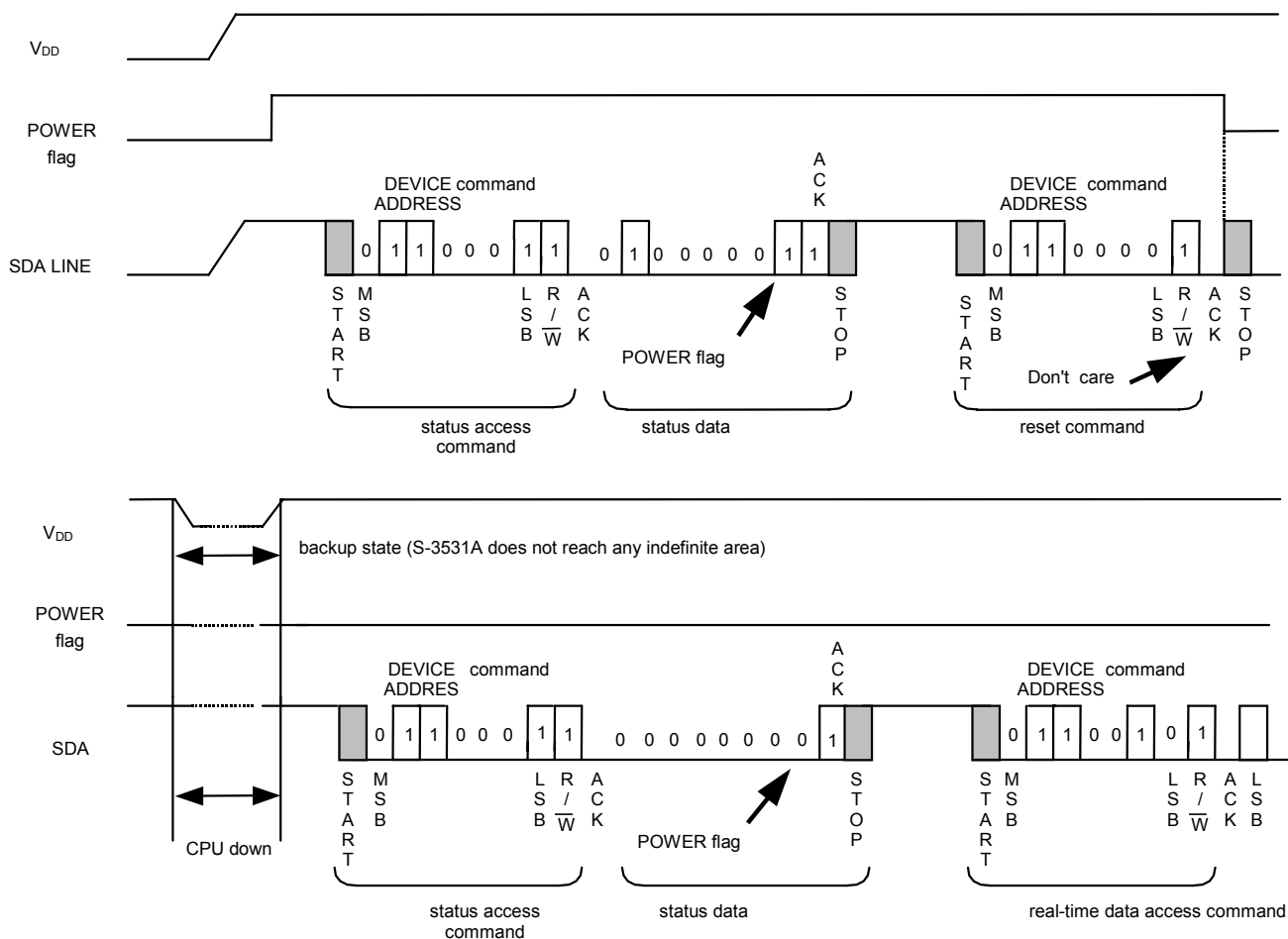


Figure 17 Initializing

4. Processing of none-existent data and end-of-month

When writing real-time data, validate it and treat any invalid data and end-of-month correction.

[None-existent data processing]

Table 10 None-existent data processing

Register	Normal data	Error data	Result
Year data	00 to 99	XA to XF, AX to FX	00
Month data	01 to 12	00, 13 to 19, XA to XF	01
Day data	01 to 31	00, 32 to 39, XA to XF	01
Day of week data	0 to 6	7	0
Hour data ^{*1} (24-hour)	0 to 23	24 to 29, 3X, XA to XF	00
(12-hour)	0 to 11	12 to 19, XA to XF	00
Minute data	00 to 59	60 to 79, XA to XF	00
Second data ^{*2}	00 to 59	60 to 79, XA to XF	00

- *1.** For 12-hour expression, write the AM/PM flag.
The AM/PM flag is ignored in 24-hour expression, but "0" for 0 to 11 o'clock and "1" for 12 to 23 o'clock are read in a read operation.
- *2.** None-existent data processing for second data is performed by a carry pulse one second after the end of writing. At this point, the carry pulse is sent to the minute counter.

[End-of-month correction]

Any none-existent day is corrected to the first day of the next month. For example, February 30 is changed to March 1. Leap-year correction is also performed here.

5. Interrupt

There are different five output formats from the $\overline{\text{INT1}}$ pin, which are chosen by the INT1AE, INT1ME and INT1FE bits of the status register.

(1) Alarm interrupt output

Alarm interrupt is enabled by setting hour and minute data to the INT1 register and turning the status register's INT1AE to "1" and INT1ME and INT1FE to "0". When set hour data is met, "L" is output from the INT1 pin. Since the output is held, rewrite INT1AE of the status register to "0" through serial communication to turn the output to "H" (OFF state). When you perform disable or enable communication while the corresponding signal is being retained (for one minute), "L" signal is output from the $\overline{\text{INT1}}$ pin again.

(2) Selected frequency steady interrupt output

When you set frequency/duty data to the INT1 register and turn the status register's INT1ME to "0" and INT1FE to "1", clock set at the INT1 register is output from the $\overline{\text{INT1}}$ pin.

(3) Per-minute edge interrupt output

When a first minute carry is performed after the status register's INT1ME is set with "1" and INT1FE with "0", "L" is output from the $\overline{\text{INT1}}$ pin. Since the output is held, rewrite INT1AE, INT1ME and INT1FE of the status register to "0" through serial communication to turn the output to "H" (OFF state). When you perform disable or enable communication while the minute carry processing signal is being retained (for 10 ms), "L" signal is output from the $\overline{\text{INT1}}$ pin again.

(4) Per-minute steady interrupt output

When a first minute carry is performed after the status register's INT1ME and INT1FE are set with "1", clock is output from the $\overline{\text{INT1}}$ pin with a period of one minute (50% duty). When you perform disable or enable communication while the $\overline{\text{INT1}}$ pin is at "L", "L" signal is output from the INT1 pin again.

Caution1. If changing an output mode, give care to the state of the INT1 register and output.

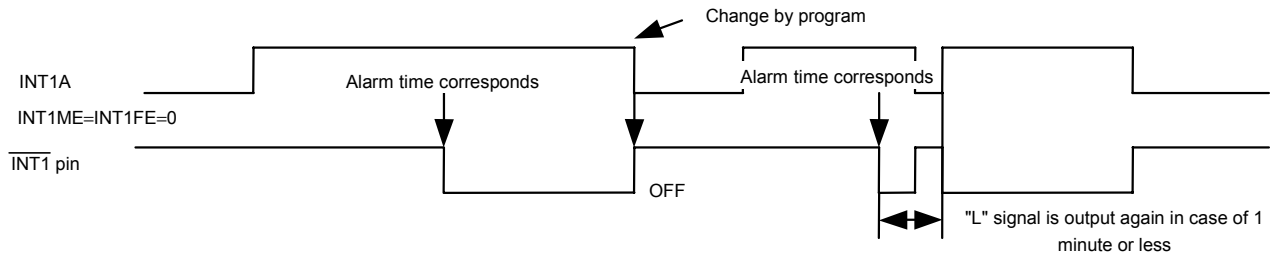
2. If per-minute edge interrupt output or per-minute steady interrupt output is chosen, the INT1 register has no meaning.

Table 11 Interrupt description

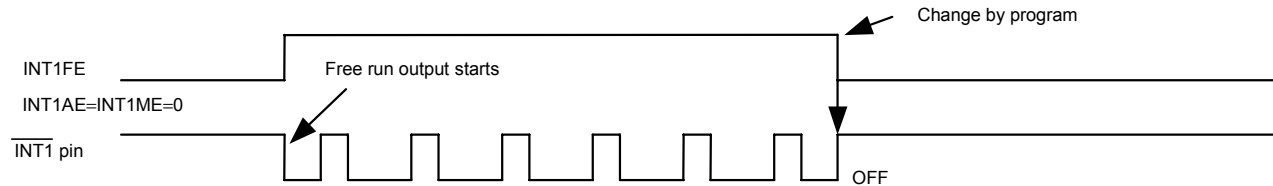
NO.	INT1AE	INT1ME	INT1FE	Description
0	0	0	0	Output disabled (No interrupt output)
1	*	0	1	Selected frequency steady interrupt output
2	*	1	0	Per-minute edge interrupt output
3	*	1	1	Per-minute steady interrupt output
4	1	0	0	Alarm interrupt output

Remark * : Don't care

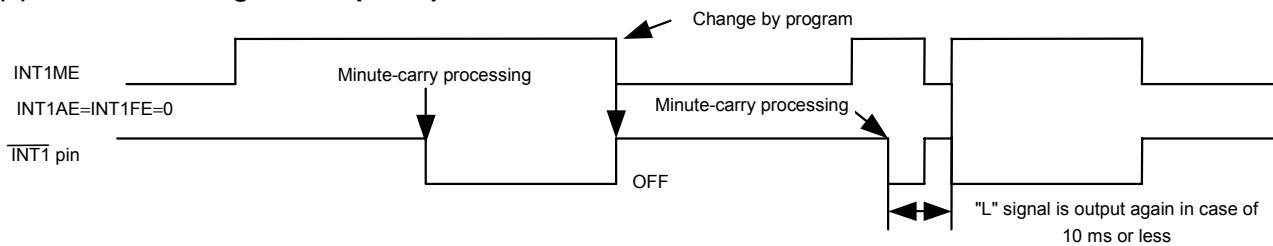
(1) Alarm interrupt output



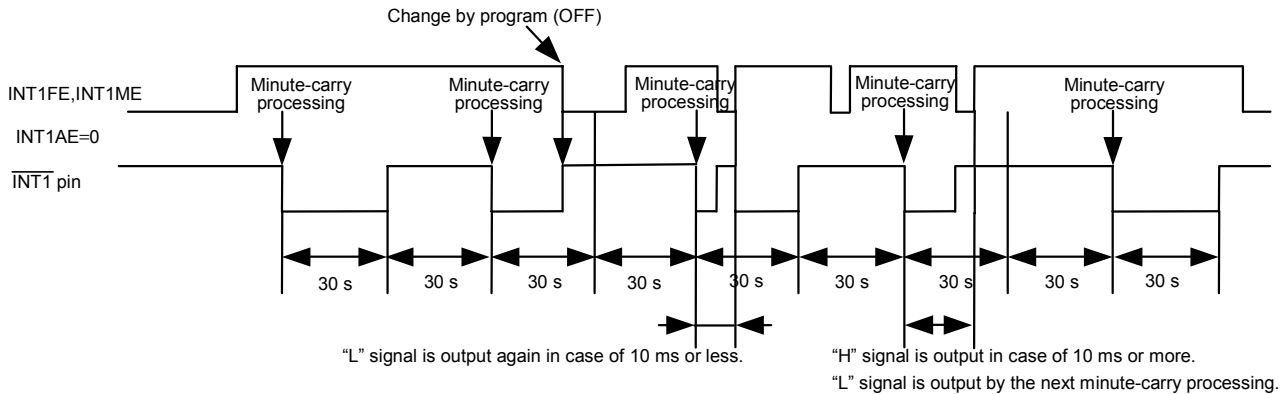
(2) Selected frequency steady interrupt output



(3) Per-minute edge interrupt output



(4) Per-minute steady interrupt output



(5) During power-on detecting circuit operation

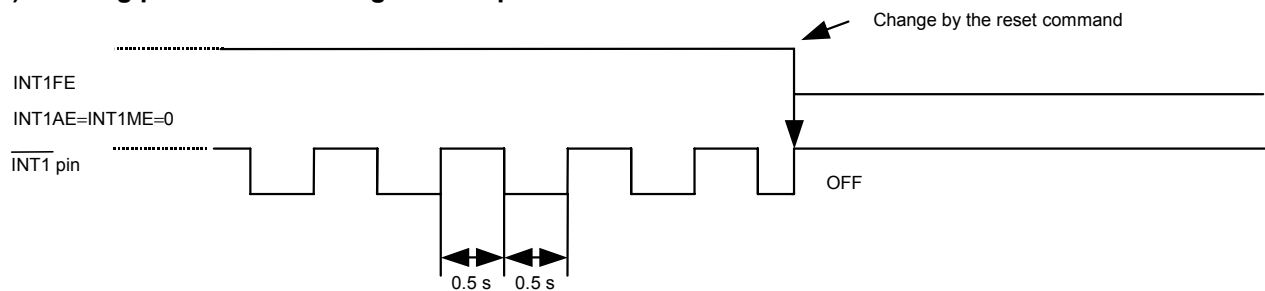


Figure 18 Output mode

6. Power voltage detecting circuit

S-3531 has an internal power voltage detecting circuit. This circuit gives sampling movement for only 15.6 ms once a second. If the power voltage decreases below the detection voltage (V_{DET}), the BLD latch circuit latches the "H" level and sampling movement stops. Only when subsequent communication is of the status read command, the output of the latch circuit is transferred to the shift register and the sampling movement is resumed. Decrease in power voltage can be monitored by reading the POWER flag. That is to say, once decrease in power voltage is detected, any detecting operation is not performed and "H" is held unless you perform initialization or send the status read command.

Caution When power voltage is increased and the first read operation is performed after decrease in power voltage occurs and the latch circuit latches "H", "1" can be read on the POWER flag, however, if the next read operation is performed after the sampling of the detecting circuit, the POWER flag is reset since sampling is subsequently allowed. See the timing diagram below.

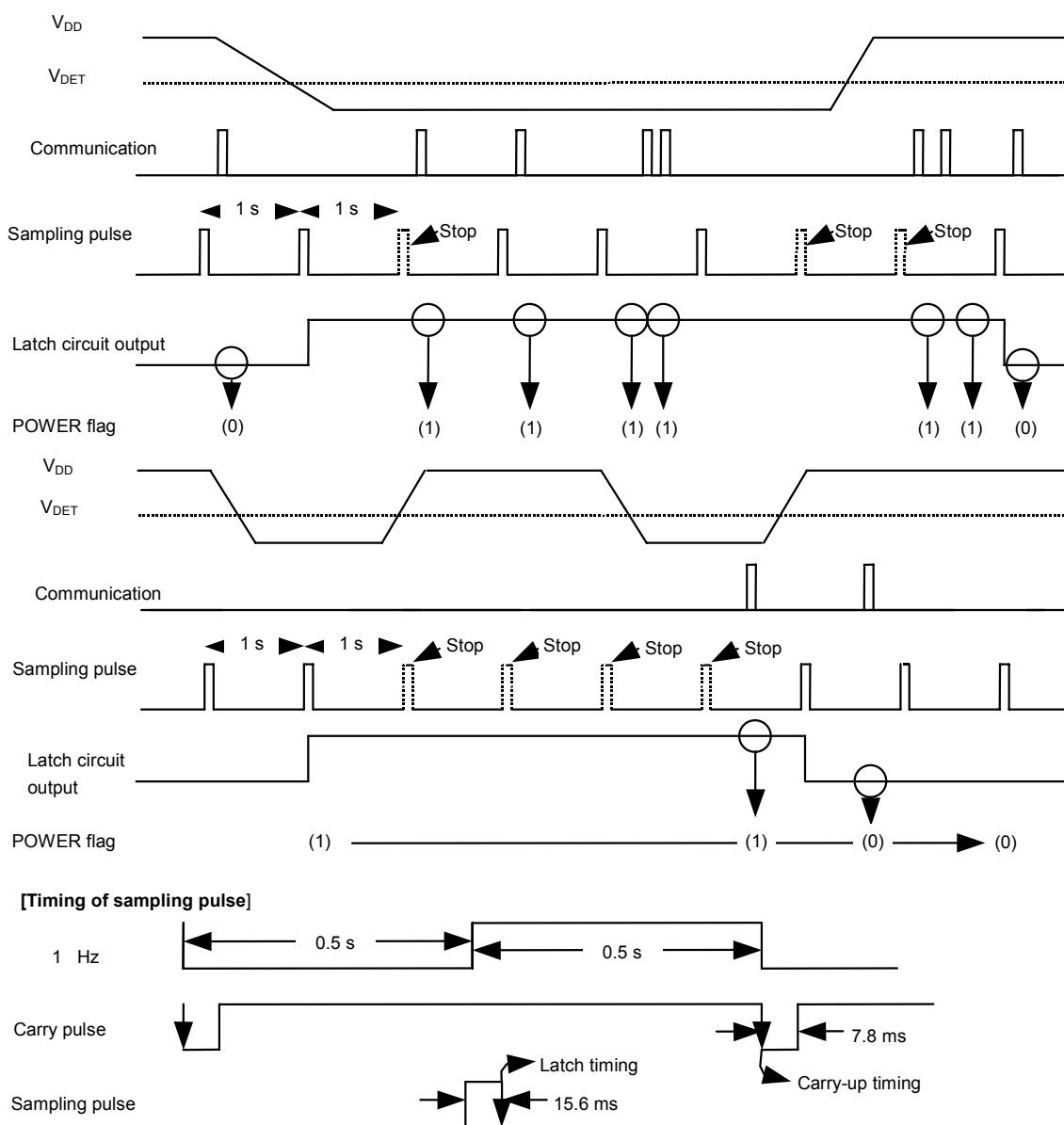
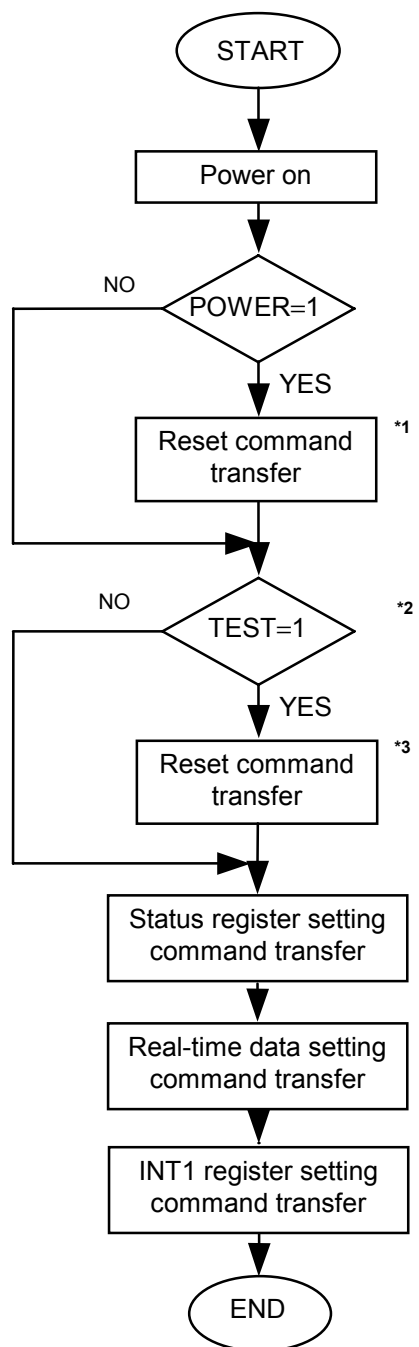


Figure 19 Timing of the power voltage detecting circuit

7. Example of software treatment

(1) Initialization flow at power-on



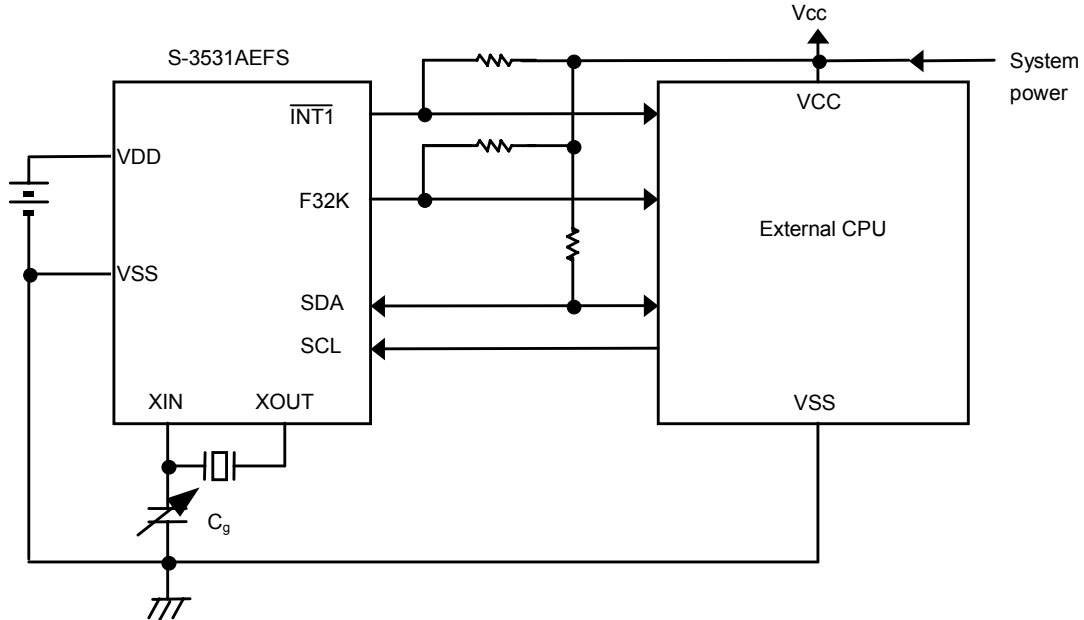
*1. If S-3531A is back-up and power is turned on only on the CPU side, the reset command does not need transferring.

*2. If conditions are no good (e.g., noise) and probable changes in commands occurs via serial communications, it is recommended to make sure the TEST flag.

*3. The test ending command may be used alternately

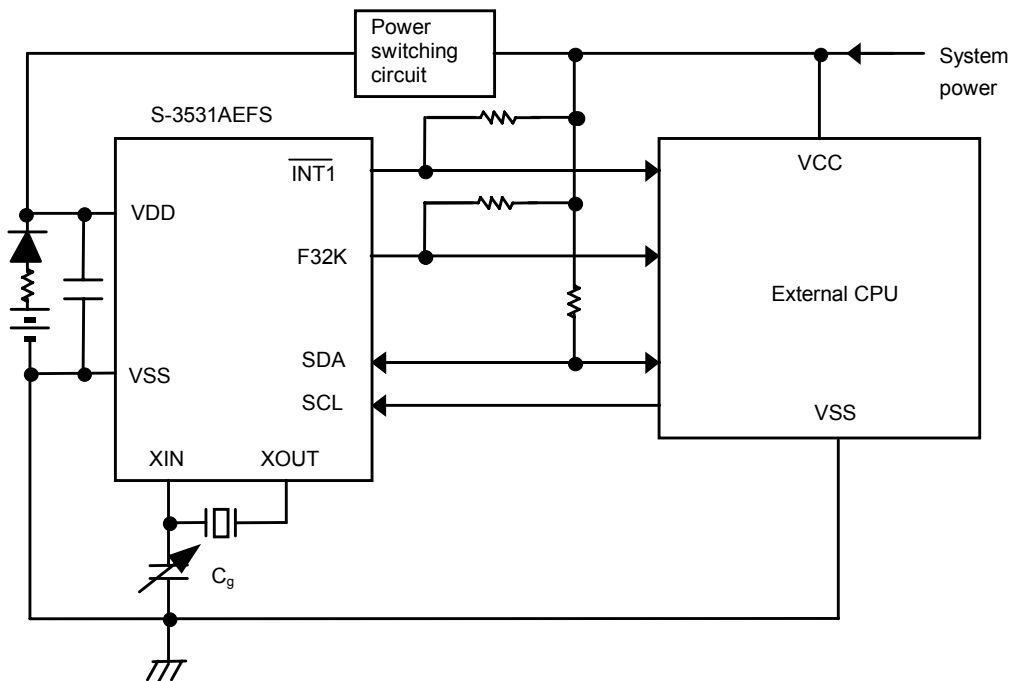
Figure 20 Initialization flow

■ Samples of Application Circuits



Due to the I/O pin with no protective diode on the VDD side, the relation of $VCC \geq VDD$ has no problem but give great care to the standard. Make communications after the system power is turned on and a stable state is obtained.

Figure 21 Application circuit 1



Make communications after the system power is turned on and a stable state is obtained.

Figure 22 Application circuit 2

Caution The application circuits above do not guarantee proper operation.
Evaluate in the actual application to determine the correct constants.

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■ Adjustment of Oscillating Frequency

1. Configuration of the oscillating circuit

Since crystal oscillation is sensitive to external noises (clock accuracy is affected), the following measures are essential for optimizing your oscillating circuit configuration:

- (1) Place S-3531A, crystal oscillator and external capacitor (C_g) as close to each other as possible.
- (2) Make high the insulation resistance between pins and the substrate wiring patterns of XIN and XOUT.
- (3) Do not place any signal or power lines close to the oscillating circuit.

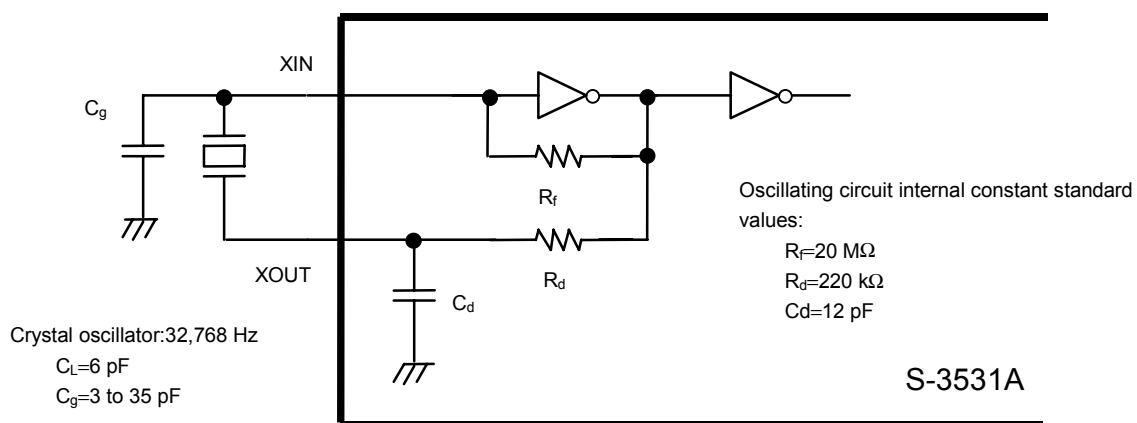


Figure 23 Connection diagram

2. Measurement of oscillating frequencies

When power is turned on, S-3531A has the internal power-on detecting circuit operating and outputs a signal of 1 Hz from the $\overline{\text{INT1}}$ pin to select the crystal oscillator and optimize the C_g value. Turn power on and measure the signal with a frequency counter following the circuit configuration shown in Figure 24.

Remark If the error range is ± 1 ppm, in relation to 1 Hz, time is shifted by approximately 2.6 s a month (as calculated using the following expression).

$$10^{-6} (1 \text{ ppm}) \times 60 \text{ seconds} \times 60 \text{ minutes} \times 24 \text{ hours} \times 30 \text{ days} = 2.592 \text{ seconds}$$

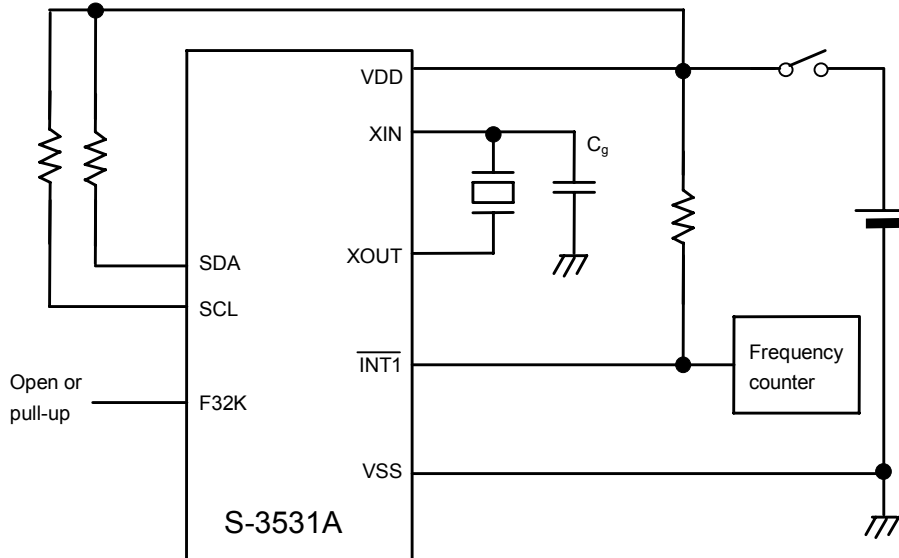


Figure 24 Connection diagram

- Caution 1.** Use a high-accuracy frequency counter (1 ppm order).
2. Since the 1 Hz signal continues to be output, you must send the reset command in normal operation.
 3. Determine C_g with its frequency slow/fast range property referred.

3. Adjustment of oscillating frequencies

Matching of a crystal oscillator with the nominal frequency must be performed with parasitic capacitance on the board included. Select a crystal oscillator and optimize the C_g value in accordance with the flow chart below.

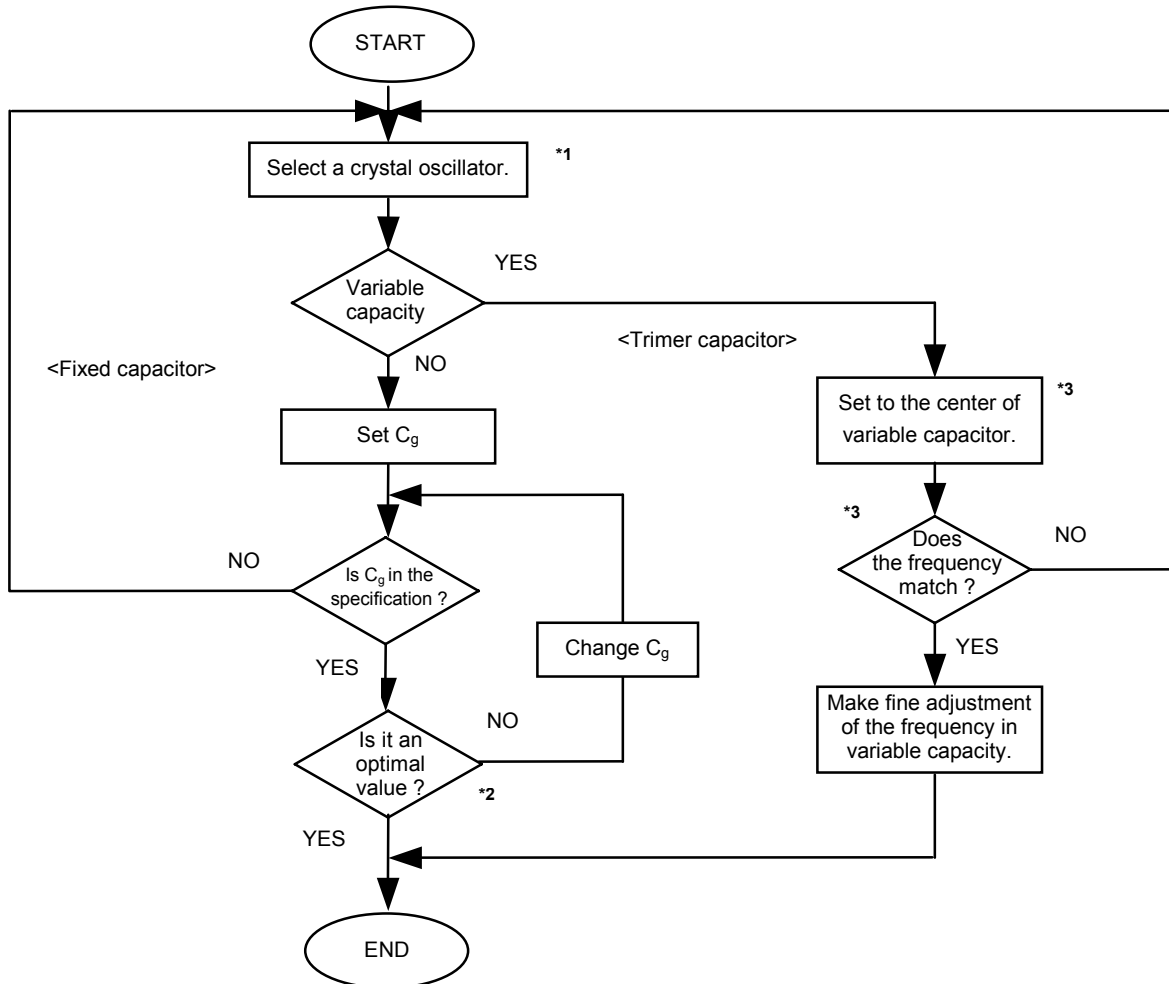


Figure 25 Crystal oscillator setting flow

- *1. For making matching adjustment of the IC with a crystal, contact an appropriate crystal maker to determine the C_L value (load capacity) and R_1 value (equivalent serial resistance). The C_L value = 6 pF and R_1 value = 30 kΩ typ. are recommended values.
- *2. C_g value selection must be performed on the actual PCB since parasitic capacitance affects it. Select the C_g value in a range from 3 pF to 35 pF. If the frequency does not match, change the C_L value of the crystal.
- *3. Adjust the rotation angle of the variable capacity so that the capacity value is somewhat smaller than the center, and confirm the oscillating frequency and the center value of the variable capacity. This is done in order to make the capacity of the center value smaller than one half of the actual capacity value because a smaller capacity value makes a greater quantity of changes in a frequency. If the frequency does not match, change the C_L value of the crystal.

Caution 1. Oscillating frequencies are changed by ambient temperature and power voltage. Refer to property samples.

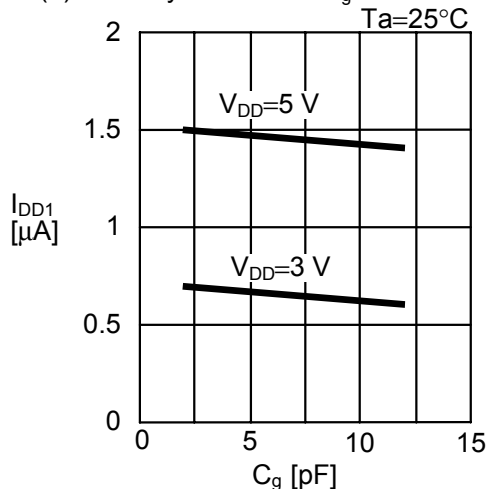
- 2. The 32 kHz crystal oscillator operates slower at higher or lower ambient temperature than 20 to 25°C. Therefore, it is recommended to adjust or set the oscillator to operate somewhat faster at normal temperature.

■ Precautions

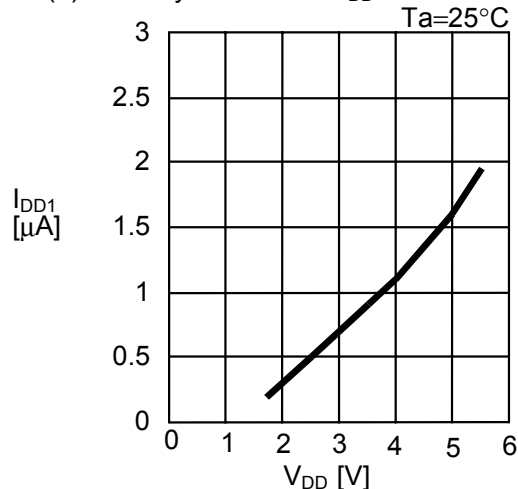
- Do not apply an electrostatic discharge to this IC that exceeds the performance ratings of the built-in electrostatic protection circuit.
- SII claims no responsibility for any disputes arising out of or in connection with any infringement by products including this IC of patents owned by a third party.

■ **Characteristics (Reference Data)**

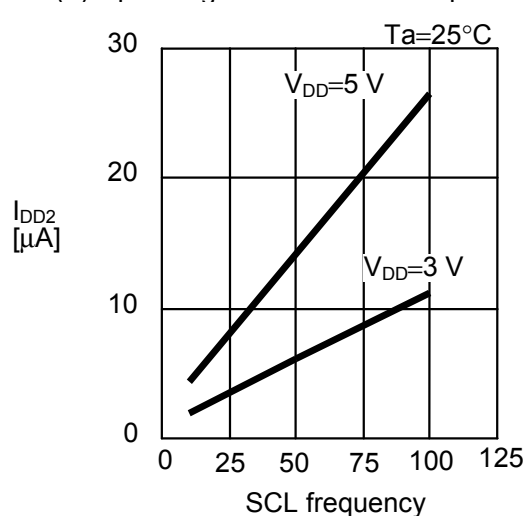
(1) Standby current vs. C_g



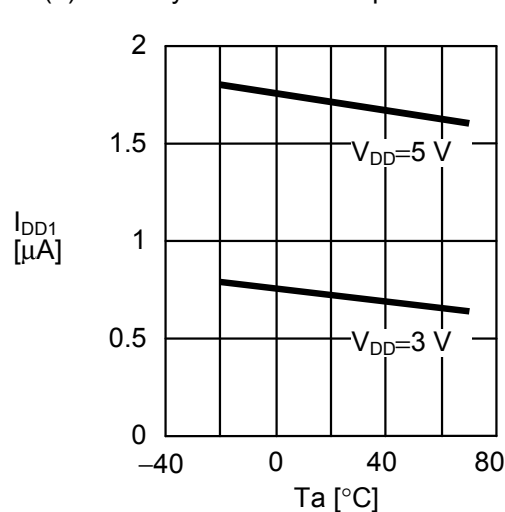
(2) Standby current vs. V_{DD}



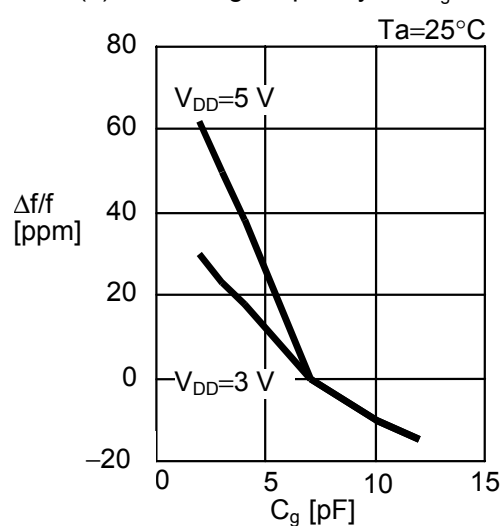
(3) Operating drain current vs. Input clock



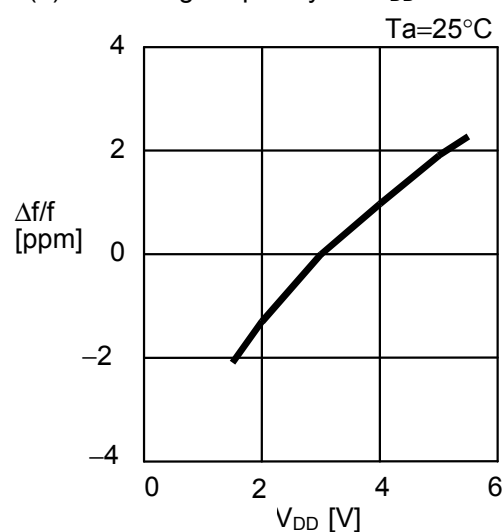
(4) Standby current vs. temperature



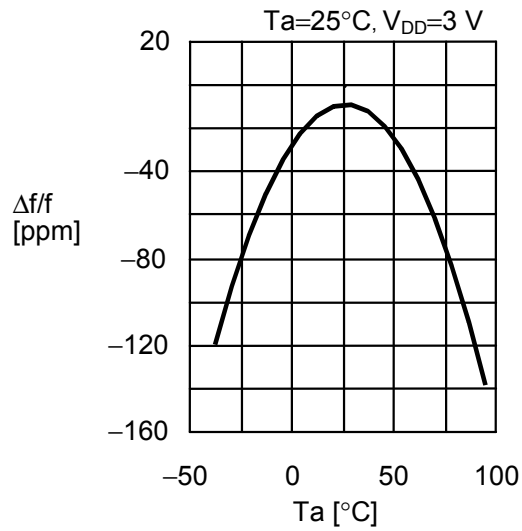
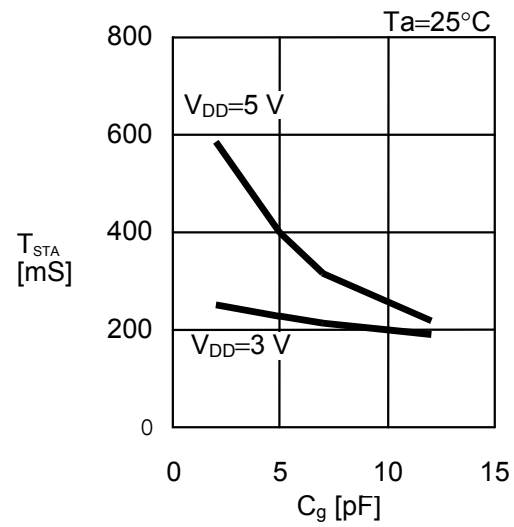
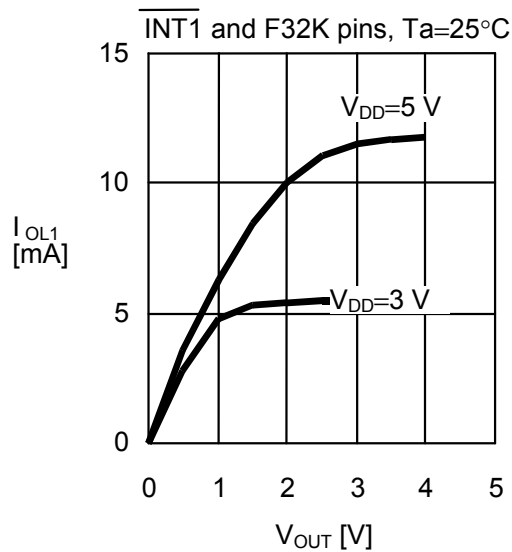
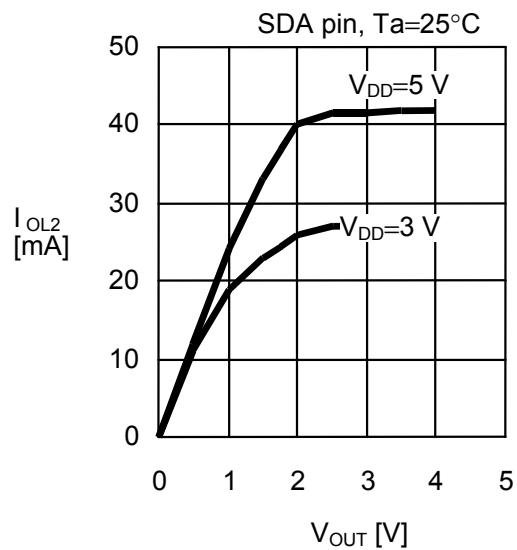
(5) Oscillating frequency vs. C_g

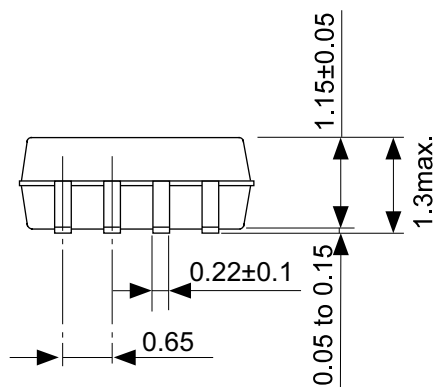
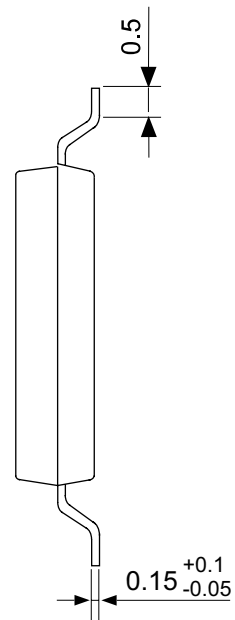
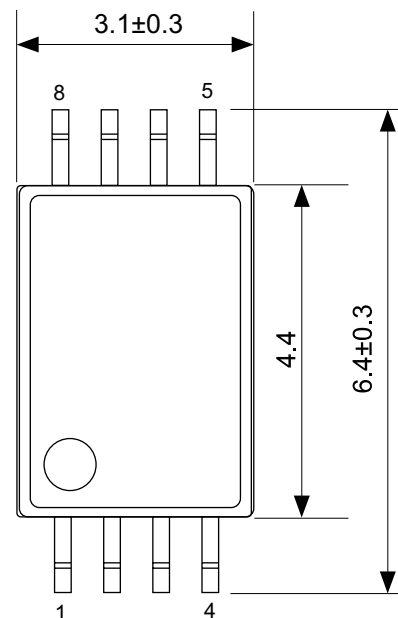


(6) Oscillating frequency vs. V_{DD}



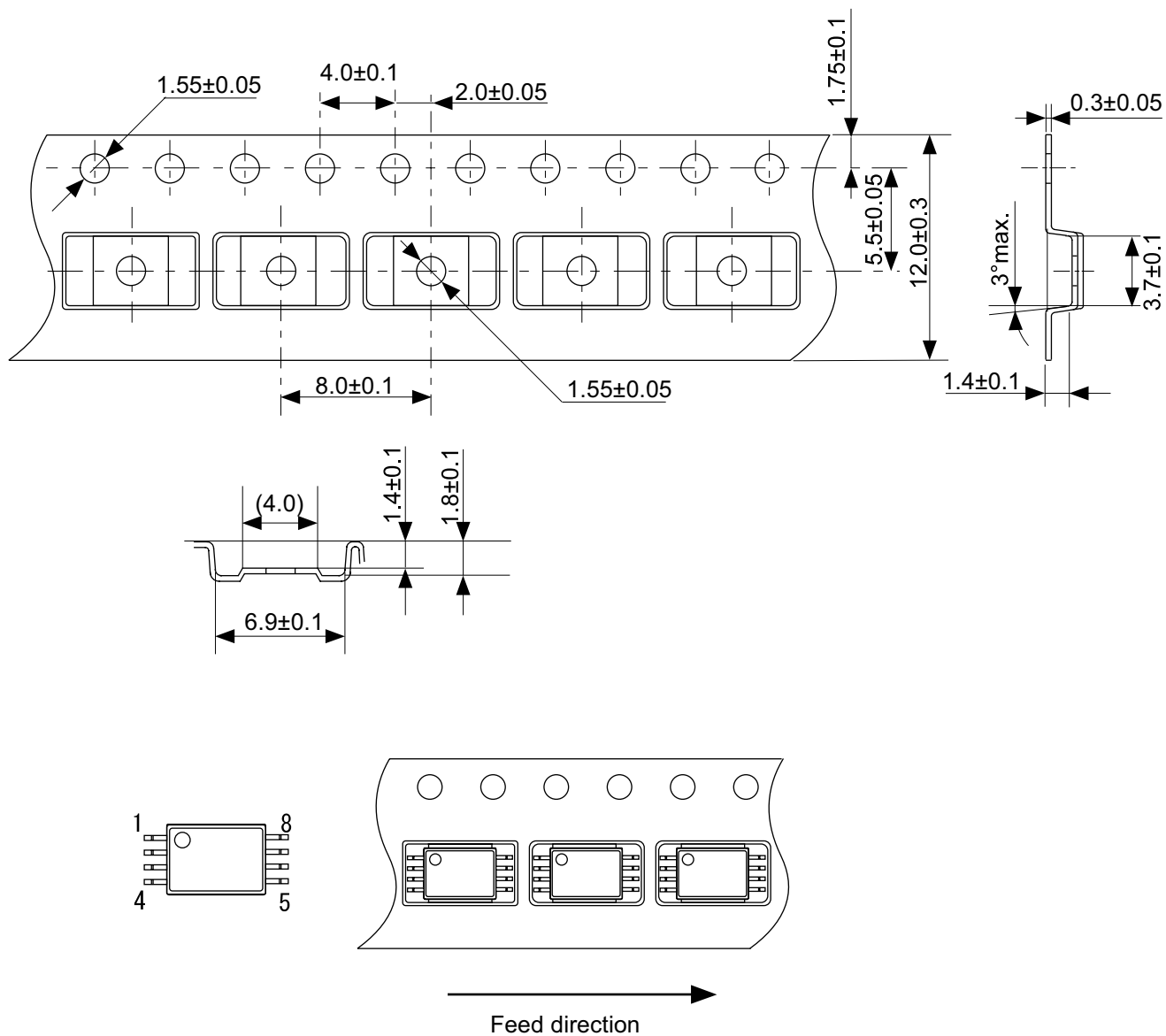
(7) Oscillating frequency vs. temperature

(8) Oscillation start time vs. C_g (9) Output current 1 (V_{OUT} vs. I_{OL1})(10) Output current 2 (V_{OUT} vs. I_{OL2})



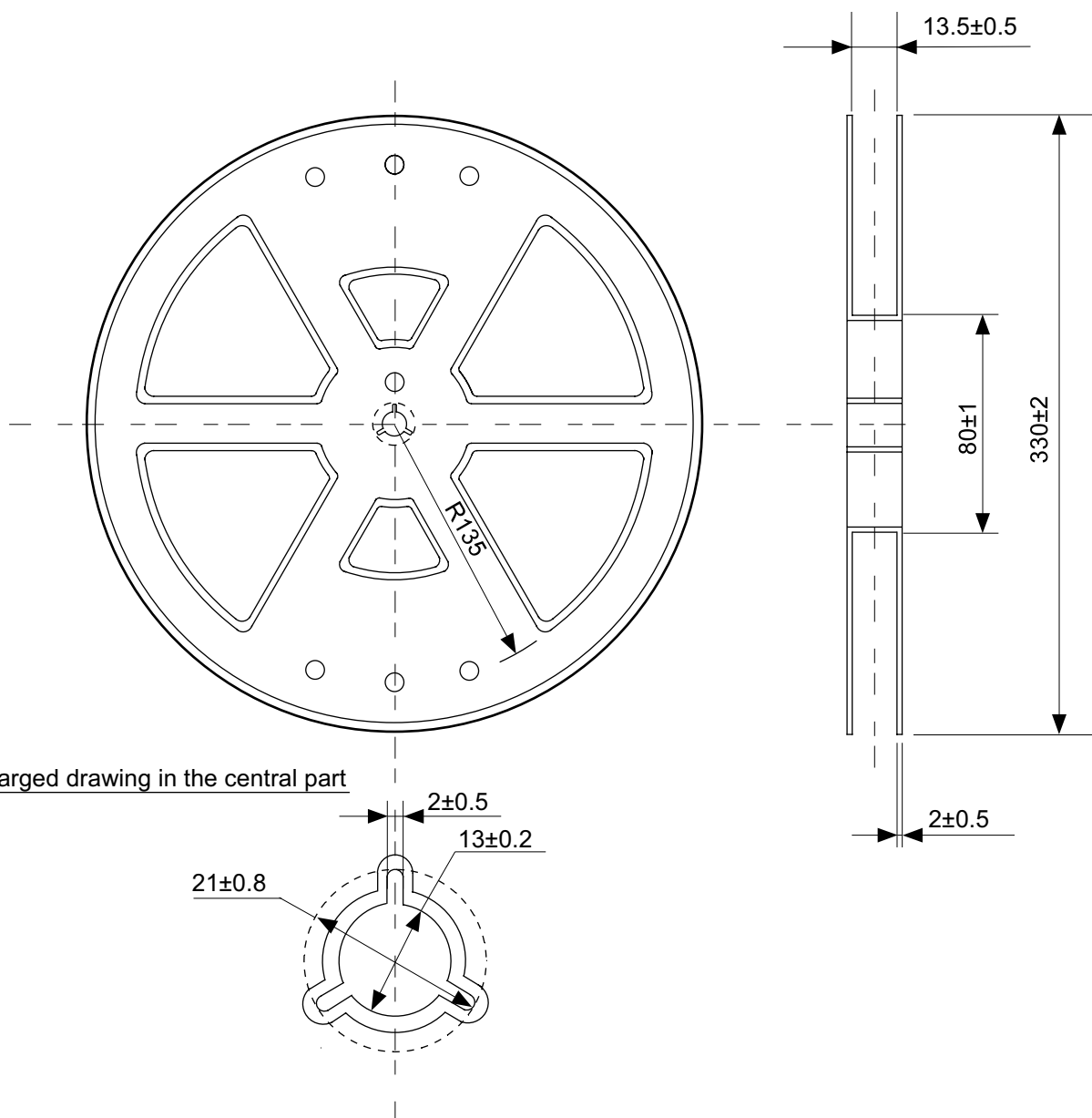
No. FS008-A-P-SD-1.1

TITLE	SSOP8-A-PKG Dimensions
No.	FS008-A-P-SD-1.1
SCALE	
UNIT	mm
Seiko Instruments Inc.	



No. FS008-A-C-SD-1.1

TITLE	SSOP8-A-Carrier Tape
No.	FS008-A-C-SD-1.1
SCALE	
UNIT	mm
Seiko Instruments Inc.	



No. FS008-A-R-SD-1.1

TITLE	SSOP8-A-Reel		
No.	FS008-A-R-SD-1.1		
SCALE		QTY.	2,000
UNIT	mm		
Seiko Instruments Inc.			

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