

AS3932

3D Low Frequency Wakeup Receiver

General Description

The AS3932 is a 3-channel low power ASK receiver that is able to generate a wake-up upon detection of a data signal which uses a LF carrier frequency between 110 - 150 kHz. The integrated correlator can be used for detection of a programmable 16-bit wake-up pattern. The device can operate using one, two, or three active channels.

The AS3932 provides a digital RSSI value for each active channel, it supports a programmable data rate. The AS3932 offers a real-time clock (RTC), which is either derived from a crystal oscillator or the internal RC oscillator.

The programmable features of AS3932 enable to optimize its settings for achieving a longer distance while retaining a reliable wake-up generation. The sensitivity level of AS3932 can be adjusted in presence of a strong field or in noisy environments.

The device is available in 16-pin TSSOP and 16LD QFN (4x4) packages.

[Ordering Information](#) and [Content Guide](#) appear at end of *datasheet*.

Key Benefits & Features

The benefits and features of AS3932, 3D Low Frequency Wakeup Receiver are listed below:

Figure 1:
Added Value of Using AS3932

| Benefits | Features |
|-----------------------------------------------|--------------------------------------------------------------------|
| Enables low power active tags | 3-channel ASK wake-up receiver |
| Selectable carrier frequency | Carrier frequency range 110 - 150 kHz |
| One, two, or three channel operation | 1-D, 2-D, or 3-D wake-up pattern detection |
| Highly resistant to false wake-ups | 16-bit programmable wake-up pattern |
| Improved immunity to false wake-ups | Supporting doubling of wake-up pattern |
| Allows frequency only detection | Wake-up without pattern detection selectable |
| Improved range with best-in-class sensitivity | Wake-up sensitivity 100 μ VRMS (typ.) |
| Adjustable range | Sensitivity level adjustable |
| Provides tracking of false wake-ups | False wake-up counter |
| Ensures wake-up in a noise environment | Periodical forced wake-up supported (1s – 2h) |
| Extended battery life | Current consumption in 3-channel listening mode 1.7 μ A (typ.) |

| Benefits | Features |
|------------------------------|--------------------------------------------------|
| Flexible clock configuration | RTC based 32 kHz XTAL, RC-OSC, or external clock |
| Operates from a 3V battery | Operating supply range 2.4V – 3.6V (TA = 25°C) |
| Industrial temperature range | Operation temperature range -40°C to +85°C |

Applications

The AS3932 is ideal for:

- Active RFID tags,
- Real-time location systems,
- Operator identification,
- Access control, and
- Wireless sensors.

Figure 2:
AS3932 Typical Application Diagram with Crystal Oscillator

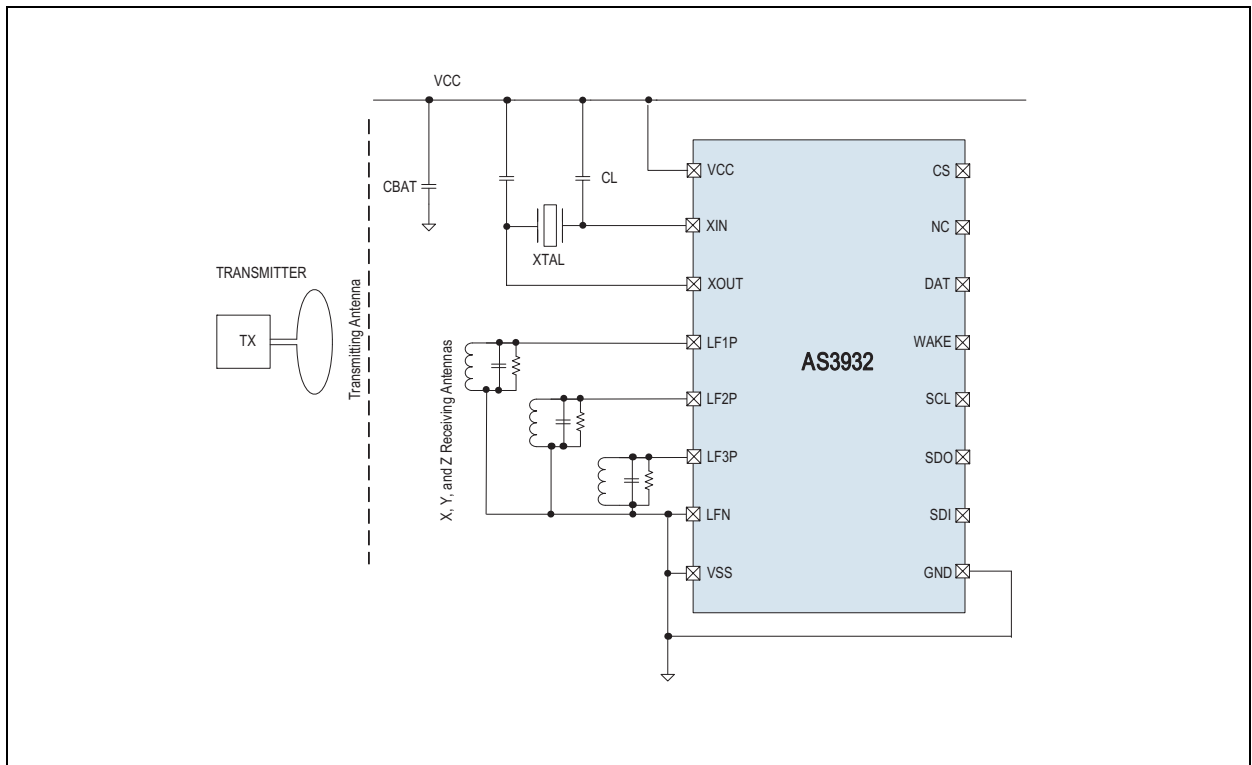


Figure 3:
AS3932 Typical Application Diagram with RC Oscillator

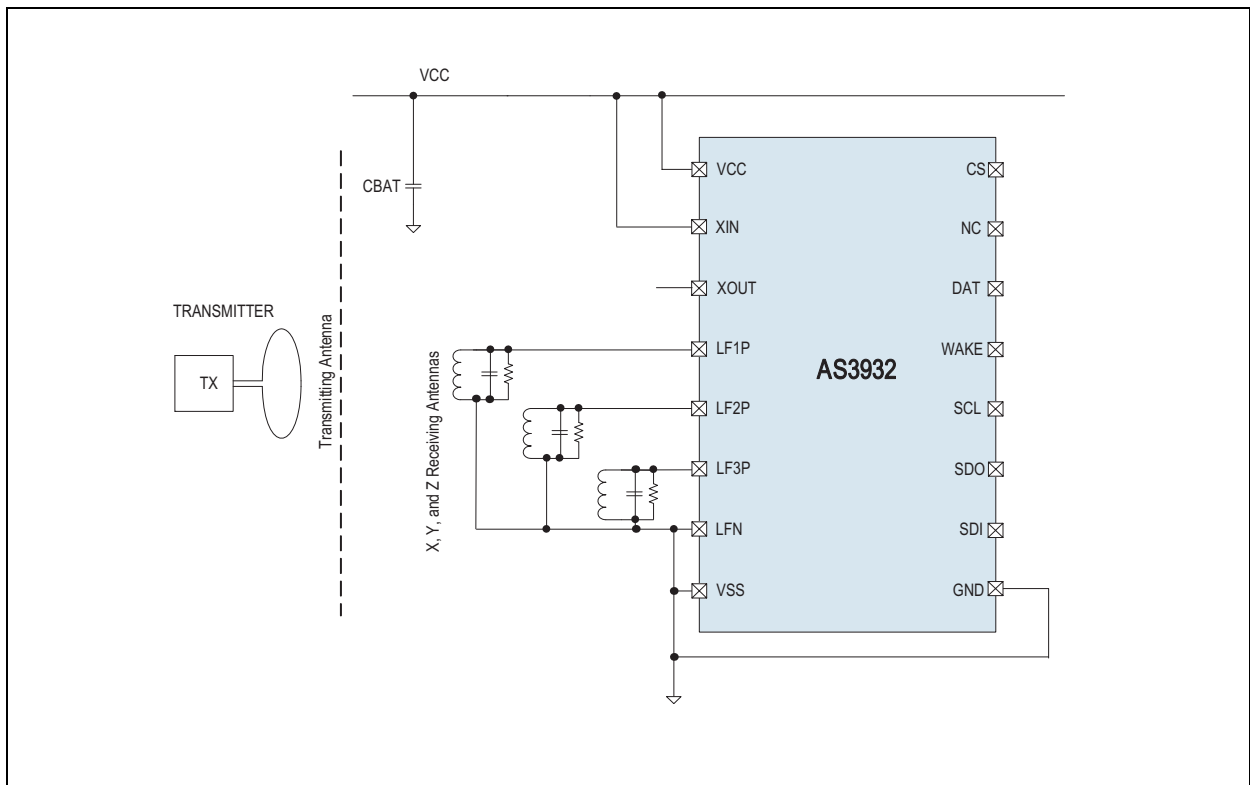
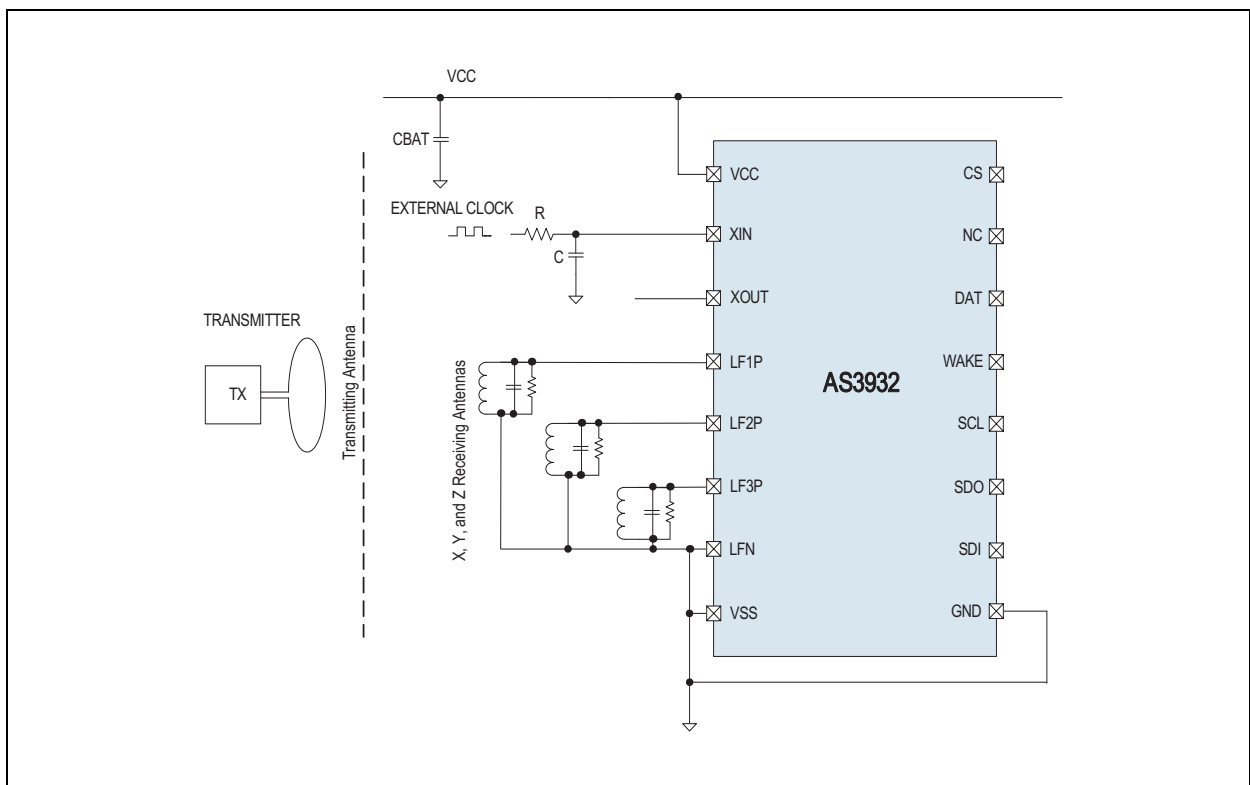


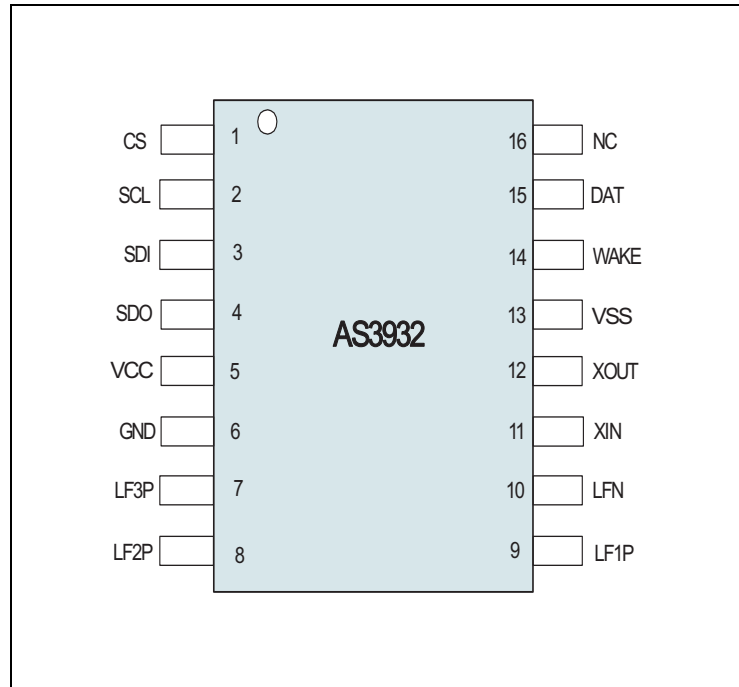
Figure 4:
AS3932 Typical Application Diagram with Clock from External Source



Pin Assignment

TSSOP Package

Figure 5:
Pin Assignments 16-pin TSSOP Package



Pin Description

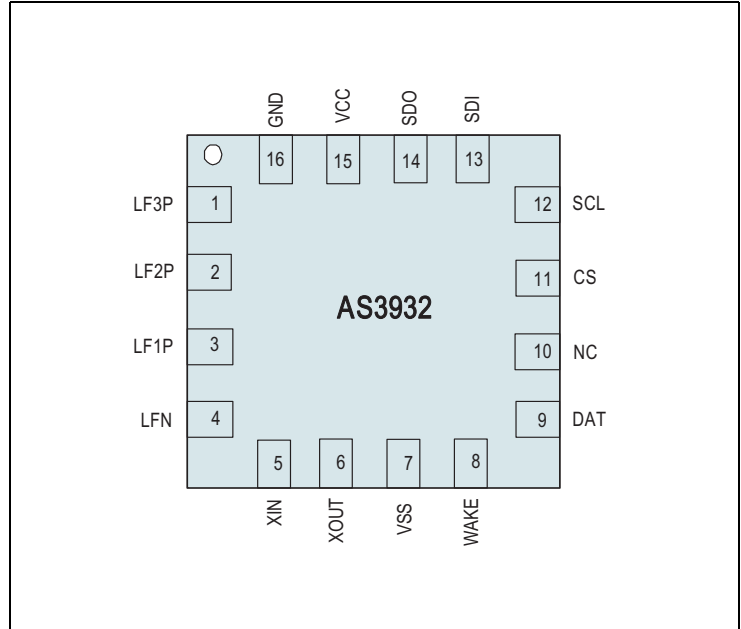
Figure 6:
Pin Descriptions 16-pin TSSOP Package

| Pin Name | Pin Number | Pin Type | Description |
|----------|------------|---------------------------|-------------------------------------------|
| CS | 1 | Digital input | Chip select |
| SCL | 2 | | SDI interface clock |
| SDI | 3 | | SDI data input |
| SDO | 4 | Digital output / tristate | SDI data output (tristate when CS is low) |
| VCC | 5 | Supply pad | Positive supply voltage |
| GND | 6 | Supply pad | Negative supply voltage |

| Pin Name | Pin Number | Pin Type | Description |
|-----------------|------------|----------------|----------------------------------------------|
| LF3P | 7 | Analog I/O | Input antenna channel three |
| LF2P | 8 | | Input antenna channel two |
| LF1P | 9 | | Input antenna channel one |
| LFN | 10 | | Common ground for antenna one, two and three |
| XIN | 11 | | Crystal oscillator input |
| XOUT | 12 | | Crystal oscillator output |
| V _{SS} | 13 | Supply pad | Substrate |
| WAKE | 14 | Digital output | Wake-up output IRQ |
| DAT | 15 | | Data output |
| NC | 16 | - | Not connected |

QFN Package

Figure 7:
Pin Assignments 16LD QFN (4x4) Package



Pin Description

Figure 8:
Pin Descriptions 16LD QFN (4×4) Package

| Pin Name | Pin Number | Pin Type | Description |
|-----------------|------------|---------------------------|----------------------------------------------|
| LF3P | 1 | Analog I/O | Input antenna channel three |
| LF2P | 2 | | Input antenna channel two |
| LF1P | 3 | | Input antenna channel one |
| LFN | 4 | | Common ground for antenna one, two and three |
| XIN | 5 | | Crystal oscillator input |
| XOUT | 6 | | Crystal oscillator output |
| V _{SS} | 7 | Supply pad | Substrate |
| WAKE | 8 | Digital output | Wake-up output IRQ |
| DAT | 9 | | Data output |
| NC | 10 | - | Not connected |
| CS | 11 | Digital input | Chip select |
| SCL | 12 | | SDI interface clock |
| SDI | 13 | | SDI data input |
| SDO | 14 | Digital output / tristate | SDI data output (tristate when CS is low) |
| VCC | 15 | Supply pad | Positive supply voltage |
| GND | 16 | Supply pad | Negative supply voltage |

Note(s) and/or Footnote(s):

1. The exposed pad has to be connected to ground.

Absolute Maximum Ratings

Stresses beyond those listed in [Absolute Maximum Ratings](#) may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated in [Electrical Characteristics](#) is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Figure 9:
Absolute Maximum Ratings

| Symbol | Parameter | Min | Max | Unit | Note |
|--------------------------------------------------|-----------------------------------|---------|------|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Electrical Parameters | | | | | |
| V_{DD} | DC supply voltage | -0.5 | 5 | V | |
| V_{IN} | Input pin voltage | -0.5 | 5 | V | |
| I_{SOURCE} | Input current (latch up immunity) | -100 | 100 | mA | Norm: Jedec 78 |
| Electrostatic Discharge | | | | | |
| ESD | Electrostatic discharge | ± 2 | | kV | Norm: MIL 883 E method 3015 (HBM) |
| Continuous Power Dissipation | | | | | |
| P_t | Total power dissipation | | 0.07 | mW | All supplies and outputs |
| Temperature Ranges and Storage Conditions | | | | | |
| T_{strg} | Storage temperature | -65 | 150 | °C | |
| T_{body} | Package body temperature | | 260 | °C | Norm: IPC/JEDEC J-STD-020 <i>The reflow peak soldering temperature (body temperature) is specified according IPC/JEDEC J-STD-020 "Moisture/Reflow Sensitivity Classification for Non-hermetic Solid State Surface Mount Devices".</i> |
| RH_{NC} | Relative Humidity non-condensing | 5 | 85 | % | |
| MSL | Moisture Sensitivity Level | 3 | | | Represents a maximum floor life time of 168h |

Electrical Characteristics

Figure 10:
Electrical Characteristics

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|-------------------------------------------------------------|---------------------------|--------------------------------|--------------------|------------------|-------------------|------|
| Operating Conditions | | | | | | |
| V_{DD} | Positive supply voltage | | 2.4 | | 3.6 | V |
| V_{SS} | Negative supply voltage | | 0 | | 0 | V |
| T_{AMB} | Ambient temperature | | -40 | | 85 | °C |
| DC/AC Characteristics for Digital Inputs and Outputs | | | | | | |
| CMOS Input | | | | | | |
| V_{IH} | High level input voltage | | 0.58* V_{DD} | 0.7* V_{DD} | 0.83* V_{DD} | V |
| V_{IL} | Low level input voltage | | 0.125* V_{DD} | 0.2* V_{DD} | 0.3* V_{DD} | V |
| I_{LEAK} | Input leakage current | | | | 100 | nA |
| CMOS Output | | | | | | |
| V_{OH} | High level output voltage | With a load current of 1 mA | $V_{DD} - 0.4$ | | | V |
| V_{OL} | Low level output voltage | With a load current of 1 mA | | | $V_{SS} + 0.4$ | V |
| C_L | Capacitive load | For a clock frequency of 1 MHz | | | 400 | pF |
| Tristate CMOS Output | | | | | | |
| V_{OH} | High level output voltage | With a load current of 1 mA | $V_{DD} - 0.4$ | | | V |
| V_{OL} | Low level output voltage | With a load current of 1 mA | | | $V_{SS} + 0.4$ | V |
| I_{OZ} | Tristate leakage current | To V_{DD} and V_{SS} | | | 100 | nA |

Figure 11:
Electrical System Specifications

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|------------------------------|---------------------------------------------------------------------------------------------------------|------------------------------------------------|-----|------|-----|------|
| Input Characteristics | | | | | | |
| R_{IN} | Input Impedance | In case no antenna damper is set ($R1<4>=0$) | | 2 | | MΩ |
| Fmin | Minimum Input Frequency | | | 110 | | kHz |
| Fmax | Maximum Input Frequency | | | 150 | | kHz |
| Current Consumption | | | | | | |
| IPWD | Power Down Mode | | | 400 | | nA |
| I1CHRC | Current Consumption in standard listening mode with one active channel and RC-oscillator as RTC | | | 2.7 | | μA |
| I2CHRC | Current Consumption in standard listening mode with two active channels and RC-oscillator as RTC | | | 4.2 | | μA |
| I3CHRC | Current Consumption in standard listening mode with three active channels and RC-oscillator as RTC | | | 5.7 | 8.3 | μA |
| I3CHSCRC | Current Consumption in scanning mode with three active channels and RC-oscillator as RTC | | | 2.7 | | μA |
| I3CHOORC | Current Consumption in ON/ OFF mode with three active channels and RC-oscillator as RTC | 11% Duty Cycle | | 1.7 | | μA |
| | | 50% Duty Cycle | | 3.45 | | |
| I3CHXT | Current Consumption in standard listening mode with three active channels and crystal oscillator as RTC | | | 6.5 | 8.9 | μA |

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|------------------------------|-------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|-----|--------|------|----------------------------|
| IDATA | Current Consumption in Preamble detection / Pattern correlation / Data receiving mode (RC-oscillator) | With 125 kHz carrier frequency and 1kbps data-rate. No load on the output pins. | | 8.3 | 12 | μA |
| Input Sensitivity | | | | | | |
| SENS | Input Sensitivity on all channels | With 125 kHz carrier frequency, chip in default mode, 4 half bits burst + 4 symbols preamble and single preamble detection | | 100 | | μVrms |
| Channel Settling Time | | | | | | |
| TSAMP | Amplifier settling time | | | 250 | | μs |
| Crystal Oscillator | | | | | | |
| FXTAL | Frequency | Crystal dependent | | 32.768 | | kHz |
| TXTAL | Start-up Time | Crystal dependent | | | 1 | s |
| IXTAL | Current consumption | | | 1 | | μA |
| External Clock Source | | | | | | |
| IEXTCL | Current consumption | | | 1 | | μA |
| RC Oscillator | | | | | | |
| FRCNCAL | Frequency | If no calibration is performed | 27 | 32.768 | 42 | kHz |
| FRCCAL32 | Frequency | If calibration with 32.768 kHz reference signal is performed | 31 | 32.768 | 34.5 | kHz |
| FRCCALMAX | Frequency | Maximum achievable frequency after calibration | | 35 | | kHz |
| FRCCALMIN | Frequency | Minimum achievable frequency after calibration | | 30 | | kHz |
| TRC | Start-up time | From RC enable (R1<0> = 0) | | | 1 | s |
| TCALRC | Calibration time | | | | 65 | Periods of reference clock |
| IRC | Current consumption | | | 200 | | nA |

Typical Operating Characteristics

Figure 12:
Sensitivity over Voltage and Temperature

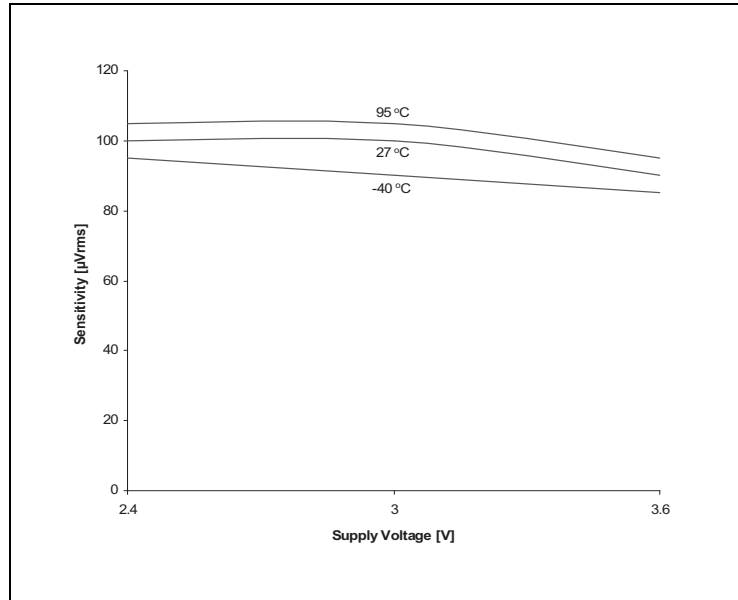


Figure 13:
Sensitivity over RSSI

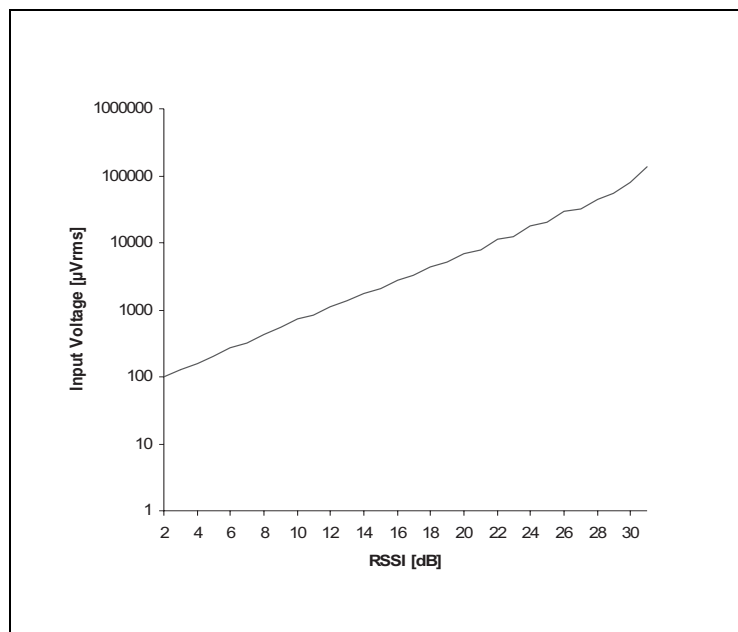


Figure 14:
RC-Osc Frequency over Voltage (calibr.)

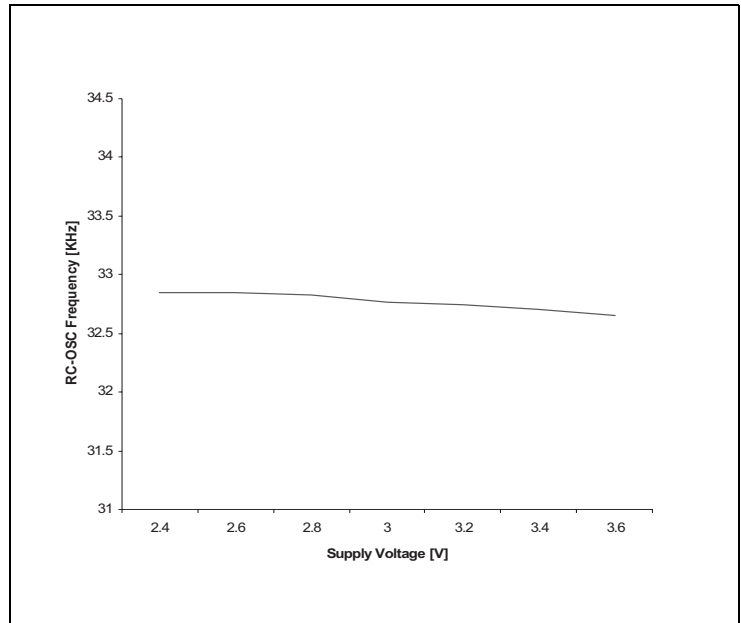
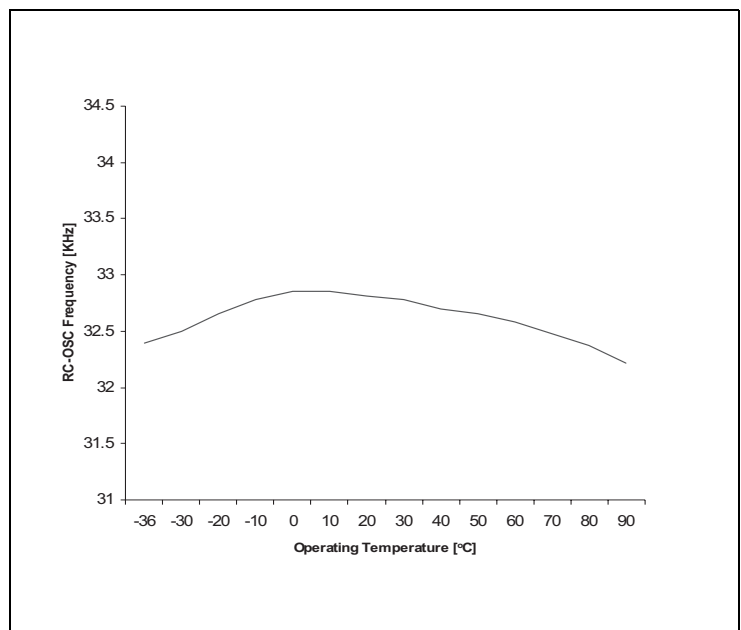


Figure 15:
RC-Osc Frequency over Temperature (calibr.)



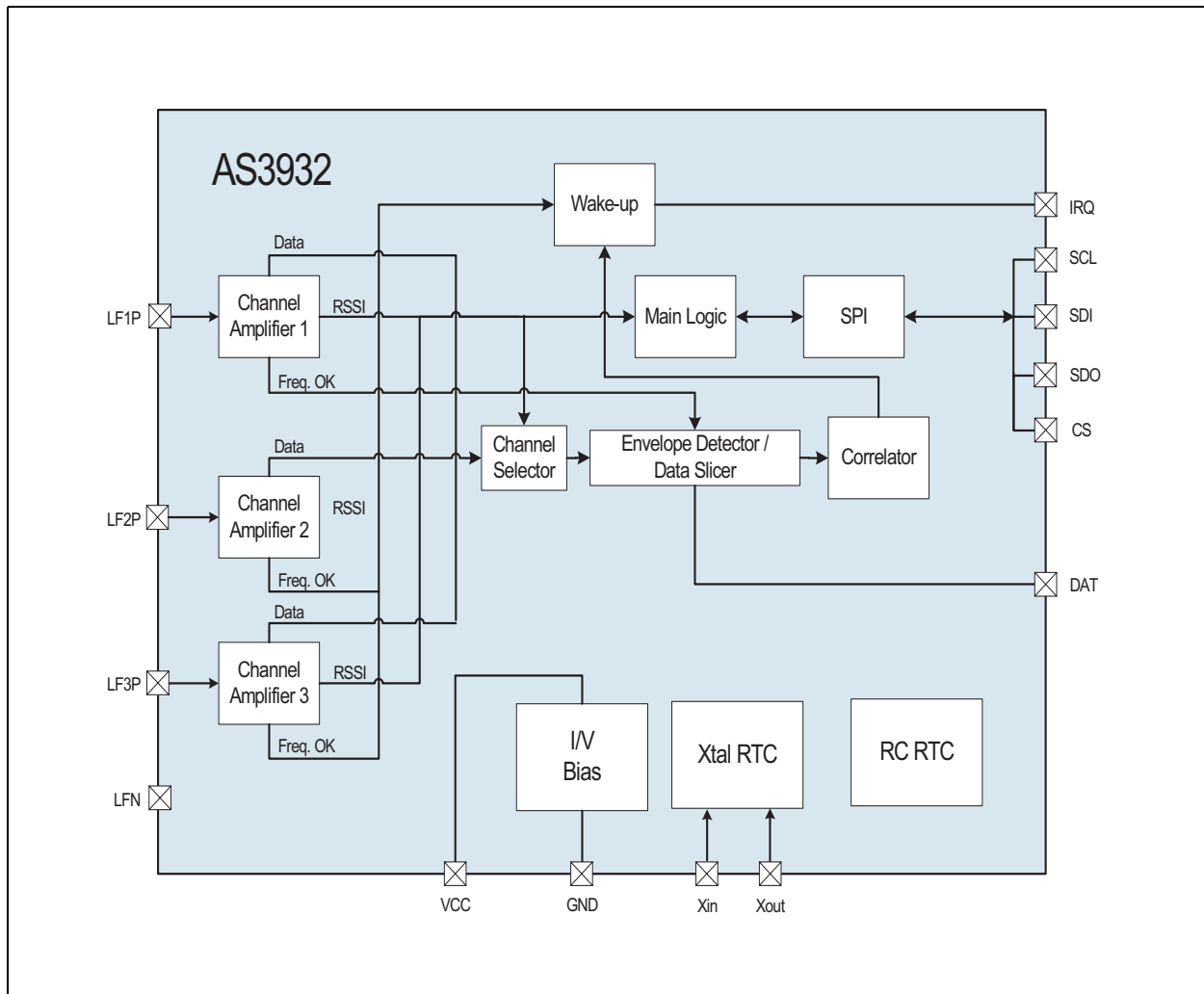
Detailed Description

The AS3932 is a three-dimensional low power low-frequency wake-up receiver. The AS3932 is capable to detect the presence of an inductive coupled carrier and extract the envelope of the ON-OFF-Keying (OOK) modulated carrier. If the detected pattern corresponds to the stored one a wake-up signal (IRQ) is risen up. The pattern correlation can be bypassed in which case the wake-up detection is based only on the frequency detection.

The AS3932 is made up by three independent receiving channels, one envelop detector, one data correlator, 8 programmable registers with the main logic and a real time clock.

The digital logic can be accessed by an SPI. The real time clock can be based on a crystal oscillator or on an internal RC one. If the internal RC oscillator is used, a calibration procedure can be performed to improve its accuracy.

Figure 16:
Block Diagram of LF Wake-up Receiver AS3932



AS3932 needs the following external components:

- Power supply capacitor - CBAT - 100 nF.
- 32.768 kHz crystal with its two pulling capacitors - XTAL and CL - (it is possible to omit these components if the internal RC oscillator is used instead of the crystal oscillator).
- One, two, or three LC resonators according to the number of used channels.

In case the internal RC-oscillator is used (no crystal oscillator is mounted), the pin XIN has to be connected to the supply, while pin XOUT should stay floating. Application diagrams with and without crystal are shown in [Figure 2](#) and [Figure 3](#).

Operating Modes

Power Down Mode

In Power Down Mode AS3932 is completely switched OFF. The typical current consumption is 400 nA.

Listening Mode

In listening mode only the active channel amplifiers and the RTC are running. In this mode the system detects the presence of a carrier. In case the carrier is detected the RSSI can be displayed.

If the three dimensional detection is not required it is possible to deactivate one or more channels. In case only two channels are required the deactivated channel must be the number two, while if only one channel detection is needed the active channel must be the number one.

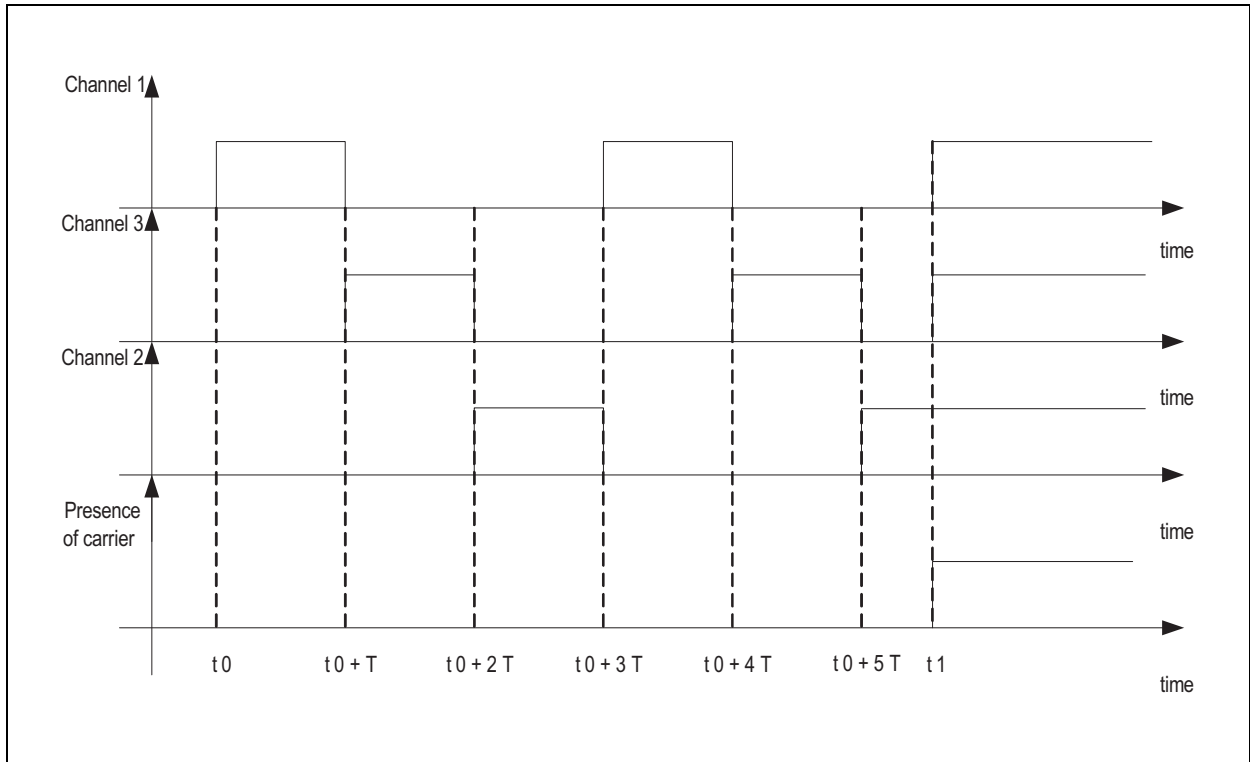
Inside this mode it is possible to distinguish the following three sub modes:

Standard Listening Mode. All channels are active at the same time.

Scanning Mode (Low Power Mode 1). All used channels are active, but only one per time slot, where the time slot T is defined as 1ms. Thus, if all three channels are active the procedure is as follows ([see Figure 17](#)): for the first millisecond only channel one is active while channel two and three are powered down; for the next millisecond only channel three is active while channel one and two are powered down; finally, channel two is active while the other two are deactivated. This channel rotation goes on until the presence of the carrier is detected by any of the channels; then immediately all three channels will become active at the same time. Now AS3932 can perform a simultaneous multidirectional evaluation (on all three channels) of the field and evaluate which channel has the strongest RSSI. The channel with the highest RSSI will be put through to the demodulator.

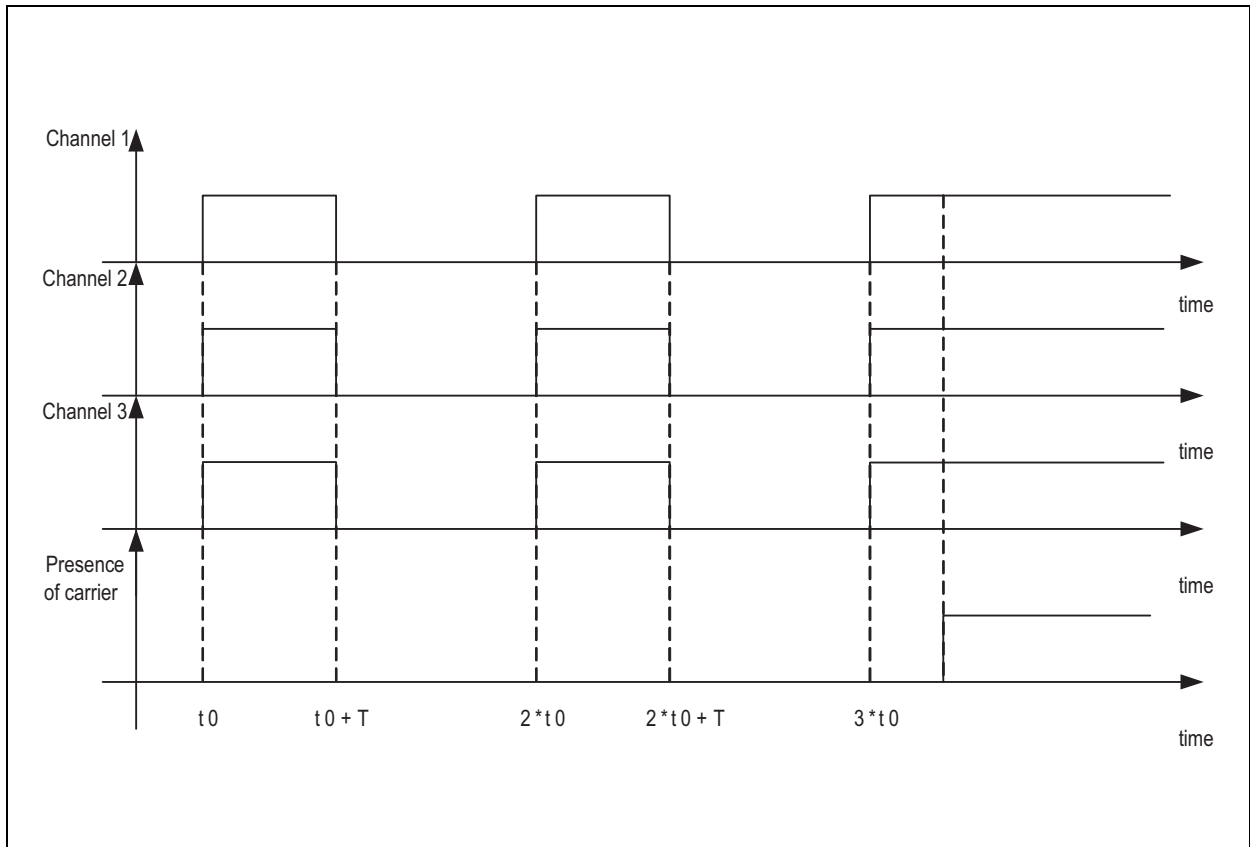
In this way it is possible to perform multidirectional monitoring of the field with a current consumption of a single channel, keeping the sensitivity as good as if all channels are active at the same time.

Figure 17:
Scanning Mode



ON/OFF Mode (Low Power Mode 2). All active channels are ON at the same time but not for the whole time (time slot T is defined as 1ms). An ON-OFF duty-ratio is defined. This duty ratio is programmable see [R4<7:6>](#).

Figure 18:
ON/OFF Mode



For each of these sub modes it is possible to enable a further feature called Artificial Wake-up. The Artificial Wake-up is a counter based on the used RTC. Three bits define a time window see [R8<2:0>](#). If no activity is seen within this time window the chip will produce an interrupt on the WAKE pin that lasts 128 μ s. With this interrupt the microcontroller (μ C) can get feedback on the surrounding environment (e.g. read the false wake-up register [R13<7:0>](#)) and/or take actions in order to change the setup.

Preamble Detection / Pattern Correlation

The preamble detection and pattern correlation are only considered for the wake-up when the data correlator function is enabled (see [R1<1>](#)). The correlator searches first for preamble frequency (constant frequency of Manchester clock defined according to bit-rate transmission, see [Figure 37](#)) and then for data pattern.

If the pattern is matched the wake-up interrupt is displayed on the WAKE output and the chip goes in Data receiving mode. If the pattern fails the internal wake-up (on all active channels) is terminated and no IRQ is produced.

Data Receiving

After a successful wake-up the chip enters the data receiving mode. In this mode the chip can be retained a normal OOK receiver. The received data are streamed out on the pin DAT. It is possible to put the chip back to listening mode either with a direct command (CLEAR_WAKE (see Figure 25)) or by using the timeout feature. This feature automatically sets the chip back to listening mode after a certain time [R7<7:5>](#).

System and Block Specification

Register Table

Figure 19:
Register Table

| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|-----|------------|--------------|-------------|-------------|---------|-------------|------------|--------|
| R0 | n.a. | | ON_OFF | MUX_123 | EN_A2 | EN_A3 | EN_A1 | PWD |
| R1 | ABS_HY | AGC_TLM | AGC_UD | ATT_ON | | EN_PAT2 | EN_WPAT | EN_RTC |
| R2 | S_ABSH | W_PAT_T<1:0> | | Reserved | | | S_WU1<1:0> | |
| R3 | HY_20m | HY_POS | FS_SLC<2:0> | | | FS_ENV<2:0> | | |
| R4 | T_OFF<1:0> | | R_VAL<1:0> | | GR<3:0> | | | |
| R5 | TS2<7:0> | | | | | | | |
| R6 | TS1<7:0> | | | | | | | |
| R7 | T_OUT<2:0> | | | T_HBIT<4:0> | | | | |
| R8 | n.a | | | | | T_AUTO<2:0> | | |
| R9 | n.a | Reserved | | | | | | |
| R10 | n.a | | | RSSI1<4:0> | | | | |
| R11 | n.a | | | RSSI3<4:0> | | | | |
| R12 | n.a | | | RSSI2<4:0> | | | | |
| R13 | F_WAKE | | | | | | | |

Register Table Description and Default Values

Figure 20:
Default Values of Registers

| Register | Name | Type | Default Value | Description |
|----------|----------|------|---------------|------------------------------------------------------------------------------------------------------------------------------------|
| R0<5> | ON_OFF | R/W | 0 | ON/OFF operation mode. (Duty-cycle defined in the register R4<7:6>) |
| R0<4> | MUX_123 | R/W | 0 | Scan mode enable |
| R0<3> | EN_A2 | R/W | 1 | Channel 2 enable |
| R0<2> | EN_A3 | R/W | 1 | Channel 3 enable |
| R0<1> | EN_A1 | R/W | 1 | Channel 1 enable |
| R0<0> | PWD | R/W | 0 | Power down |
| R1<7> | ABS_HY | R/W | 0 | Data slicer absolute reference |
| R1<6> | AGC_TLIM | R/W | 0 | AGC acting only on the first carrier burst |
| R1<5> | AGC_UD | R/W | 1 | AGC operating in both direction (up-down) |
| R1<4> | ATT_ON | R/W | 0 | Antenna damper enable |
| R1<2> | EN_PAT2 | R/W | 0 | Double wake-up pattern correlation |
| R1<1> | EN_WPAT | R/W | 1 | Data correlation enable |
| R1<0> | EN_RTC | R/W | 1 | Crystal oscillator enable |
| R2<7> | S_ABSH | R/W | 0 | Data slicer threshold reduction |
| R2<6:5> | W_PAT | R/W | 00 | Pattern correlation tolerance (see Figure 38) |
| R2<4:2> | Reserved | | 000 | Reserved |
| R2<1:0> | S_WU1 | R/W | 00 | Tolerance setting for the stage wake-up (see Figure 32) |
| R3<7> | HY_20m | R/W | 0 | Data slicer hysteresis if HY_20m = 0 then comparator hysteresis = 40mV if HY_20m = 1 then comparator hysteresis = 20mV |
| R3<6> | HY_POS | R/W | 0 | Data slicer hysteresis on both edges (HY_POS = 0 → hysteresis on both edges; HY_POS = 1 → hysteresis only on positive edges) |
| R3<5:3> | FS_SCL | R/W | 100 | Data slicer time constant (see Figure 36) |
| R3<2:0> | FS_ENV | R/W | 000 | Envelop detector time constant (see Figure 35) |

| Register | Name | Type | Default Value | Description | |
|----------|----------|------|---------------|------------------------------------------|-----------------------|
| R4<7:6> | T_OFF | R/W | 00 | OFF time in ON/OFF operation mode | |
| | | | | T_OFF=00 | 1ms |
| | | | | T_OFF=01 | 2ms |
| | | | | T_OFF=10 | 4ms |
| | | | | T_OFF=11 | 8ms |
| R4<5:4> | D_RES | R/W | 01 | Antenna damping resistor (see Figure 34) | |
| R4<3:0> | GR | R/W | 0000 | Gain reduction (see Figure 33) | |
| R5<7:0> | TS2 | R/W | 01101001 | 2nd Byte of wake-up pattern | |
| R6<7:0> | TS1 | R/W | 10010110 | 1st Byte of wake-up pattern | |
| R7<7:5> | T_OUT | R/W | 000 | Automatic time-out (see Figure 39) | |
| R7<4:0> | T_HBIT | R/W | 01011 | Bit rate definition (see Figure 37) | |
| R8<2:0> | T_AUTO | R/W | 000 | Artificial wake-up | |
| | | | | T_AUTO=000 | No artificial wake-up |
| | | | | T_AUTO=001 | 1 sec |
| | | | | T_AUTO=010 | 5 sec |
| | | | | T_AUTO=011 | 20 sec |
| | | | | T_AUTO=100 | 2 min |
| | | | | T_AUTO=101 | 15min |
| | | | | T_AUTO=110 | 1 hour |
| | | | | T_AUTO=111 | 2 hour |
| R9<6:0> | Reserved | | 000000 | Reserved | |
| R10<4:0> | RSSI1 | R | | RSSI channel 1 | |
| R11<4:0> | RSSI2 | R | | RSSI channel 2 | |
| R12<4:0> | RSSI3 | R | | RSSI channel 3 | |
| R13<7:0> | F_WAK | R | | False wake-up register | |

Serial Data Interface (SDI)

This 4-wires interface is used by the Microcontroller (μ C) to program the AS3932. The maximum clock frequency of the SDI is 2MHz.

Figure 21:
Serial Data Interface (SDI) Pins

| Name | Signal | Signal Level | Description |
|------|------------------------------|--------------|----------------------------------------------------------------------------------------------------------------|
| CS | Digital Input with pull down | CMOS | Chip Select |
| SDI | Digital Input with pull down | CMOS | Serial Data input for writing registers, data to transmit and/or writing addresses to select readable register |
| SDO | Digital Output | CMOS | Serial Data output for received data or read value of selected registers |
| SCLK | Digital Input with pull down | CMOS | Clock for serial data read and write |

Note(s): SDO is set to tristate if CS is low. In this way more than one device can communicate on the same SDO bus.

SDI Command Structure. To program the SDI the CS signal has to go high. A SDI command is made up by a two bytes serial command and the data is sampled on the falling edge of SCLK. The [Figure 22](#) shows how the command looks like, from the MSB (B15) to LSB (B0). The command stream has to be sent to the SDI from the MSB (B15) to the LSB (B0).

Figure 22:
SDI Command Structure

| Mode | | Register Address / Direct Command | | | | | | Register Data | | | | | | |
|------|-----|-----------------------------------|-----|-----|-----|----|----|---------------|----|----|----|----|----|----|
| B15 | B14 | B13 | B12 | B11 | B10 | B9 | B8 | B7 | B6 | B5 | B3 | B2 | B1 | B0 |

The first two bits (B15 and B14) define the operating mode. There are three modes available (write, read, direct command) plus one spare (not used), as shown in [Figure 23](#).

Figure 23:
SDI Command Structure

| B15 | B14 | Mode |
|-----|-----|----------------|
| 0 | 0 | WRITE |
| 0 | 1 | READ |
| 1 | 0 | NOT ALLOWED |
| 1 | 1 | DIRECT COMMAND |

In case a write or read command happens the next 6 bits (B13 to B8) define the register address which has to be written respectively read, as shown in [Figure 24](#).

Figure 24:
SDI Command Structure

| B13 | B12 | B11 | B10 | B9 | B8 | Read/Write Register |
|-----|-----|-----|-----|----|----|---------------------|
| 0 | 0 | 0 | 0 | 0 | 0 | R0 |
| 0 | 0 | 0 | 0 | 0 | 1 | R1 |
| 0 | 0 | 0 | 0 | 1 | 0 | R2 |
| 0 | 0 | 0 | 0 | 1 | 1 | R3 |
| 0 | 0 | 0 | 1 | 0 | 0 | R4 |
| 0 | 0 | 0 | 1 | 0 | 1 | R5 |
| 0 | 0 | 0 | 1 | 1 | 0 | R6 |
| 0 | 0 | 0 | 1 | 1 | 1 | R7 |
| 0 | 0 | 1 | 0 | 0 | 0 | R8 |
| 0 | 0 | 1 | 0 | 0 | 1 | R9 |
| 0 | 0 | 1 | 0 | 1 | 0 | R10 |
| 0 | 0 | 1 | 0 | 1 | 1 | R11 |
| 0 | 0 | 1 | 1 | 0 | 0 | R12 |
| 0 | 0 | 1 | 1 | 0 | 1 | R13 |

The last 8 bits are the data that has to be written respectively read. A CS toggle high-low-high terminates the command mode.

If a direct command is sent (B15-B14=11) the bits from B13 to B8 defines the direct command while the last 8 bits are omitted. The [Figure 25](#) shows all possible direct commands:

Figure 25:
List of Direct Commands

| COMMAND_MODE | B13 | B12 | B11 | B10 | B9 | B8 |
|----------------|-----|-----|-----|-----|----|----|
| clear_wake | 0 | 0 | 0 | 0 | 0 | 0 |
| reset_RSSI | 0 | 0 | 0 | 0 | 0 | 1 |
| trim_osc | 0 | 0 | 0 | 0 | 1 | 0 |
| clear_false | 0 | 0 | 0 | 0 | 1 | 1 |
| preset_default | 0 | 0 | 0 | 1 | 0 | 0 |

All direct commands are explained below:

- clear_wake: clears the wake state of the chip. In case the chip has woken up (WAKE pin is high) the chip is set back to listening mode.
- reset_RSSI: resets the RSSI measurement.
- trim_osc: starts the trimming procedure of the internal RC oscillator (see [Figure 46](#)).
- clear_false: resets the false wake-up register (R13<7:0>=00).
- preset_default: sets all register in the default mode, as shown in [Figure 20](#).

Writing of Data to Addressable Registers (WRITE Mode). The SDI is sampled at the falling edge of SCLK (as shown in the following diagrams).

A CS toggling high-low-high indicates the end of the WRITE command after register has been written. The following example shows a write command.

Figure 26:
Writing of a Single Byte (falling edge sampling)

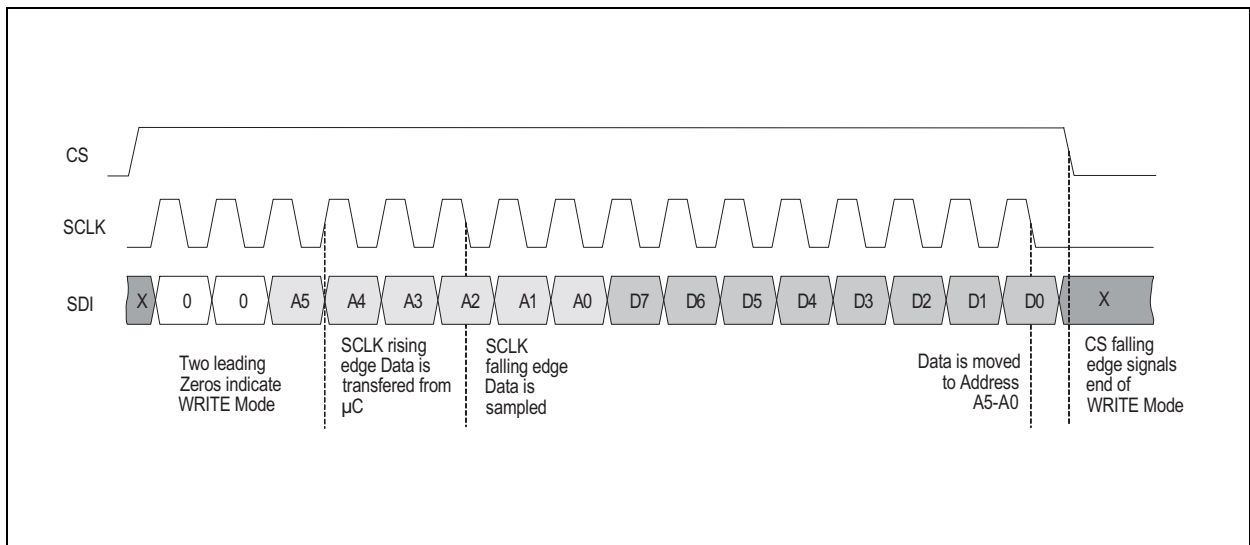
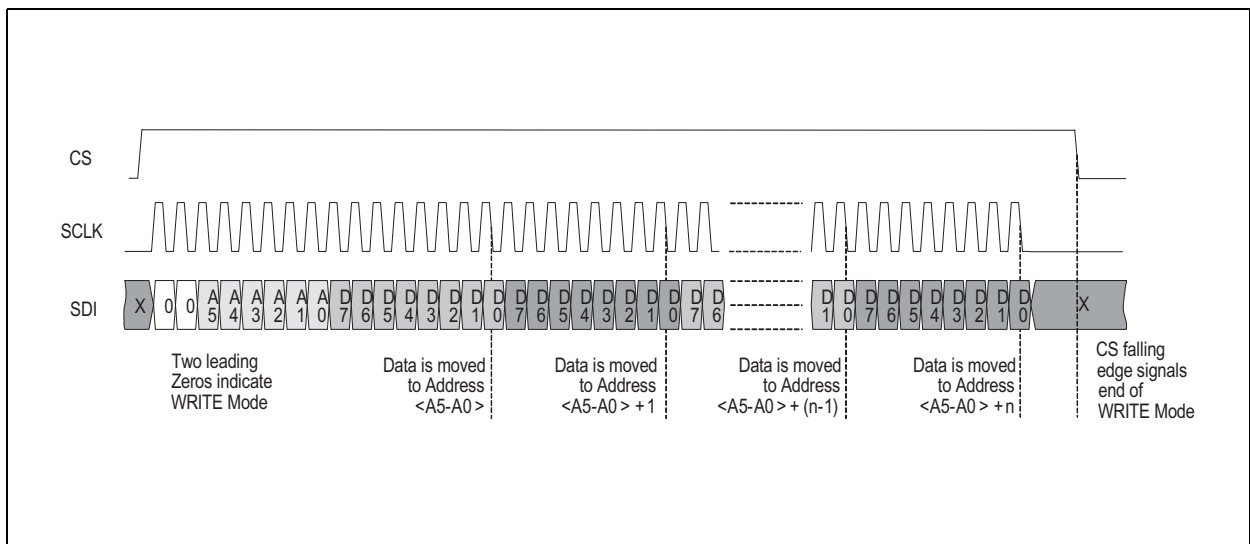


Figure 27:
Writing of Register Data with Auto-incrementing Address



Reading of Data from Addressable Registers (READ Mode)

Once the address has been sent through SDI, the data can be fed through the SDO pin out to the microcontroller.

A CS LOW toggling high-low-high has to be performed after finishing the read mode session, in order to indicate the end of the READ command and prepare the Interface to the next command control Byte.

To transfer bytes from consecutive addresses, SDI master has to keep the CS signal high and the SCLK clock has to be active as long as data need to be read.

Figure 28:
Reading of Single Register Byte

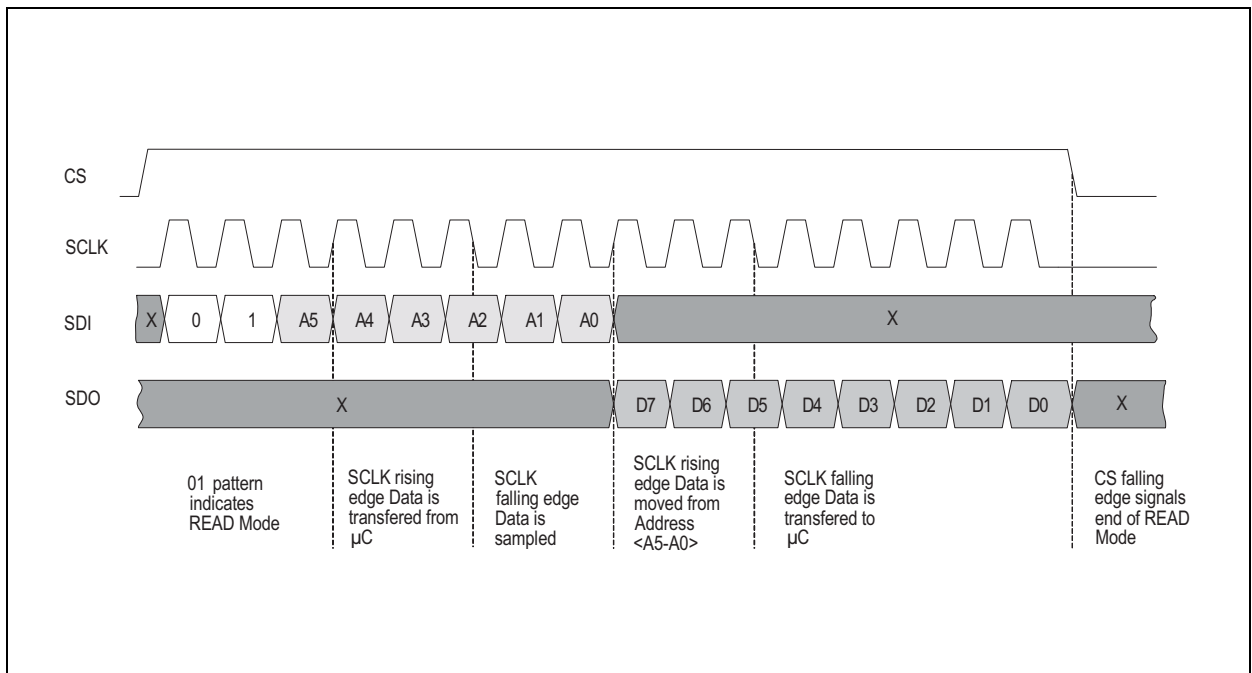
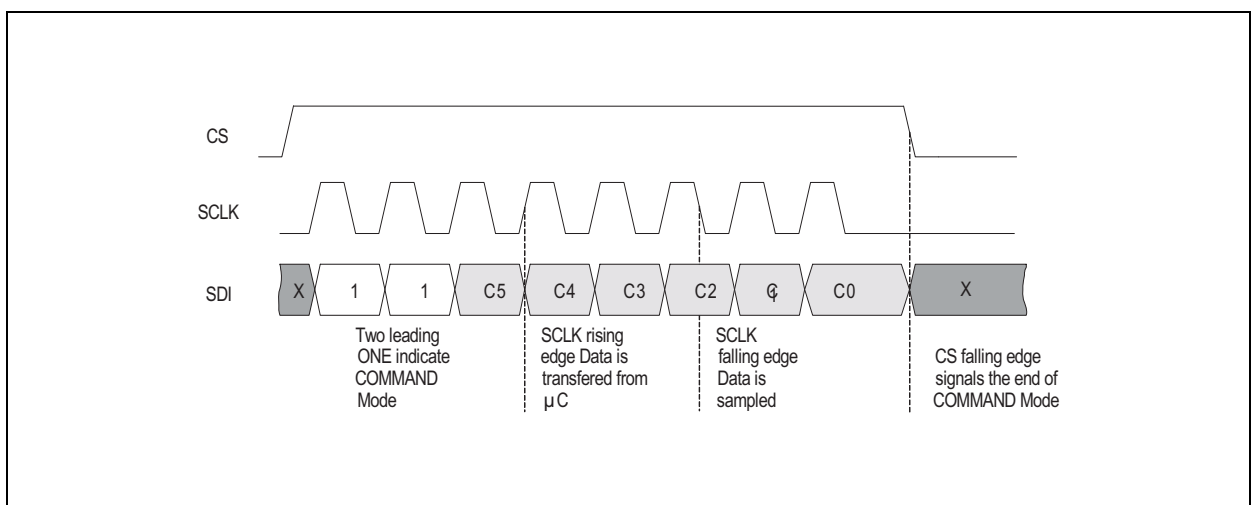


Figure 29:
Send Direct COMMAND Byte

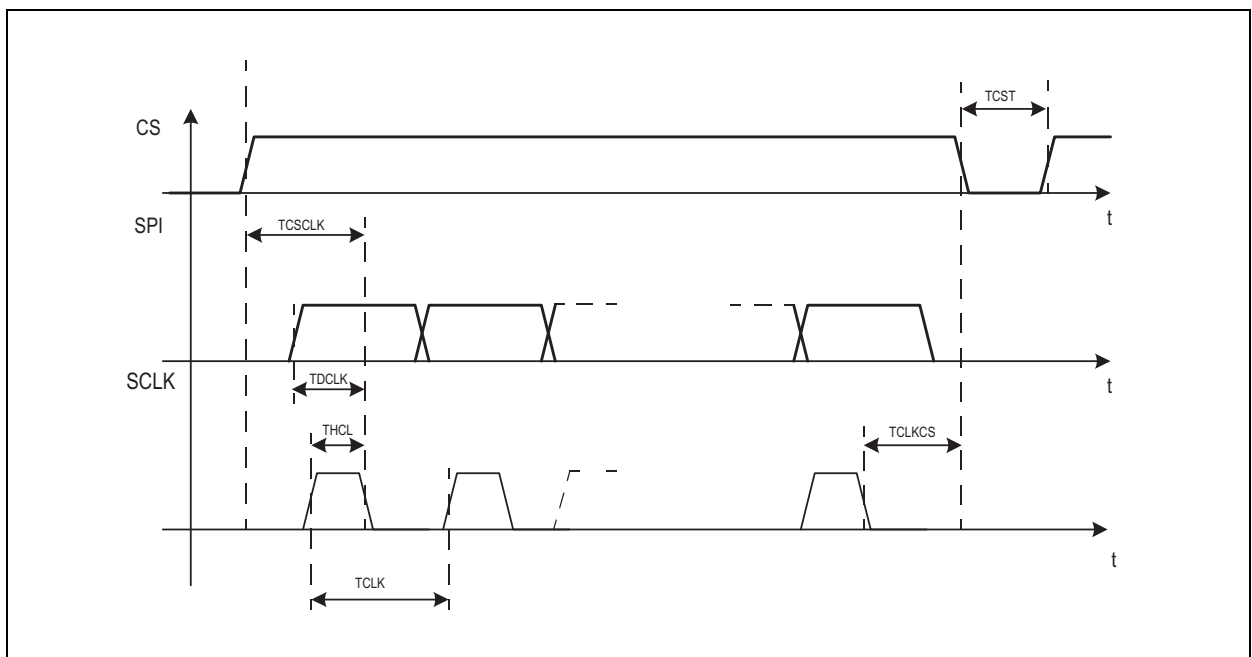


SDI Timing

Figure 30:
SDI Timing Parameters

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|--------|-------------------------------|------------|-----|-----|-----|-------|
| TCCLK | Time CS to Sampling Data | | 500 | | | ns |
| TDCLK | Time Data to Sampling Data | | 300 | | | ns |
| THCL | SCLK High Time | | 200 | | | ns |
| TCLK | SCLK period | | 500 | | | ns |
| TCLKCS | Time Sampling Data to CS down | | 500 | | | ns |
| TCST | CS Toggling time | | 500 | | | ns |

Figure 31:
SDI Timing Diagram



Channel Amplifier and Frequency Detector

Each of the 3 channels consists of a variable gain amplifier, an automatic gain control and a frequency detector. The latter detects the presence of a carrier. As soon as the carrier is detected the AGC is enabled, the gain of the VGA is reduced and set to the right value and the RSSI can be displayed.

It is possible to enable/disable individual channels, in case not all three channels are needed. This enables to reduce the current consumption by 1.5 μ A (typ.) per channel.

Frequency Detector / AGC

The frequency detection uses the RTC as time base. In case the internal RC oscillator is used as RTC, it must be calibrated, but the calibration is guaranteed for a 32.768 kHz crystal oscillator only. The frequency detection criteria can be tighter or more relaxed according to the setup described in R2<1:0> (see Figure 32).

Figure 32:
Tolerance Settings for Wake-up

| R2<1> | R2<0> | Tolerance |
|-------|-------|------------------|
| 0 | 0 | relaxed |
| 0 | 1 | tighter (medium) |
| 1 | 0 | stringent |
| 1 | 1 | reserved |

The AGC can operate in two modes:

- AGC down only (R1<5>=0)
- AGC up and down (R1<5>=1)

As soon as the AGC starts to operate, the gain in the VGA is set to maximum. If the AGC down only mode is selected, the AGC can only decrease the gain. Since the RSSI is directly derived from the VGA gain, the system holds the RSSI peak.

When the AGC up and down mode is selected, the RSSI can follow the input signal strength variation in both directions.

Regardless which AGC operation mode is used, the AGC needs maximum 35 carrier periods to settle.

The RSSI is available for all 3 channels at the same time and it is stored in 3 registers (R10<4:0>, R11<4:0>, R12<4:0>)

Both AGC modes (only down or down and up) can also operate with time limitation. This option allows AGC operation only in time slot of 256 μ s following the internal wake-up. Then the AGC (RSSI) is frozen till the wake-up or RSSI reset occurs.

The RSSI is reset either with the direct command 'clear_wakeup' or 'reset_RSSI'. The 'reset_RSSI' command resets only the AGC setting but does not terminate wake-up condition. This means that if the signal is still present the new AGC setting (RSSI) will appear not later than 300 μ s (35 LF carrier periods) after the command was received. The AGC setting is reset if for duration of 3 Manchester half symbols no carrier is detected. If the wake-up IRQ is cleared the chip will go back to listening mode.

In case the maximum amplification at the beginning is a drawback (e.g. in noisy environment) it is possible to set a smaller starting gain on the amplifier, according to the [Figure 33](#). In this way it is possible to reduce the false frequency detection.

Figure 33:
Bit Setting of Gain Reduction

| R4<3> | R4<2> | R4<1> | R4<0> | Gain Reduction |
|-------|-------|-------|--------|-------------------|
| 0 | 0 | 0 | 0 | No gain reduction |
| 0 | 0 | 0 | 1 | n.a. |
| 0 | 0 | 1 | 0 or 1 | n.a. |
| 0 | 1 | 0 | 0 or 1 | -4dB |
| 0 | 1 | 1 | 0 or 1 | -8dB |
| 1 | 0 | 0 | 0 or 1 | -12dB |
| 1 | 0 | 1 | 0 or 1 | -16dB |
| 1 | 1 | 0 | 0 or 1 | -20dB |
| 1 | 1 | 1 | 0 or 1 | -24dB |

Antenna Damper

The antenna damper allows the chip to deal with higher field strength, it is enabled by register R1<4>. It consists of shunt resistors which degrade the quality factor of the resonator by reducing the signal at the input of the amplifier. In this way the resonator sees a smaller parallel resistance (in the band of interest) which degrades its quality factor in order to increase the linear range of the channel amplifier (the amplifier doesn't saturate in presence of bigger signals). Figure 34 shows the bit setup.

Figure 34:
Antenna Damper Bit Setup

| R4<5> | R4<4> | Shunt Resistor (parallel to the resonator at 125 kHz) |
|-------|-------|-------------------------------------------------------|
| 0 | 0 | 1 kΩ |
| 0 | 1 | 3 kΩ |
| 1 | 0 | 9 kΩ |
| 1 | 1 | 27 kΩ |

Channel Selector / Demodulator / Data Slicer

When at least one of three gain channel enters initial wake-up state the channel selector makes a decision which gain channel to connect to the envelope detector. If only one channel is in wake-up state the selection is obvious. If more than one channel enters wake-up state in 256μs following the first active channel the channel with highest RSSI value is selected. The output signal (amplified LF carrier) of selected channel is connected to the input of the demodulator.

The performance of the demodulator can be optimized according to bit rate and preamble length as described in Figure 35 and Figure 36.

Figure 35:
Bit Setup for the Envelop Detector for Different Symbol Rate

| R3<2> | R3<1> | R3<0> | Symbol Rate [Manchester symbols/s] |
|-------|-------|-------|------------------------------------|
| 0 | 0 | 0 | 4096 |
| 0 | 0 | 1 | 2184 |
| 0 | 1 | 0 | 1490 |
| 0 | 1 | 1 | 1130 |
| 1 | 0 | 0 | 910 |
| 1 | 0 | 1 | 762 |
| 1 | 1 | 0 | 655 |
| 1 | 1 | 1 | 512 |

If the bit rate gets higher the time constant in the envelop detector must be set to a smaller value. This means that higher noise is injected because of the wider band. The next table is a rough indication of how the envelop detector looks like for different bit rates. By using proper data slicer settings it is possible to improve the noise immunity paying the penalty of a longer preamble. In fact if the data slicer has a bigger time constant it is possible to reject more noise, but every time a transmission occurs, the data slicer need time to settle. This settling time will influence the length of the preamble.

[Figure 36](#) gives a correlation between data slicer setup and minimum required preamble length.

Figure 36:
Bit Setup for the Data Slicer for Different Preamble Length

| R3<5> | R3<4> | R3<3> | Minimum Preamble Length [ms] |
|-------|-------|-------|------------------------------|
| 0 | 0 | 0 | 0.8 |
| 0 | 0 | 1 | 1.15 |
| 0 | 1 | 0 | 1.55 |
| 0 | 1 | 1 | 1.9 |
| 1 | 0 | 0 | 2.3 |
| 1 | 0 | 1 | 2.65 |
| 1 | 1 | 0 | 3 |
| 1 | 1 | 1 | 3.5 |

Note(s): These times are minimum required, but it is recommended to prolong the preamble.

The comparator of the data slicer can work only with positive or with symmetrical threshold (R3<6>). In addition the threshold can be 20 or 40 mV (R3<7>).

In case the length of the preamble is an issue the data slicer can also work with an absolute threshold (R1<7>). In this case the bits R3<2:0> would not influence the performance. It is even possible to reduce the absolute threshold in case the environment is not particularly noisy (R2<7>).

Correlator

After frequency detection the data correlation is only performed if the correlator is enabled ($R1<1>=1$).

The data correlation consists of checking the presence of a preamble (ON/OFF modulated carrier) followed by a certain pattern.

After the frequency detection the correlator waits 16 bits (see bit rate definition in [Figure 37](#)) and if no preamble is detected the chip is set back to listening mode and the false wake-up register ($R13<7:0>$) is incremented by one.

To get started with the pattern correlation the correlator needs to detect at least 4 bits of the preamble (ON/OFF modulated carrier).

The bit duration is defined in the register $R7<4:0>$ according to the [Figure 37](#) as function of the Real Time Clock (RTC) periods.

Figure 37:
Bit Rate Setup

| R7<4> | R7<3> | R7<2> | R7<1> | R7<0> | Bit Duration in RTC Clock Periods | Bit Rate (bits/s) | Symbol Rate (Manchester symbols/s) |
|-------|-------|-------|-------|-------|-----------------------------------|-------------------|------------------------------------|
| 0 | 0 | 0 | 1 | 1 | 4 | 8192 | 4096 |
| 0 | 0 | 1 | 0 | 0 | 5 | 6552 | 3276 |
| 0 | 0 | 1 | 0 | 1 | 6 | 5460 | 2730 |
| 0 | 0 | 1 | 1 | 0 | 7 | 4680 | 2340 |
| 0 | 0 | 1 | 1 | 1 | 8 | 4096 | 2048 |
| 0 | 1 | 0 | 0 | 0 | 9 | 3640 | 1820 |
| 0 | 1 | 0 | 0 | 1 | 10 | 3276 | 1638 |
| 0 | 1 | 0 | 1 | 0 | 11 | 2978 | 1489 |
| 0 | 1 | 0 | 1 | 1 | 12 | 2730 | 1365 |
| 0 | 1 | 1 | 0 | 0 | 13 | 2520 | 1260 |
| 0 | 1 | 1 | 0 | 1 | 14 | 2340 | 1170 |
| 0 | 1 | 1 | 1 | 0 | 15 | 2184 | 1092 |
| 0 | 1 | 1 | 1 | 1 | 16 | 2048 | 1024 |
| 1 | 0 | 0 | 0 | 0 | 17 | 1926 | 963 |
| 1 | 0 | 0 | 0 | 1 | 18 | 1820 | 910 |
| 1 | 0 | 0 | 1 | 0 | 19 | 1724 | 862 |
| 1 | 0 | 0 | 1 | 1 | 20 | 1638 | 819 |

| R7<4> | R7<3> | R7<2> | R7<1> | R7<0> | Bit Duration in RTC Clock Periods | Bit Rate (bits/s) | Symbol Rate (Manchester symbols/s) |
|-------|-------|-------|-------|-------|-----------------------------------|-------------------|------------------------------------|
| 1 | 0 | 1 | 0 | 0 | 21 | 1560 | 780 |
| 1 | 0 | 1 | 0 | 1 | 22 | 1488 | 744 |
| 1 | 0 | 1 | 1 | 0 | 23 | 1424 | 712 |
| 1 | 0 | 1 | 1 | 1 | 24 | 1364 | 682 |
| 1 | 1 | 0 | 0 | 0 | 25 | 1310 | 655 |
| 1 | 1 | 0 | 0 | 1 | 26 | 1260 | 630 |
| 1 | 1 | 0 | 1 | 0 | 27 | 1212 | 606 |
| 1 | 1 | 0 | 1 | 1 | 28 | 1170 | 585 |
| 1 | 1 | 1 | 0 | 0 | 29 | 1128 | 564 |
| 1 | 1 | 1 | 0 | 1 | 30 | 1092 | 546 |
| 1 | 1 | 1 | 1 | 0 | 31 | 1056 | 528 |
| 1 | 1 | 1 | 1 | 1 | 32 | 1024 | 512 |

If the preamble is detected correctly the correlator keeps searching for a data pattern. The duration of the preamble plus the pattern should not be longer than 40 bits (see bit rate definition in [Figure 37](#)). The data pattern can be defined by the user and consists of two bytes which are stored in the registers [R5<7:0>](#) and [R6<7:0>](#). The two bytes define the pattern consisting of 16 half bit periods. This means the pattern and the bit period can be selected by the user. The only limitation is that the pattern (in combination with preamble) must obey Manchester coding and timing. It must be noted that according to Manchester coding a down-to-up bit transition represents a symbol "0", while a transition up-to-down represents a symbol "1". If the default code is used (96 [hex]) the binary code is (10 01 01 10 01 10 10 01). MSB has to be transmitted first.

The user can also select ([R1<2>](#)) if single or double data pattern is used for wake-up. In case double pattern detection is set, the same pattern has to be repeated 2 times.

Additionally it is possible to set the number of allowed missing zero bits (not symbols) in the received bitstream ([R2<6:5>](#)), as shown in the [Figure 38](#).

Figure 38:
Allowed Pattern Detection Errors

| R2<6> | R2<5> | Maximum Allowed Error in the Pattern Detection |
|-------|-------|------------------------------------------------|
| 0 | 0 | No error allowed |
| 0 | 1 | 1 missed zero |
| 1 | 0 | 2 missed zeros |
| 1 | 1 | 3 missed zeros |

If the pattern matches the wake-up, interrupt is displayed on the WAKE output.

If the pattern detection fails, the internal wake-up (on all active channels) is terminated with no signal sent to MCU and the false wake-up register will be incremented (R13<7:0>).

Wake-up Protocol - Carrier Frequency 125 kHz

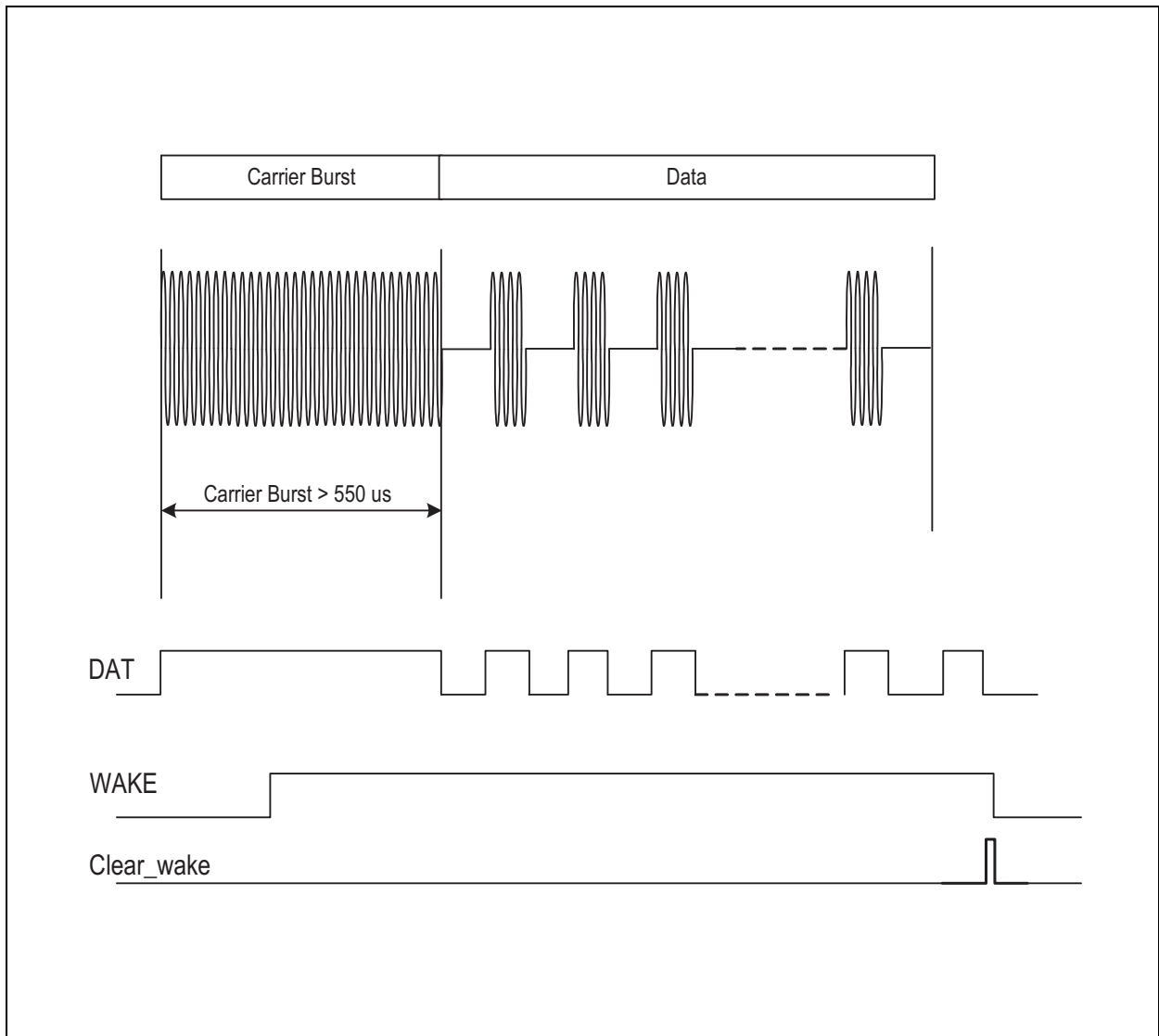
The wake-up state is terminated with the direct command 'clear_wake' Figure 25. This command terminates the MCU activity. The termination can also be automatic in case there is no response from MCU. The time out for automatic termination is set in a register R7<7:5>, as shown in the Figure 39.

Figure 39:
Timeout Setup

| R7<7> | R7<6> | R7<5> | Time Out |
|-------|-------|-------|----------|
| 0 | 0 | 0 | 0 sec |
| 0 | 0 | 1 | 50 msec |
| 0 | 1 | 0 | 100 msec |
| 0 | 1 | 1 | 150 msec |
| 1 | 0 | 0 | 200 msec |
| 1 | 0 | 1 | 250 msec |
| 1 | 1 | 0 | 300 msec |
| 1 | 1 | 1 | 350 msec |

Without Pattern Detection

Figure 40:
Wake-up Protocol Overview without Pattern Detection (only carrier frequency detection)



In case the data correlation is disabled ($R1<1>=0$) the AS3932 wakes up upon detection of the carrier frequency only as shown in Figure 40. In order to ensure that AS3932 wakes up the carrier burst has to last longer than 550 μ s. To set AS3932 back to listening mode there are two possibilities: either the microcontroller sends the direct command clear_wake via SDI or the time out option is used ($R7<7:5>$). In case the latter is chosen, AS3932 is automatically set to listening mode after the time defined in T_OUT ($R7<7:5>$), counting starts at the low-to-high WAKE edge on the WAKE pin.

Single Pattern Detection

The Figure 41 shows the wake-up protocol in case the pattern correlation is enabled ($R1<1>=1$) for a 125 kHz carrier frequency. The initial carrier burst has to be longer than 550 μ s and can last maximum 16 bits (see bit rate definition in Figure 37). If the ON/OFF mode is used ($R1<5>=1$), the minimum value of the maximum carrier burst duration is limited to 10 ms. This is summarized in Figure 42. In case the carrier burst is too long the internal wake-up will be set back to low and the false wake-up counter ($R13<7:0>$) will be incremented by one. The carrier burst must be followed by a preamble (0101... modulated carrier with a bit duration defined in Figure 37) and the wake-up pattern stored in the registers $R5<7:0>$ and $R6<7:0>$. The preamble must have at least 4 bits and the preamble duration together with the pattern should not be longer than 40 bits. If the wake-up pattern is correct, the signal on the WAKE pin goes high one bit after the end of the pattern and the data transmission can get started. To set the chip back to listening mode the direct command clear_wake, as well as the time out option ($R7<7:5>$) can be used.

Figure 41:
Wake-up Protocol Overview with Single Pattern Detection

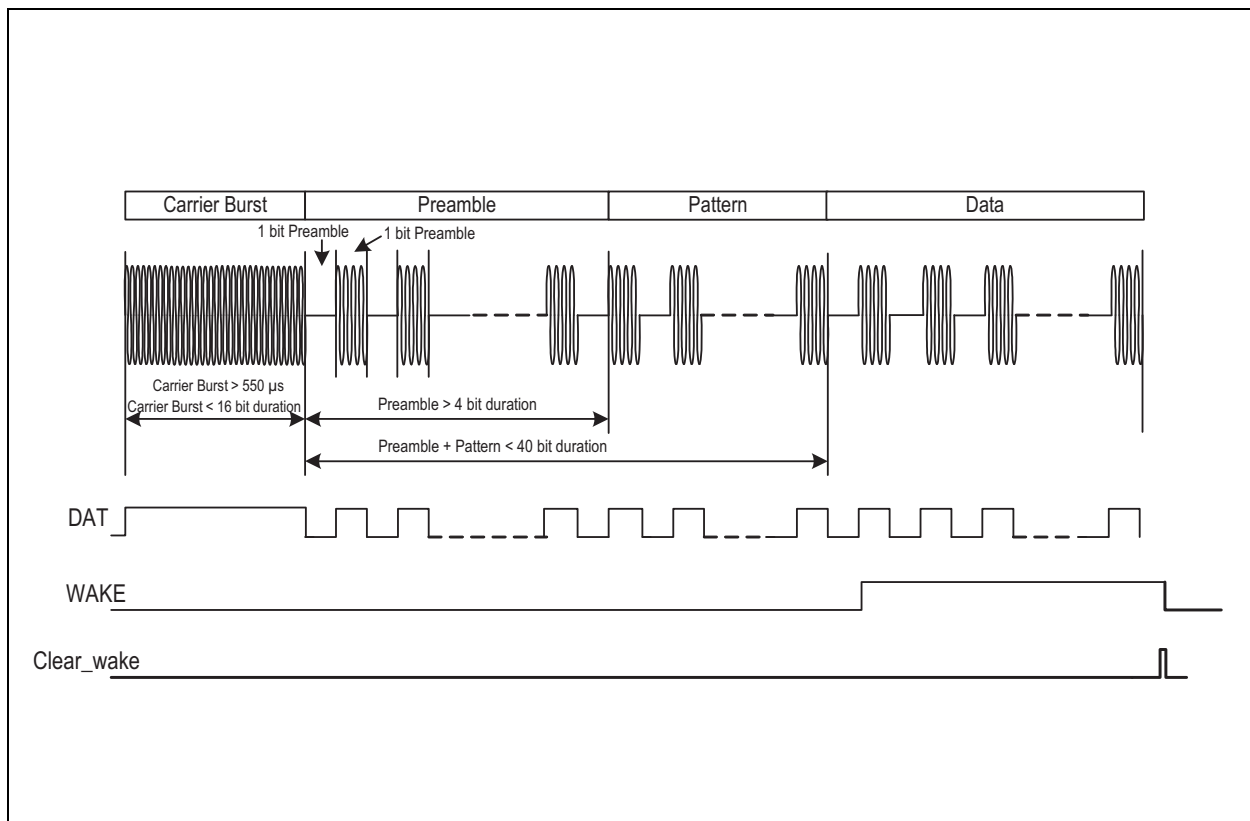


Figure 42:
Preamble Requirements in Standard Mode, Scanning Mode and ON/OFF Mode

| Bit Rate (bits/s) | Maximum Duration of The Carrier Burst in Standard Mode and Scanning Mode (ms) | Maximum Duration of the Carrier Burst in ON/OFF Mode (ms) |
|-------------------|-------------------------------------------------------------------------------|-----------------------------------------------------------|
| 8192 | 1.95 | 10 |
| 6552 | 2.44 | 10 |
| 5460 | 2.93 | 10 |
| 4680 | 3.41 | 10 |
| 4096 | 3.90 | 10 |
| 3640 | 4.39 | 10 |
| 3276 | 4.88 | 10 |
| 2978 | 5.37 | 10 |
| 2730 | 5.86 | 10 |
| 2520 | 6.34 | 10 |
| 2340 | 6.83 | 10 |
| 2184 | 7.32 | 10 |
| 2048 | 7.81 | 10 |
| 1926 | 8.30 | 10 |
| 1820 | 8.79 | 10 |
| 1724 | 9.28 | 10 |
| 1638 | 9.76 | 10 |
| 1560 | 10.25 | 10.25 |
| 1488 | 10.75 | 10.75 |
| 1424 | 11.23 | 11.23 |
| 1364 | 11.73 | 11.73 |
| 1310 | 12.21 | 12.21 |
| 1260 | 12.69 | 12.69 |
| 1212 | 13.20 | 13.20 |
| 1170 | 13.67 | 13.67 |
| 1128 | 14.18 | 14.18 |
| 1092 | 14.65 | 14.65 |

| Bit Rate (bits/s) | Maximum Duration of The Carrier Burst in Standard Mode and Scanning Mode (ms) | Maximum Duration of the Carrier Burst in ON/OFF Mode (ms) |
|-------------------|-------------------------------------------------------------------------------|-----------------------------------------------------------|
| 1056 | 15.15 | 15.15 |
| 1024 | 15.62 | 15.62 |

False Wake-up Register

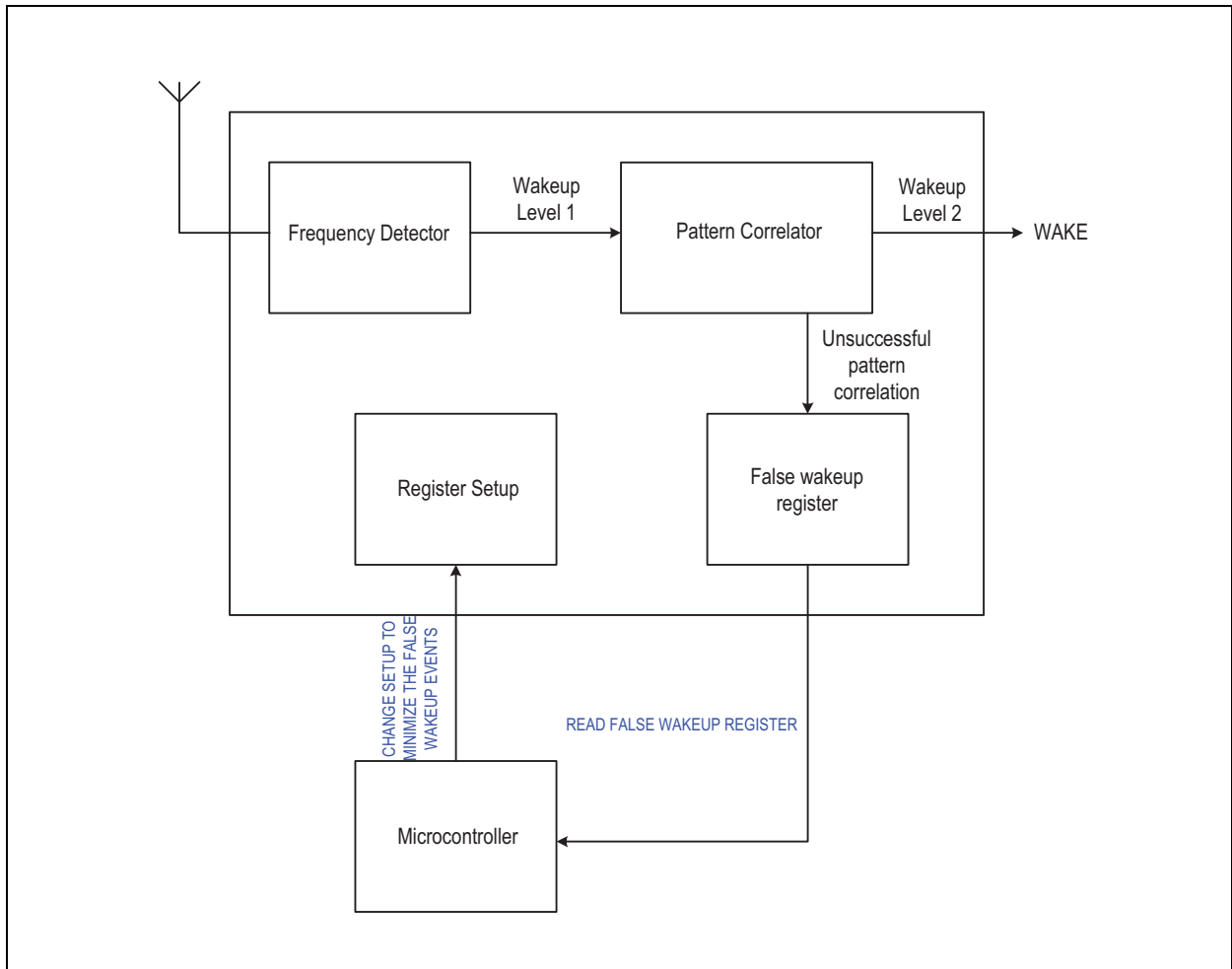
The wake-up strategy in the AS3932 is based on 2 steps:

1. Frequency Detection: in this phase the frequency of the received signal is checked.
2. Pattern Correlation: here the pattern is demodulated and checked whether it corresponds to the valid one.

If there is a disturber or noise capable to overcome the first step (frequency detection) without producing a valid pattern, then a false wake-up call happens. Each time this event is recognized a counter is incremented by one and the respective counter value is stored in a memory cell (false wake-up register). Thus, the microcontroller can periodically look at the false wake-up register, to get a feeling how noisy the surrounding environment is and can then react accordingly (e.g. reducing the gain of the LNA during frequency detection, set the AS3932 temporarily to power down etc.), as shown in the [Figure 43](#). The false wake-up counter is a useful tool to quickly adapt the system to any changes in the noise environment and thus avoid false wake-up events.

Most wake-up receivers have to deal with environments that can rapidly change. By periodically monitoring the number of false wake-up events it is possible to adapt the system setup to the actual characteristics of the environment and enables a better use of the full flexibility of AS3932.

Figure 43:
Concept of the False Wake-up Register Together With the System



Real Time Clock (RTC)

The RTC can be based on a crystal oscillator ($R1<0>=1$), the internal RC-oscillator ($R1<0>=0$), or an external clock source ($R1<0>=1$). The crystal oscillator has higher precision of the frequency with higher current consumption and needs three external components (crystal plus two capacitors). The RC-oscillator is completely integrated and can be calibrated if a reference signal is available for a very short time to improve the frequency accuracy. The calibration gets started with the trim_osc direct command. Since no non-volatile memory is available the calibration must be done every time after the RCO is turned OFF. The RCO is turned OFF when the chip is in power down mode, a POR happened, or the crystal oscillator is enabled.

Since the RTC defines the time base of the frequency detection, the selected frequency (frequency of the crystal oscillator or the reference frequency used for calibration of the RC oscillator) should be about one fourth of the carrier frequency:

$$(EQ1) \quad F_{RTC} \sim F_{CAR} * 0.25$$

Where: F_{CAR} is the carrier frequency and F_{RTC} is the RTC frequency.

The third option for the RTC is the use of an external clock source, which must be applied directly to the XIN pin (XOUT floating).

Crystal Oscillator

Figure 44:
Characteristics of XTAL

| Symbol | Parameter | Conditions | Min | Max | Typ | Units |
|--------|-------------------------------------------------------|-------------------|-----|--------|------|--------|
| | Crystal accuracy (initial) | Overall accuracy | | | ±120 | p.p.m. |
| | Crystal motional resistance | | | | 60 | KΩ |
| | Frequency | | | 32.768 | | kHz |
| | Contribution of the oscillator to the frequency error | | | ±5 | | p.p.m |
| | Start-up Time | Crystal dependent | | 1 | | s |
| | Duty cycle | | 45 | 50 | 55 | % |
| | Current consumption | | | 1 | | μA |

RC-Oscillator

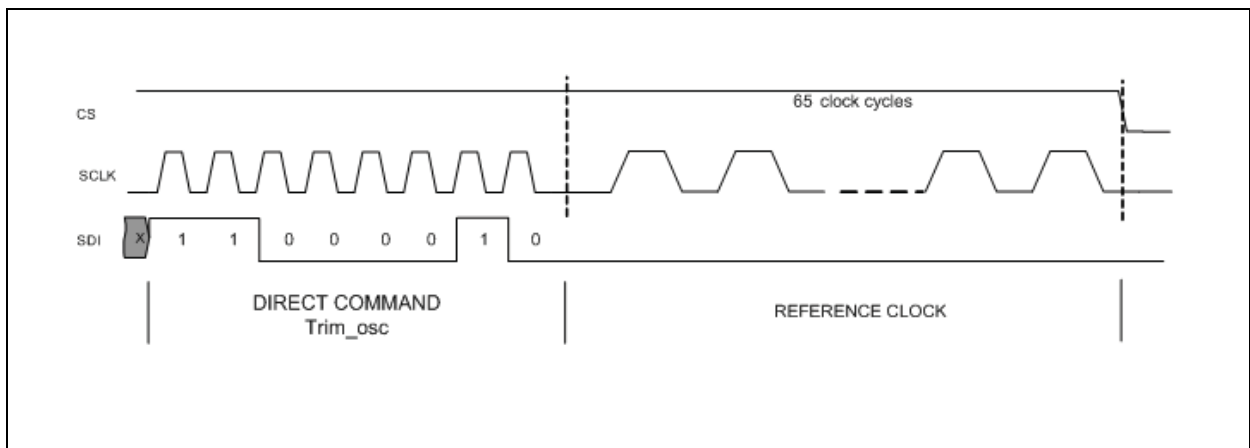
Figure 45:
Characteristics of RCO

| Symbol | Parameter | Conditions | Min | Max | Typ | Units |
|--------|---------------------|--------------------------------|-----|--------|------|--------|
| | Frequency | If no calibration is performed | 27 | 32.768 | 42 | kHz |
| | | If calibration is performed | 31 | 32.768 | 34.5 | kHz |
| | Calibration time | Periods of reference clock | | | 65 | cycles |
| | Current consumption | | | 200 | | nA |

To trim the RC-Oscillator, set the chip select (CS) to high before sending the direct command trim_osc over SDI. Then 65 digital clock cycles of the reference clock (e.g. 32.768 kHz) have to be sent on the clock bus (SCLK), as shown in Figure 46. After that the signal on the chip select (CS) has to be pulled down.

The calibration is effective after the 65th reference clock edge and it will be stored in a volatile memory. In case the RC-oscillator is switched OFF or a power-on-reset happens (e.g. battery change) the calibration has to be repeated.

Figure 46:
RC-Oscillator Calibration via SDI



External Clock Source

To clock the AS3932 with an external signal the crystal oscillator has to be enabled ($R1<0>=1$). As shown in the [Figure 4](#) the clock must be applied on the pin XIN while the pin XOUT must stay floating. The RC time constant has to be $15\mu\text{s}$ with a tolerance of $\pm 10\%$ (e.g. $R=680\text{ k}\Omega$ and $C=22\text{ pF}$). In the [Figure 47](#) the clock characteristics are summarized.

Figure 47:
Characteristics of External Clock

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|--------|------------------|------------|----------------|-----|----------------|---------------|
| VI | Low level | | 0 | | $0.1 * V_{DD}$ | V |
| Vh | High level | | $0.9 * V_{DD}$ | | V_{DD} | V |
| Tr | Rise-time | | | | 3 | μs |
| Tf | Fall-time | | | | 3 | μs |
| T = RC | RC Time constant | | 13.5 | 15 | 16.5 | μs |

Note(s): In power down mode the external clock has to be set to VDD.

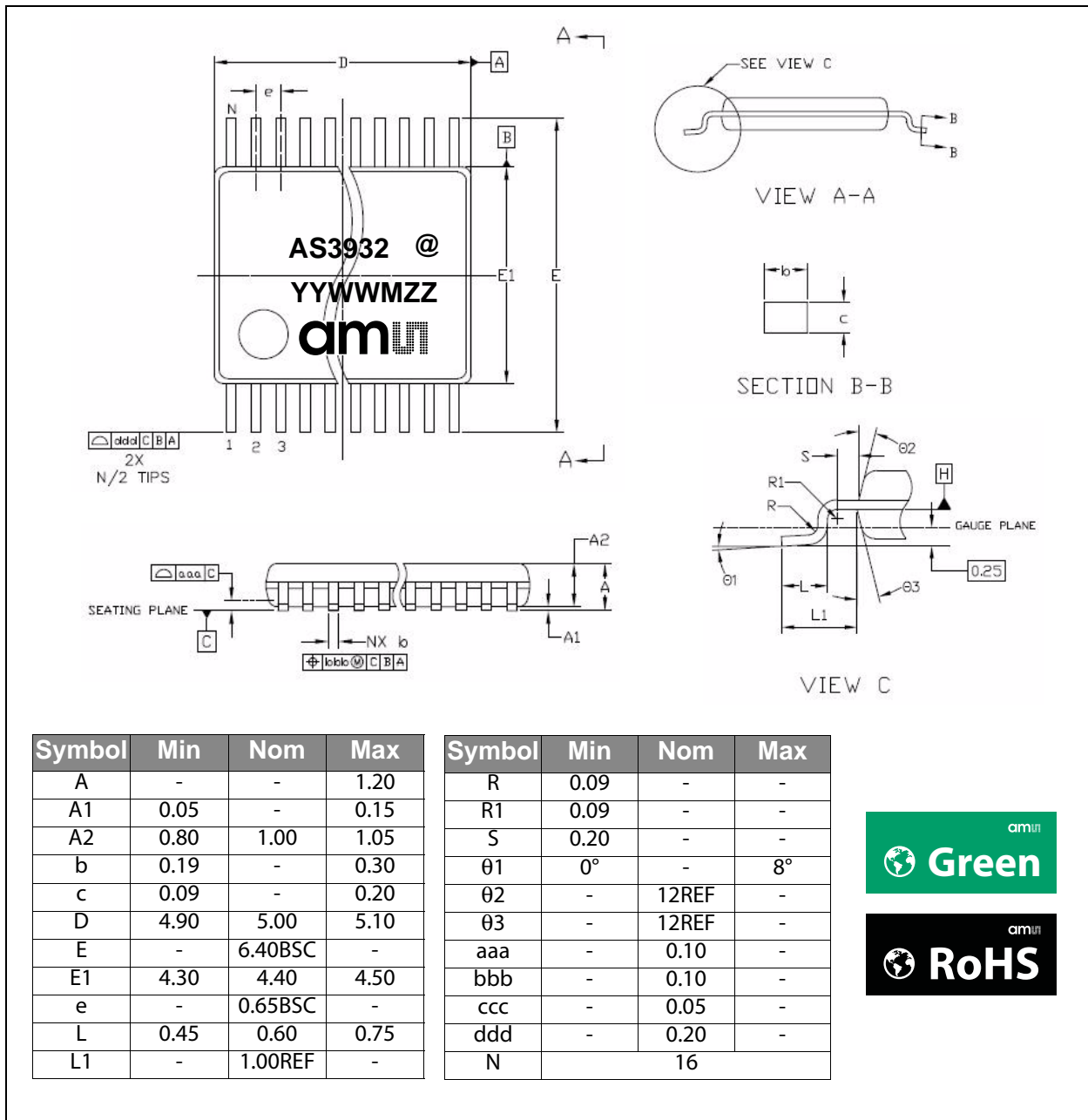
Channel Selection in Scanning Mode and ON/OFF Mode

In case only 2 channels are active and one of the Low Power modes is enabled, then the channels 1 and 3 have to be active. If the chip works in ON-OFF mode and only one channel is active then the active channel has to be the channel 1.

Both Low Power modes are not allowed to be enabled at the same time.

Package Drawings & Markings The product is available in a 16-pin TSSOP package.

Figure 48:
Drawings and Dimensions (TSSOP)



Note(s) and/or Footnote(s):

1. Dimensions and tolerancing conform to ASME Y14.5M-1994.
2. All dimensions are in millimeters. Angles are in degrees.

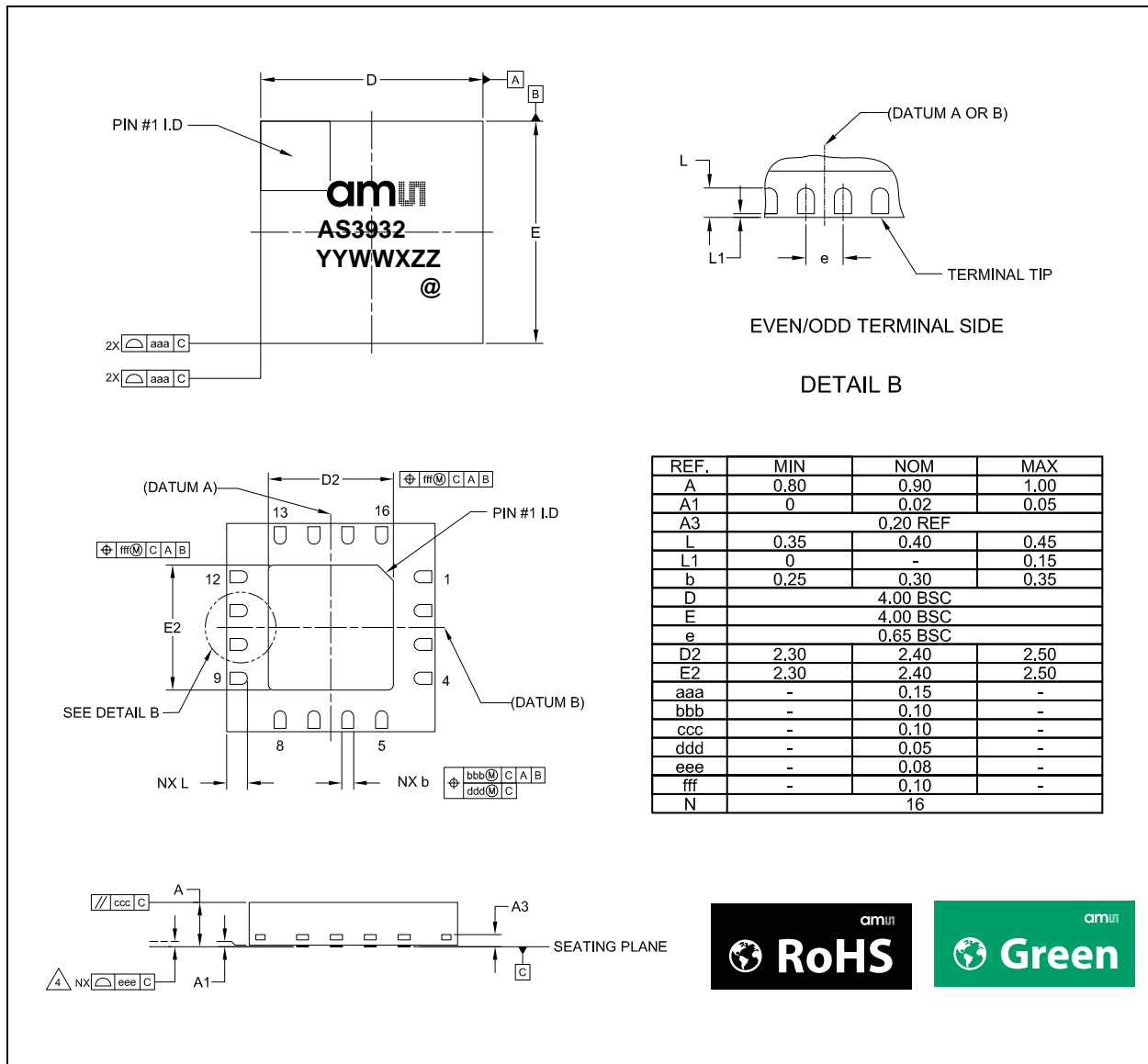
Figure 49:
Marking: YYWWMZZ

| YY | WW | M | ZZ | @ |
|-------------------------|--------------------|---------------------------|----------------------------|-------------------|
| Year (i.e. 10 for 2010) | Manufacturing Week | Assembly plant identifier | Assembly traceability code | Sublot identifier |



The product is available in a 16LD QFN (4x4) package.

Figure 50:
Drawings and Dimensions (QFN)



Note(s) and/or Footnote(s):

1. Dimensioning and tolerancing conform to *ASME Y14.5M-1994*.
2. All dimensions are in millimeters. Angles are in degrees.
3. Dimension b applies to metallized terminal and is measured between 0.25mm and 0.30mm from terminal tip. Dimension L1 represents terminal full back from package edge up to 0.15mm is acceptable.
4. Coplanarity applies to the exposed heat slug as well as the terminal.
5. Radius on terminal is optional.
6. N is the total number of terminals.

Figure 51:
Marking: YYWWXZZ

| YY | WW | X | ZZ | @ |
|-------------------------|--------------------|---------------------------|----------------------------|-------------------|
| Year (i.e. 10 for 2010) | Manufacturing Week | Assembly plant identifier | Assembly traceability code | Sublot identifier |

Ordering & Contact Information

The devices are available as the standard products shown in Figure 52.

Figure 52:
Ordering Information

| Ordering Code | Type | Marking | Delivery Form ⁽¹⁾ | Delivery Quantity |
|---------------|----------------|---------|------------------------------|-------------------|
| AS3932-BTST | 16-pin TSSOP | AS3932 | 7 inches Tape & Reel | 1000 pcs |
| AS3932-BQFT | 16LD QFN (4×4) | AS3932 | 7 inches Tape & Reel | 1000 pcs |

Note(s) and/or Footnote(s):

1. Dry Pack Sensitivity Level =3 according to IPC/JEDEC J-STD-033A for full reels.

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Document Status

| Document Status | Product Status | Definition |
|--------------------------|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Product Preview | Pre-Development | Information in this datasheet is based on product ideas in the planning phase of development. All specifications are design goals without any warranty and are subject to change without notice |
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| 1.7 (2013-Jun-18) to 1-82 (2014-Nov-05) | |
| Content was converted to latest ams design | |
| Added benefits to Key Features | 1 |
| Added TRC (start-up time) parameter in Figure 11 | 9 |
| Updated text under Detailed Description section | 13 |
| Updated Figure 30 | 25 |
| 1-82 (2014-Nov-05) to 1-83 (2015-Mar-02) | |
| Updated Figure 50 (QFN (4×4) package) | 43 |

Note(s) and/or Footnote(s):

1. Page and figure numbers for the previous version may differ from page and figure numbers in the current revision.
2. Correction of typographical errors is not explicitly mentioned.

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