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### UHF ASK/FSK Industrial Transmitter

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### DATASHEET

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#### Features

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- Integrated PLL loop filter
- ESD protection (3kV HBM/150V MM)
- High output power (7.5dBm) with low supply current (9.0mA)
- Modulation scheme ASK/FSK
  - FSK modulation is achieved by connecting an additional capacitor between the XTAL load capacitor and the open drain output of the modulating microcontroller
- Easy to design-in due to excellent isolation of the PLL from the PA and power supply
- Single Li-cell for power supply
- Supply voltage 2.0V to 4.0V in the temperature range of  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$
- Package TSSOP8L
- Single-ended antenna output with high efficient power amplifier
- CLK output for clocking the microcontroller
- One-chip solution with minimum external circuitry

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#### Applications

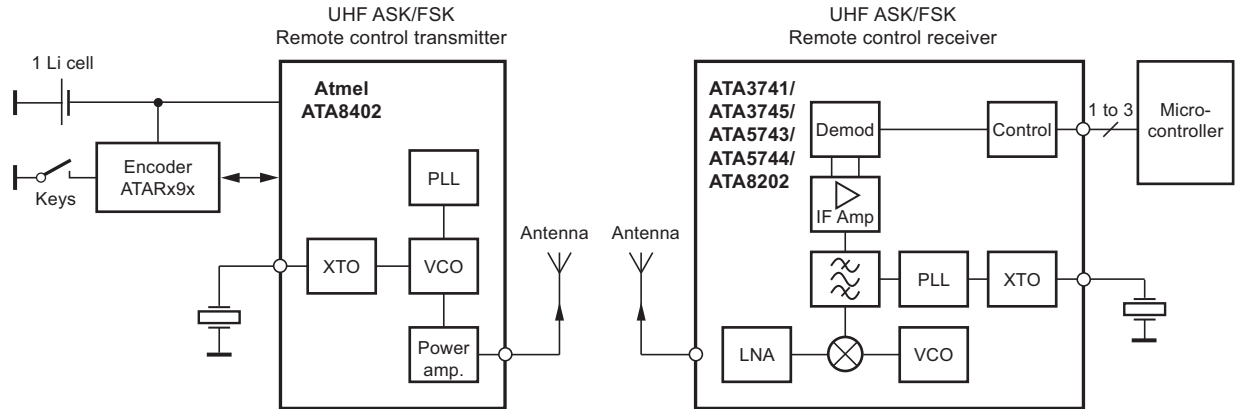
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- Industrial/aftermarket remote keyless entry systems
- Alarm, telemetering, and energy metering systems
- Remote control systems for consumer and industrial markets
- Access control systems
- Home automation
- Home entertainment
- Toys

# 1. Description

The ATA8402 is a PLL transmitter IC, which has been developed for the demands of RF low-cost transmission systems for industrial applications at data rates up to 50kBaude ASK and 32kBaude FSK modulation scheme. The transmitting frequency range is 429MHz to 439MHz. It can be used in both FSK and ASK systems.

Figure 1-1. System Block Diagram



## 2. Pin Configuration

Figure 2-1. Pinning TSSOP8L

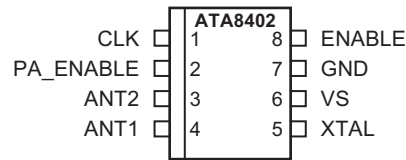
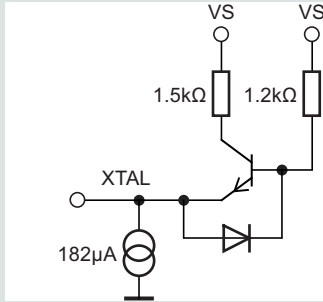
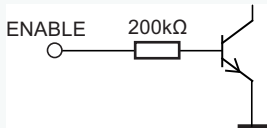


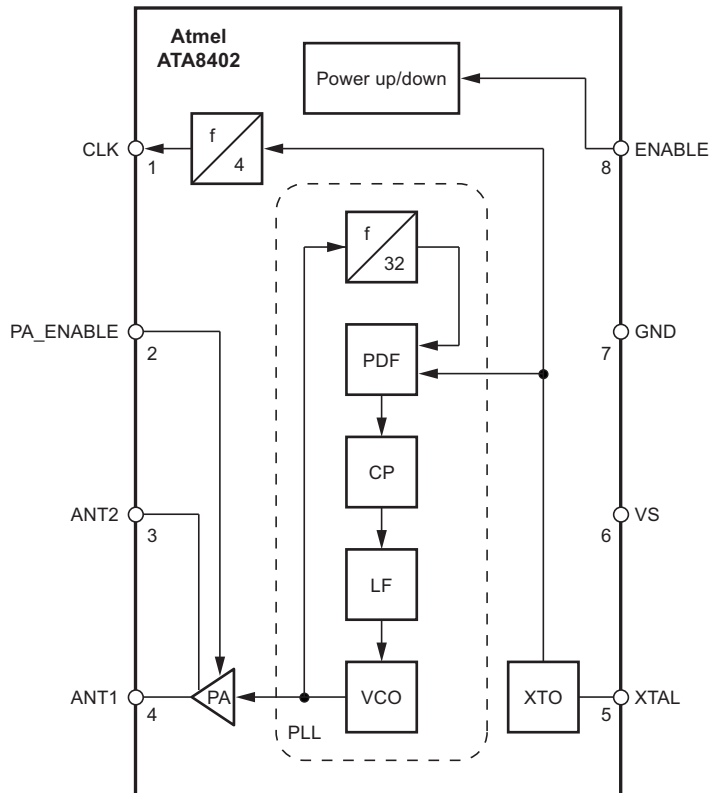
Table 2-1. Pin Description

| Pin | Symbol    | Function  | Configuration |
|-----|-----------|---|---------------|
| 1   | CLK       | Clock output signal for microcontroller<br>The clock output frequency is set by the crystal to $f_{XTAL}/4$ |               |
| 2   | PA_ENABLE | Switches on power amplifier, which is used for ASK modulation   |               |
| 3   | ANT2      | Emitter of antenna output stage   |               |
| 4   | ANT1      | Open collector antenna output   |               |

**Table 2-1. Pin Description (Continued)**

| Pin | Symbol | Function               | Configuration   |
|-----|--------|------------------------|---|
| 5   | XTAL   | Connection for crystal |  |
| 6   | VS     | Supply voltage         | See ESD protection circuitry (see <a href="#">Figure 4-5 on page 8</a> )            |
| 7   | GND    | Ground                 | See ESD protection circuitry (see <a href="#">Figure 4-5 on page 8</a> )            |
| 8   | ENABLE | Enable input           |  |

**Figure 2-2. Block Diagram**



### 3. General Description

This fully integrated PLL transmitter allows particularly simple, low-cost RF miniature transmitters to be assembled. The VCO is locked to  $32 f_{XTAL}$ , and therefore a 13.56MHz crystal is needed for a 433.92MHz transmitter. All other PLL and VCO peripheral elements are integrated.

The XTO is a series resonance oscillator so that only one capacitor together with a crystal connected in series to GND are needed as external elements.

The crystal oscillator together with the PLL typically needs  $< 1$  ms until the PLL is locked and the CLK output is stable. There is a wait time of  $\geq 1$  ms until the CLK is used for the microcontroller and the PA is switched on.

The power amplifier is an open-collector output delivering a current pulse, which is nearly independent from the load impedance. The delivered output power is therefore controllable via the connected load impedance.

This output configuration enables a simple matching to any kind of antenna or to  $50\Omega$ . A high power efficiency of  $\eta = P_{out}/(I_{S,PA} V_S)$  of 36% for the power amplifier results when an optimized load impedance of  $Z_{Load} = (166 + j223)\Omega$  is used at 3V supply voltage.

### 4. Functional Description

If ENABLE = L and the PA\_ENABLE = L, the circuit is in standby mode, consuming only a very small amount of current, so that a lithium cell used as power supply can work for several years.

With ENABLE = H the XTO, PLL, and the CLK driver are switched on. If PA\_ENABLE remains L, only the PLL and the XTO are running, and the CLK signal is delivered to the microcontroller. The VCO locks to 32 times the XTO frequency.

With ENABLE = H and PA\_ENABLE = H the PLL, XTO, CLK driver, and the power amplifier are on. The power amplifier can be switched on and off with PA\_ENABLE. This is used to perform the ASK modulation.

#### 4.1 ASK Transmission

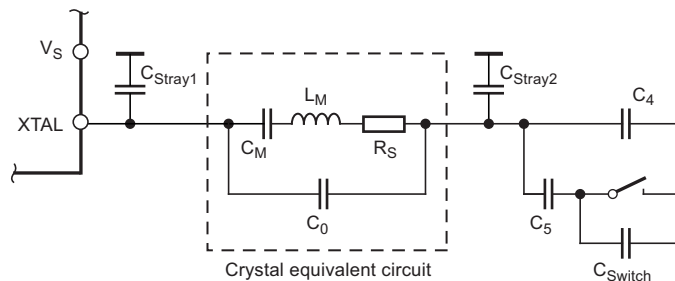
The ATA8402 is activated by ENABLE = H. PA\_ENABLE must remain L for  $t \geq 1$  ms, then the CLK signal can be taken to clock the microcontroller and the output power can be modulated by means of the PA\_ENABLE pin. After transmission, PA\_ENABLE is switched to L and the microcontroller switches back to internal clocking. The ATA8402 is switched back to standby mode with ENABLE = L.

#### 4.2 FSK Transmission

The ATA8402 is activated by ENABLE = H. PA\_ENABLE must remain L for  $t \geq 1$  ms, then the CLK signal can be taken to clock the microcontroller, and the power amplifier is switched on with PA\_ENABLE = H. The chip is then ready for FSK modulation. The microcontroller starts to switch on and off the capacitor between the XTAL load capacitor and GND with an open-drain output port, thus changing the reference frequency of the PLL. If the switch is closed, the output frequency is lower than if the switch is open. After transmission, PA\_ENABLE is switched to L, and the microcontroller switches back to internal clocking. The ATA8402 is switched back to standby mode with ENABLE = L.

The accuracy of the frequency deviation with XTAL pulling method is about  $\pm 25\%$  when the following tolerances are considered.

Figure 4-1. Tolerances of Frequency Modulation



Using  $C_4 = 9.2\text{pF} \pm 2\%$ ,  $C_5 = 6.8\text{pF} \pm 5\%$ , a switch port with  $C_{Switch} = 3\text{pF} \pm 10\%$ , stray capacitances on each side of the crystal of  $C_{Stray1} = C_{Stray2} = 1\text{pF} \pm 10\%$ , a parallel capacitance of the crystal of  $C_0 = 3.2\text{pF} \pm 10\%$  and a crystal with  $C_M = 13\text{fF} \pm 10\%$ , typically results in an FSK deviation of  $\pm 21\text{kHz}$  with worst case tolerances of  $\pm 16.3\text{kHz}$  to  $\pm 28.8\text{kHz}$ .

## 4.3 CLK Output

An output CLK signal is provided for a connected microcontroller. The delivered signal is CMOS compatible if the load capacitance is lower than 10pF.

### 4.3.1 Clock Pulse Take-over

The clock of the crystal oscillator can be used for clocking the microcontroller. A special feature of Atmel®'s ATARx9x is that it starts with an integrated RC-oscillator to switch on the ATA8402 with ENABLE = H, and after 1 ms assumes the clock signal of the transmission IC, so that the message can be sent with crystal accuracy.

### 4.3.2 Output Matching and Power Setting

The output power is set by the load impedance of the antenna. The maximum output power is achieved with a load impedance of  $Z_{Load,opt} = (166 + j223)\Omega$ . There must be a low resistive path to  $V_S$  to deliver the DC current.

The delivered current pulse of the power amplifier is 9mA. The maximum output power is delivered to a resistive load of  $465\Omega$  if the 1.0pF output capacitance of the power amplifier is compensated by the load impedance.

An optimum load impedance of:

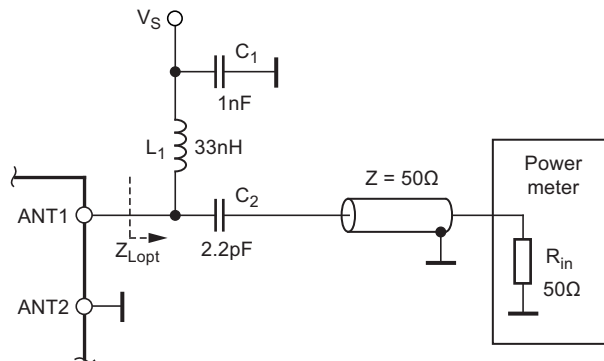
$Z_{Load} = 465\Omega \parallel j/(2 \times \pi \times 1.0pF) = (166 + j223)\Omega$  thus results for the maximum output power of 7.5dBm.

The load impedance is defined as the impedance seen from the ATA8402's ANT1, ANT2 into the matching network. Do not confuse this large signal load impedance with a small signal input impedance delivered as input characteristic of RF amplifiers and measured from the application into the IC instead of from the IC into the application for a power amplifier.

Less output power is achieved by lowering the real parallel part of  $465\Omega$  where the parallel imaginary part should be kept constant.

Output power measurement can be done with the circuit shown in [Figure 4-2 on page 6](#). Note that the component values must be changed to compensate for individual board parasitics until the ATA8402 has the right load impedance  $Z_{Load,opt} = (166 + j223)\Omega$ . Also the damping of the cable used to measure the output power must be calibrated out.

**Figure 4-2. Output Power Measurement**



## 4.4 Application Circuit

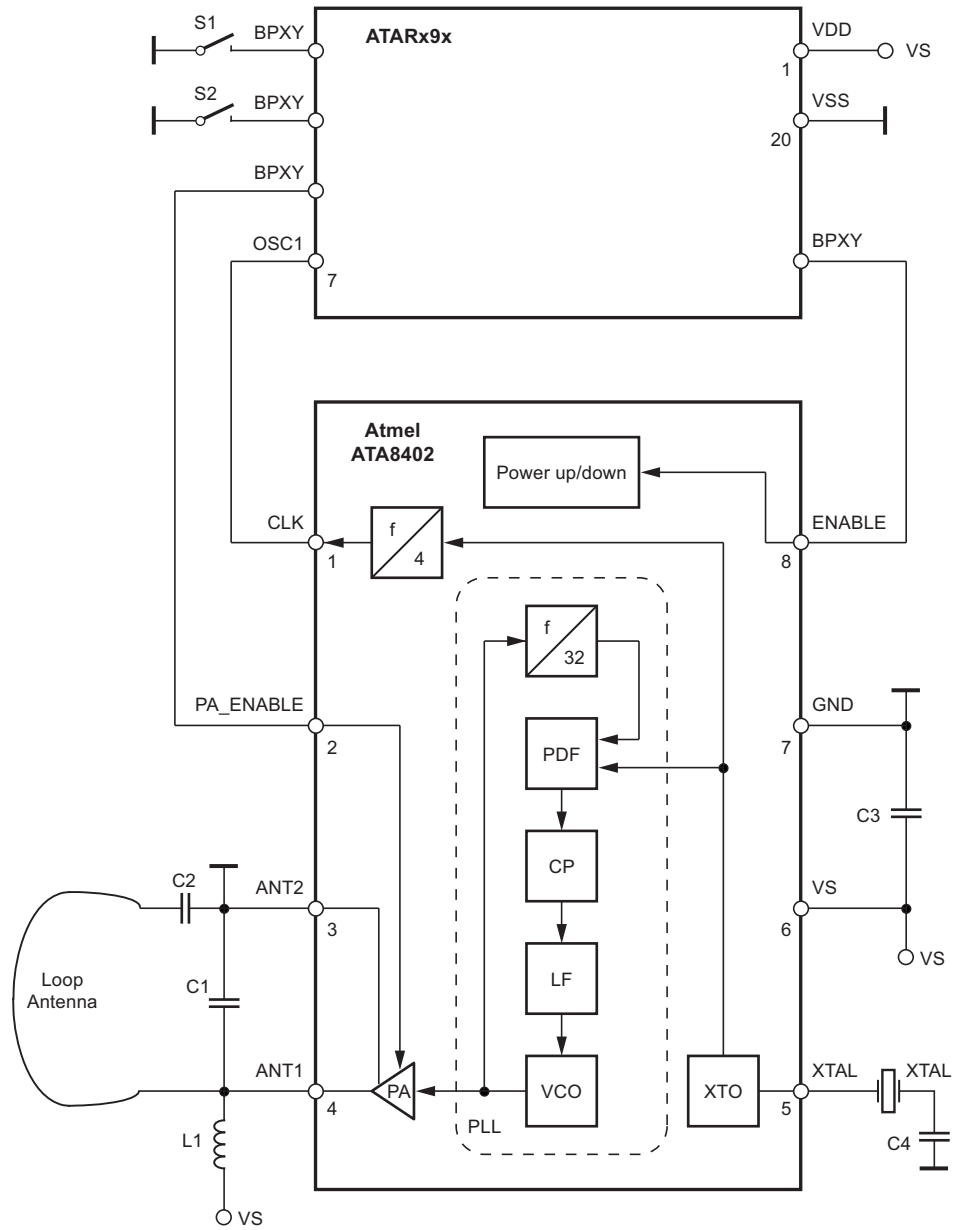
A value of 68 nF/X7R is recommended for the supply-voltage blocking capacitor  $C_3$  (see [Figure 4-3 on page 7](#) and [Figure 4-4 on page 8](#)).  $C_1$  and  $C_2$  are used to match the loop antenna to the power amplifier where  $C_1$  typically is 8.2pF/NP0 and  $C_2$  is 6pF/NP0 (10pF + 15pF in series). For  $C_2$ , two capacitors in series should be used to achieve a better tolerance value and to have the possibility of realizing the  $Z_{Load,opt}$  using standard valued capacitors.

$C_1$ , together with the pins of ATA8402 and the PCB board wires, forms a series resonance loop that suppresses the 1<sup>st</sup> harmonic. Therefore, the position of  $C_1$  on the PCB is important. Normally the best suppression is achieved when  $C_1$  is placed as close as possible to the pins ANT1 and ANT2.

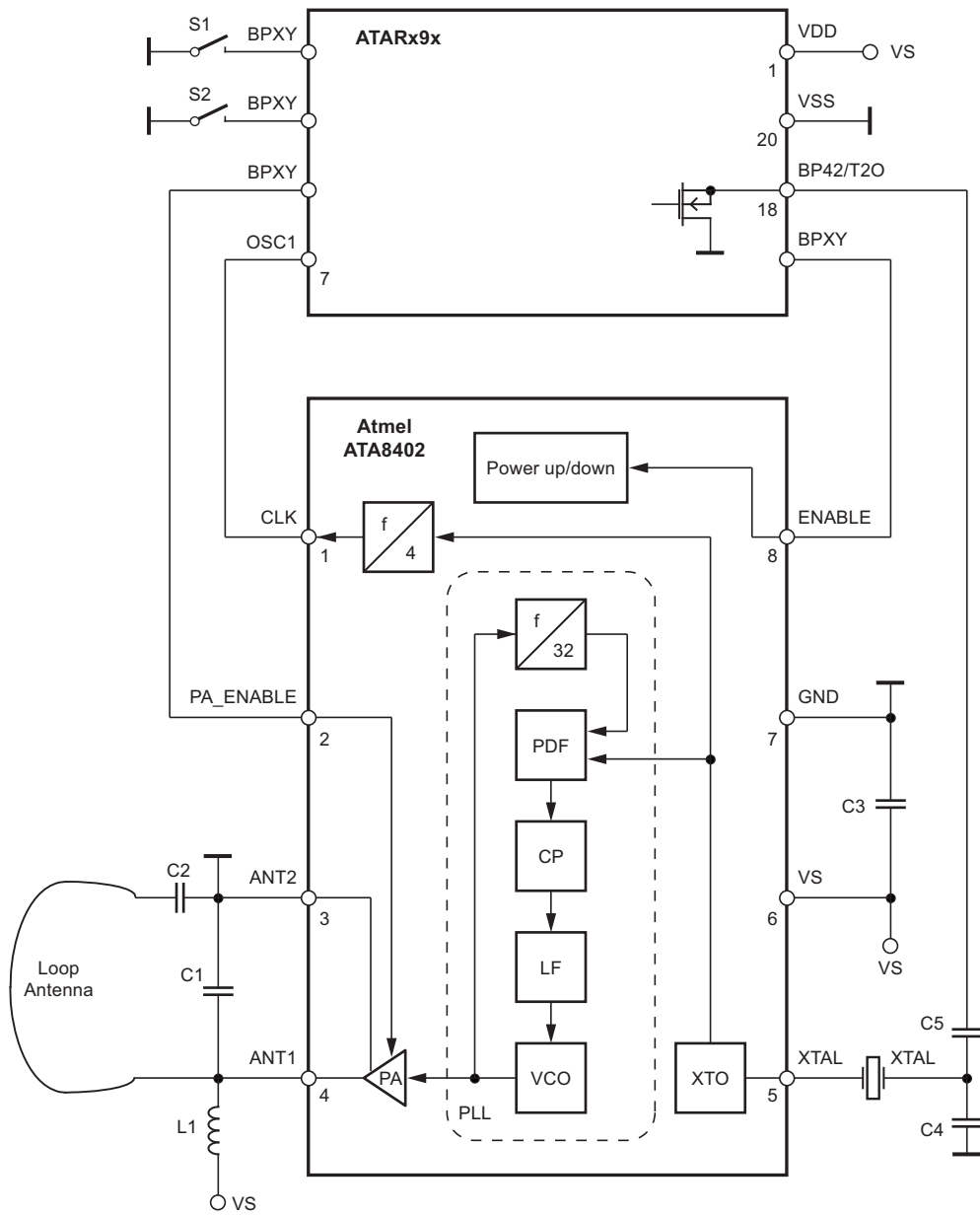
The loop antenna should not exceed a width of 1.5mm, otherwise the Q-factor of the loop antenna is too high.

$L_1$  ([50nH to 100nH]) can be printed on PCB.  $C_4$  should be selected so that the XTO runs on the load resonance frequency of the crystal. Normally, a 15pF load-capacitance crystal results in a value of 12pF.

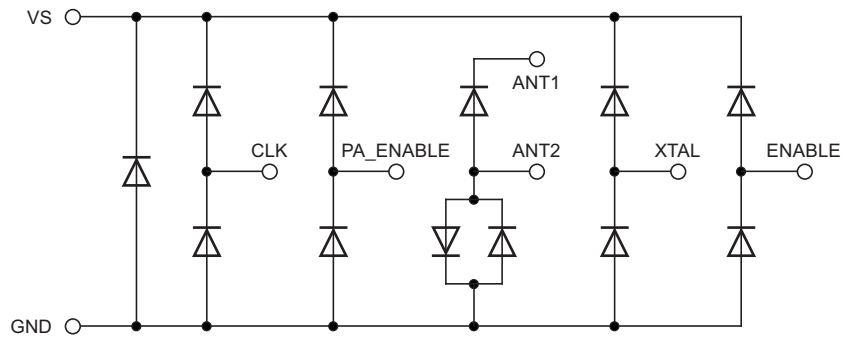
Figure 4-3. ASK Application Circuit



**Figure 4-4. FSK Application Circuit**



**Figure 4-5. ESD Protection Circuit**





## 5. Absolute Maximum Ratings

Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

| Parameters           | Symbol              | Minimum | Maximum             | Unit |
|----------------------|---------------------|---------|---------------------|------|
| Supply voltage       | $V_S$               |         | 5                   | V    |
| Power dissipation    | $P_{tot}$           |         | 100                 | mW   |
| Junction temperature | $T_j$               |         | 150                 | °C   |
| Storage temperature  | $T_{stg}$           | -55     | +85                 | °C   |
| Ambient temperature  | $T_{amb}$           | -55     | +85                 | °C   |
| Input voltage        | $V_{maxPA\_ENABLE}$ | -0.3    | $(V_S + 0.3)^{(1)}$ | V    |

Note: 1. If  $V_S + 0.3$  is higher than 3.7V, the maximum voltage will be reduced to 3.7V.

## 6. Thermal Resistance

| Parameters       | Symbol     | Value | Unit |
|------------------|------------|-------|------|
| Junction ambient | $R_{thJA}$ | 170   | K/W  |

## 7. Electrical Characteristics

$V_S = 2.0V$  to  $4.0V$ ,  $T_{amb} = 25^\circ C$  unless otherwise specified.

Typical values are given at  $V_S = 3.0V$  and  $T_{amb} = 25^\circ C$ . All parameters are referred to GND (pin 7).

| Parameters  | Test Conditions   | Symbol                               | Min. | Typ.       | Max.         | Unit       |
|---|---|--------------------------------------|------|------------|--------------|------------|
| Supply current  | Power down<br>$V_{ENABLE} < 0.25V$ , $-40^\circ C$ to $85^\circ C$<br>$V_{PA-ENABLE} < 0.25V$ , $25^\circ C$<br>(100% correlation tested)         | $I_{S\_off}$                         |      | < 10       | 350          | nA<br>nA   |
| Supply current  | Power up, PA off, $V_S = 3V$ ,<br>$V_{ENABLE} > 1.7V$ , $V_{PA-ENABLE} < 0.25V$   | $I_S$                                |      | 3.7        | 4.8          | mA         |
| Supply current  | Power up, $V_S = 3.0V$ ,<br>$V_{ENABLE} > 1.7V$ , $V_{PA-ENABLE} > 1.7V$  | $I_{S\_Transmit}$                    |      | 9          | 11.6         | mA         |
| Output power  | $V_S = 3.0V$ , $T_{amb} = 25^\circ C$ ,<br>$f = 433.92MHz$ , $Z_{Load} = (166 + j233)\Omega$  | $P_{Ref}$                            | 5.5  | 7.5        | 10           | dBm        |
| Output power variation for the full temperature range | $T_{amb} = 25^\circ C$ ,<br>$V_S = 3.0V$<br>$V_S = 2.0V$  | $\Delta P_{Ref}$<br>$\Delta P_{Ref}$ |      |            | -1.5<br>-4.0 | dB<br>dB   |
| Output power variation for the full temperature range | $T_{amb} = 25^\circ C$ ,<br>$V_S = 3.0V$<br>$V_S = 2.0V$<br>$P_{Out} = P_{Ref} + \Delta P_{Ref}$  | $\Delta P_{Ref}$<br>$\Delta P_{Ref}$ |      |            | -2.0<br>-4.5 | dB<br>dB   |
| Achievable output-power range                         | Selectable by load impedance  | $P_{Out\_typ}$                       | 0    |            | 7.5          | dBm        |
| Spurious emission                                     | $f_{CLK} = f_0/128$<br>Load capacitance at pin CLK = 10pF<br>$f_0 \pm 1 \times f_{CLK}$<br>$f_0 \pm 4 \times f_{CLK}$<br>Other spurious are lower |                                      |      | -55<br>-52 |              | dBc<br>dBc |

Note: 1. If  $V_S$  is higher than 3.6V, the maximum voltage will be reduced to 3.6V.

## 7. Electrical Characteristics (Continued)

$V_S = 2.0V$  to  $4.0V$ ,  $T_{amb} = 25^\circ C$  unless otherwise specified.

Typical values are given at  $V_S = 3.0V$  and  $T_{amb} = 25^\circ C$ . All parameters are referred to GND (pin 7).

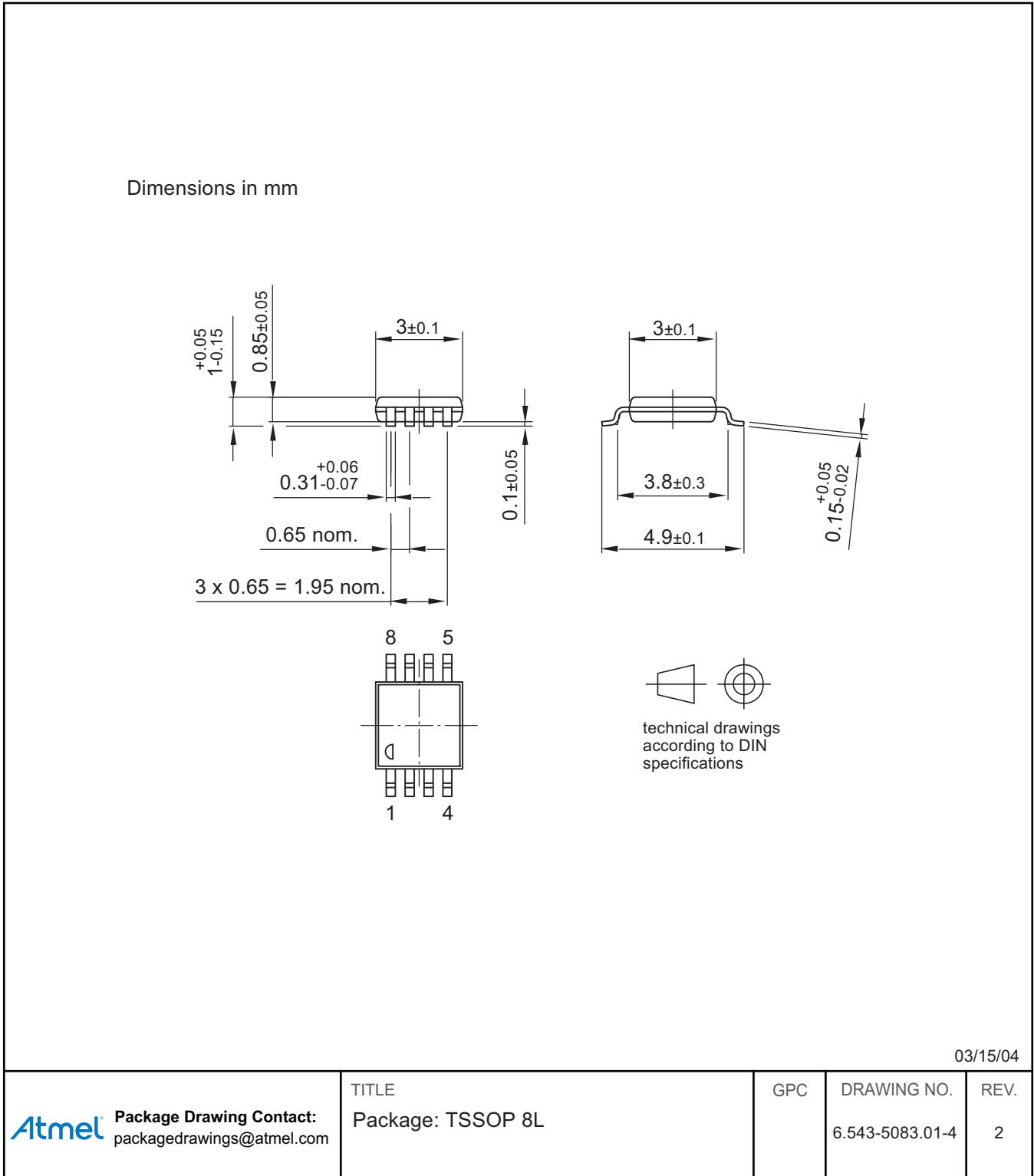
| Parameters  | Test Conditions  | Symbol                           | Min.             | Typ.        | Max.                     | Unit              |
|---|--|----------------------------------|------------------|-------------|--------------------------|-------------------|
| Oscillator frequency XTO<br>(= phase comparator frequency)  | $f_{XTO} = f_0/32$<br>$f_{XTAL}$ = resonant frequency of the XTAL,<br>$C_M \leq 10$ fF, load capacitance selected<br>accordingly<br>$T_{amb} = 25^\circ C$ | $f_{XTO}$                        |                  | $f_{XTAL}$  |                          | ppm               |
| PLL loop bandwidth  |  |                                  |                  | 250         |                          | kHz               |
| Phase noise of phase comparator                             | Referred to $f_{PC} = f_{XTO}$ ,<br>25kHz distance to carrier  |                                  |                  | -116        | -110                     | dBc/Hz            |
| In-loop phase noise PLL                                     | 25kHz distance to carrier  |                                  |                  | -86         | -80                      | dBc/Hz            |
| Phase noise VCO   | At 1MHz<br>At 36MHz  |                                  |                  | -94<br>-125 | -90<br>-121              | dBc/Hz<br>dBc/Hz  |
| Frequency range of VCO                                      |  | $f_{VCO}$                        | 429              |             | 439                      | MHz               |
| Clock output frequency (CMOS<br>microcontroller compatible) |  |                                  |                  | $f_0/128$   |                          | MHz               |
| Voltage swing at pin CLK                                    | $C_{Load} \leq 10pF$   | $V_{OH}$<br>$V_{OL}$             | $V_S \times 0.8$ |             | $V_S \times 0.2$         | V<br>V            |
| Series resonance R of the crystal                           |  | $R_s$                            |                  |             | 110                      | $\Omega$          |
| Capacitive load at pin XTO                                  |  |                                  |                  |             | 7                        | pF                |
| FSK modulation frequency rate                               | Duty cycle of the modulation signal =<br>50%   |                                  | 0                |             | 32                       | kHz               |
| ASK modulation frequency rate                               | Duty cycle of the modulation signal =<br>50%   |                                  | 0                |             | 50                       | kHz               |
| ENABLE input  | Low level input voltage<br>High level input voltage<br>Input current high  | $V_{IL}$<br>$V_{IH}$<br>$I_{In}$ | 1.7              |             | 0.25<br>20               | V<br>V<br>$\mu A$ |
| PA_ENABLE input   | Low level input voltage<br>High level input voltage<br>Input current high  | $V_{IL}$<br>$V_{IH}$<br>$I_{In}$ | 1.7              |             | 0.25<br>$V_S^{(1)}$<br>5 | V<br>V<br>$\mu A$ |

Note: 1. If  $V_S$  is higher than 3.6V, the maximum voltage will be reduced to 3.6V.

## 8. Ordering Information

| Extended Type Number | Package | MOQ      | Remarks                   |
|----------------------|---------|----------|---------------------------|
| ATA8402C-6AQY        | TSSOP8L | 5000 pcs | Taped and reeled, Pb-free |

## 9. Package Information



03/15/04



Package Drawing Contact:  
packagedrawings@atmel.com

TITLE  
Package: TSSOP 8L

GPC

DRAWING NO.  
6.543-5083.01-4

REV.  
2

## 10. Revision History

Please note that the following page numbers referred to in this section refer to the specific revision mentioned, not to this document.

| Revision No.      | History  |
|-------------------|--|
| 4982D-INDCO-07/14 | <ul style="list-style-type: none"><li>• Put datasheet in the latest template</li></ul>   |
| 4982C-INDCO-08/12 | <ul style="list-style-type: none"><li>• Features on page 1 changed</li></ul>   |
| 4982B-INDCO-03/12 | <ul style="list-style-type: none"><li>• Features on page 1 changed</li><li>• Section 8 “Ordering Information” on page 11 changed</li></ul> |



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