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## Integrated Circuit Solution for Active Antennas

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### DATASHEET

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### Features

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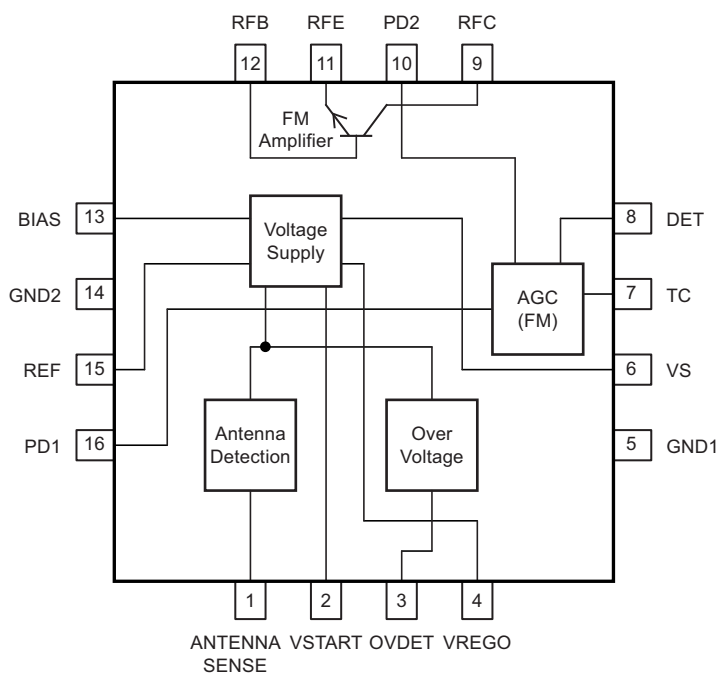
- Highly integrated - All-in-one active antenna IC
- Operating frequency range: 50MHz to 900MHz
- Main application 76MHz to 108MHz (broadcast FM worldwide)
- Integrated AGC
- Integrated driver for PIN diodes
- Integrated power supply regulator
- Integrated antenna sensor
- High dynamic range
- Excellent noise performance
- High intercept point 3rd order
- RF amplifier adjustable to various cable impedances
- Low noise output voltage
- Low power consumption

## 1. Description

The Atmel® ATR4253C is a highly integrated high-performance IC for active antenna amplification. The device has a built-in AGC, antenna detection, a power supply regulator and two driver stages for external PIN diodes.

The Atmel ATR4253C is based on BICMOS technology. The device is designed in particular for car applications and is suitable for active antennas located in several positions within the car such as bumpers, windscreen, mirrors or windows.

**Figure 1-1. Block Diagram**



## 2. Pin Configuration

Figure 2-1. Pinning QFN 3x3 / 16 Pins

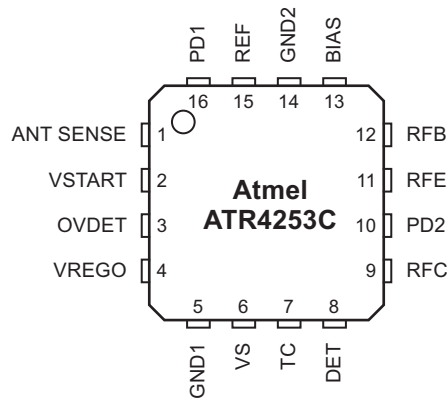


Table 2-1. Pin Description

| Pin    | Symbol    | Function                                    |
|--------|-----------|---|
| 1      | ANT SENSE | Antenna sense input                         |
| 2      | VSTART    | Comparator input of voltage detector        |
| 3      | OVDET     | Overvoltage detection input                 |
| 4      | VREGO     | Voltage regulator output                    |
| 5      | GND1      | Ground voltage regulator                    |
| 6      | VS        | Supply voltage                              |
| 7      | TC        | AGC time constant                           |
| 8      | DET       | AGC level detector input                    |
| 9      | RFC       | Amplifier Collector (NPN)                   |
| 10     | PD2       | 2 <sup>nd</sup> AGC output for pin diode    |
| 11     | RFE       | Amplifier emitter (NPN)                     |
| 12     | RFB       | Amplifier base (NPN)                        |
| 13     | BIAS      | Bias voltage (2.7V)                         |
| 14     | GND2      | Ground FM                                   |
| 15     | REF       | Reference voltage (6V)                      |
| 16     | PD1       | 1 <sup>st</sup> FM AGC output for pin diode |
| Paddle | GND       | Ground paddle                               |

## 3. Functional Description

The Atmel® ATR4253C is a highly integrated antenna amplifier with a broad range of features and functions. It compensates cable losses between the antenna and the car radio, which is usually placed far away from the antenna. The device can be used in the frequency range of 50MHz up to 900MHz (i.e., FM, DAB (+), DMB, DVB-T, ISDB-T, etc.) and has the flexibility to address different antenna types (e.g., glass, windscreen, roof antennas).

A separate automatic gain control (AGC) function is integrated in order to avoid overdriving the RF amplifier at large signal conditions.

The integrated PIN diode drivers help to reduce the external component cost and to minimize the board space.

The external component cost can be further reduced as the voltage regulation stage is also integrated. This stage provides overvoltage protection and current limitation. An external transistor is used as power driver for this stage.

### 3.1 RF Amplifier Stage

The RF amplifier is realized with a high-performance NPN transistor. This allows the use of an amplifier configuration which is optimized for the individual application requirements. For low-cost applications, the common emitter configuration enables good performance at reasonable BOM cost. For high-end applications, a common base configuration with transformer feedback provides high IP3 and low noise figures at reasonable current consumption. In both configurations, gain, input and output impedance can be adjusted by modifying the external components.

The bias voltage (BIAS) for the base of the NPN transistor is derived from an integrated voltage reference and has a PTAT (proportional to absolute temperature) behavior. The bias current of the RF amplifier is defined by an external resistor and is kept constant over temperature.

### 3.2 AGC

The IC is equipped with an AGC functionality to prevent overdriving the amplifier in case the amplifier is operated at strong antenna signals, e.g., near transmitters. It is possible to realize an additional antenna amplifier path with integrated AGC and external RF transistor. The bandwidth of the integrated AGC circuit is 900MHz.

The amplifier output (RFC) is connected to a capacitive voltage divider and the divided signal is applied to the AGC level detector at pin DET. This level detector input is optimized for low distortion. The rectified signal is compared against an internal reference. The divider ratio of the external voltage divider defines the AGC's threshold. If the threshold is reached, pin PD1 drives a positive current through one or two external pin diodes in shunt configuration. In case the limiting range of the shunt configuration is not sufficient an additional pin diode in serial configuration can be added and controlled via pin PD2. The current from PD2 through the serial pin diode is opposite to the current of PD1. This helps to limit the amplifier input signal and thus to prevent the FM amplifier from signal overdrive.

The drivers required for the external pin diode(s) are built-in into the Atmel ATR4253C IC, which reduces the BOM cost and the application size.

### 3.3 Supply Voltage Regulator

The driving voltage for an external power transistor is provided by an integrated regulator circuit.

An overvoltage protection circuit detects overvoltage condition and switches off the amplifier and AGC circuit in order to reduce current consumption and avoid thermal overload.

### 3.4 Antenna Sensor

The Atmel® ATR4253C provides a built-in antenna sensor that detects if the antenna is properly connected to the amplifier module. If no antenna is detected, the amplifier and AGC circuit are switched off to signal this error via supply current reduction to the unit that provides and monitors the supply current for the antenna amplifier (e.g., the car radio).

## 4. 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                | Pin | Symbol    | Min. | Max. | Unit |
|---------------------------|-----|-----------|------|------|------|
| Supply voltage            | 6   | $V_S$     | −0.3 | +12  | V    |
| Antenna sense current     | 1   | ANT SENSE | −500 | +500 | μA   |
| Comparator input current  | 2   | VSTART    | 0    | 2    | mA   |
| Overvoltage detector      | 3   | OVDET     | −0.3 | +3.3 | V    |
| Collector of FM amplifier | 9   | RFC       | 3    | 16   | V    |
| Power dissipation         |     | $P_{tot}$ |      | 700  | mW   |
| Junction temperature      |     | $T_j$     |      | 150  | °C   |
| Ambient temperature       |     | $T_{amb}$ | −40  | +115 | °C   |
| Storage temperature       |     | $T_{stg}$ | −50  | +150 | °C   |
| ESD HBM                   | All | $V_{HBM}$ | −2   | +2   | kV   |

## 5. Thermal Resistance

| Parameters   | Symbol     | Value | Unit |
|--|------------|-------|------|
| Junction ambient, soldered on PCB, dependent on PCB layout | $R_{thJA}$ | 40    | K/W  |

## 6. Operating Range

| Parameters         | Test Conditions                            | Pin | Symbol    | Min. | Typ. | Max. | Unit |
|--------------------|--|-----|-----------|------|------|------|------|
| Supply voltage     | Normal operation                           | 6   | $V_S$     | 7.5  | 10   | 11   | V    |
| Supply voltage     | Performance may be reduced, no malfunction | 6   | $V_S$     | 7    |      | 11   | V    |
| FM emitter current | Thermal condition                          | 11  | $I_{RFE}$ |      |      | 35   | mA   |

## 7. Electrical Characteristics

See test circuit (Figure 8-2 on page 9),  $V_S = 10V$ ,  $T_{amb} = 25^\circ C$ , unless otherwise specified.

| No.  | Parameters                     | Test Conditions  | Pin           | Symbol         | Min. | Typ.     | Max. | Unit       | Type* |
|------|--------------------------------|--|---------------|----------------|------|----------|------|------------|-------|
| 1.1  | Supply current                 | AGC OFF  | VS            | $I_S$          |      | 12       |      | mA         | B     |
|      |                                | AGC ON ; includes 7mA pin diode current  | VS            | $I_S$          |      | 19       |      | mA         | B     |
|      |                                | Antenna sense error detected   | VS            | $I_S$          | 15   | 20       | 25   | mA         | A     |
|      |                                | Over voltage   | VS            | $I_S$          |      | 10       | 14.9 | mA         | A     |
|      |                                | $T_{amb} = -40$ to $+115^\circ C$ ; AGC ON; includes 7mA pin diode current and 31mA RF current | VS, RFC       | $I_S, I_{RFC}$ |      | 50       | 70   | mA         | C     |
| 1.2  | Bias voltage output            |  | BIAS          | $V_{BIAS}$     | 2.5  | 2.8      | 3.1  | V          | A     |
| 1.3  | Output current of bias voltage |  | BIAS          | $I_{BIAS}$     | 0    |          | 3    | mA         | B     |
| 1.5  | Bias voltage output            | 1k $\Omega$ output resistor  | REF           | $V_{REF}$      | 5.7  | 6        | 6.3  | V          | A     |
| 2    | RF Amplifier                   |  |               |                |      |          |      |            |       |
| 2.1  | Emitter voltage                | $T = 25^\circ C$   | RFE           |                | 2.0  | 2.1      | 2.2  | V          | A     |
| 2.2  | Emitter voltage                | $T = -40^\circ C$ to $+115^\circ C$  | RFE           |                | 1.9  | 2.1      | 2.3  | V          | C     |
| 2.3  | Supply current <sup>(1)</sup>  | Common base  | RFC           | $I_{RFC}$      |      | 31       |      | mA         | B     |
| 2.4  | Supply current <sup>(2)</sup>  | Common emitter   | RFC           | $I_{RFC}$      |      | 35       |      | mA         | A     |
| 2.5  | Maximum output voltage         | $V_S = 10V$  | RFC           |                | 12   |          |      | $V_{pp}$   | C     |
| 2.6  | Input resistance               | $f = 100MHz$   | RF IN         | $R_{FMIN}$     |      | 50       |      | $\Omega$   | C     |
| 2.7  | Output resistance              | $f = 100MHz$   | RF OUT        | $R_{FMOUT}$    |      | 50       |      | $\Omega$   | C     |
| 2.8  | Power gain                     | $f = 100MHz$   | RF IN, RF OUT | G              |      | 5.2      |      | dB         | C     |
| 2.9  | OIP3 at FMOUT                  | Common base  | RF OUT        |                |      | 146      |      | dB $\mu V$ | C     |
| 2.10 | NF                             | Common base  | RF OUT        |                |      | 1.6      |      | dB         | C     |
| 2.11 | Power gain                     | $f = 100MHz$ , common emitter  | RF OUT        | G              |      | 13.5     |      | dB         | B     |
| 2.12 | OIP3 at FMOUT                  | Common emitter   | RF OUT        |                |      | 140      |      | dB $\mu V$ | B     |
| 2.13 | NF                             | Common emitter   | RF OUT        |                |      | 3.5      |      | dB         | C     |
| 2.14 | Maximum operating frequency    | 3dB corner, common emitter   | RF OUT        |                | 450  |          |      | MHz        | C     |
| 3    | AGC                            |  |               |                |      |          |      |            |       |
| 3.1  | AGC input voltage threshold    | FM range: $f = 100MHz$   | DET           | $V_{th1,100}$  | 83   | 85       | 87   | dB $\mu V$ | B     |
|      |                                | Extended: $f = 900MHz$   |               | $V_{th1,900}$  | 81   | 85       | 89   | dB $\mu V$ | C     |
| 3.2  | Saturation voltage             | 10mA   | PD1,2         |                |      | VS – 2.0 |      | V          | B     |
| 3.3  | Leakage current                |  | PD1,2         |                |      |          | 1    | $\mu A$    | B     |
| 3.4  | Maximum pin diode current      | AGC active, $115^\circ C$  | PD1           |                | 12   | 19       |      | mA         | D     |
| 3.5  | Maximum pin diode current      | AGC not active   | PD2           |                | 12   |          |      | mA         | A     |

\*) Type means: A = 100% tested, B = 100% correlation tested, C = Characterized on samples, D = Design parameter

Notes: 1. Current defined by R11= 68 $\Omega$

2. Current defined by R11= 56 $\Omega$

## 7. Electrical Characteristics (Continued)

See test circuit (Figure 8-2 on page 9),  $V_S = 10V$ ,  $T_{amb} = 25^\circ C$ , unless otherwise specified.

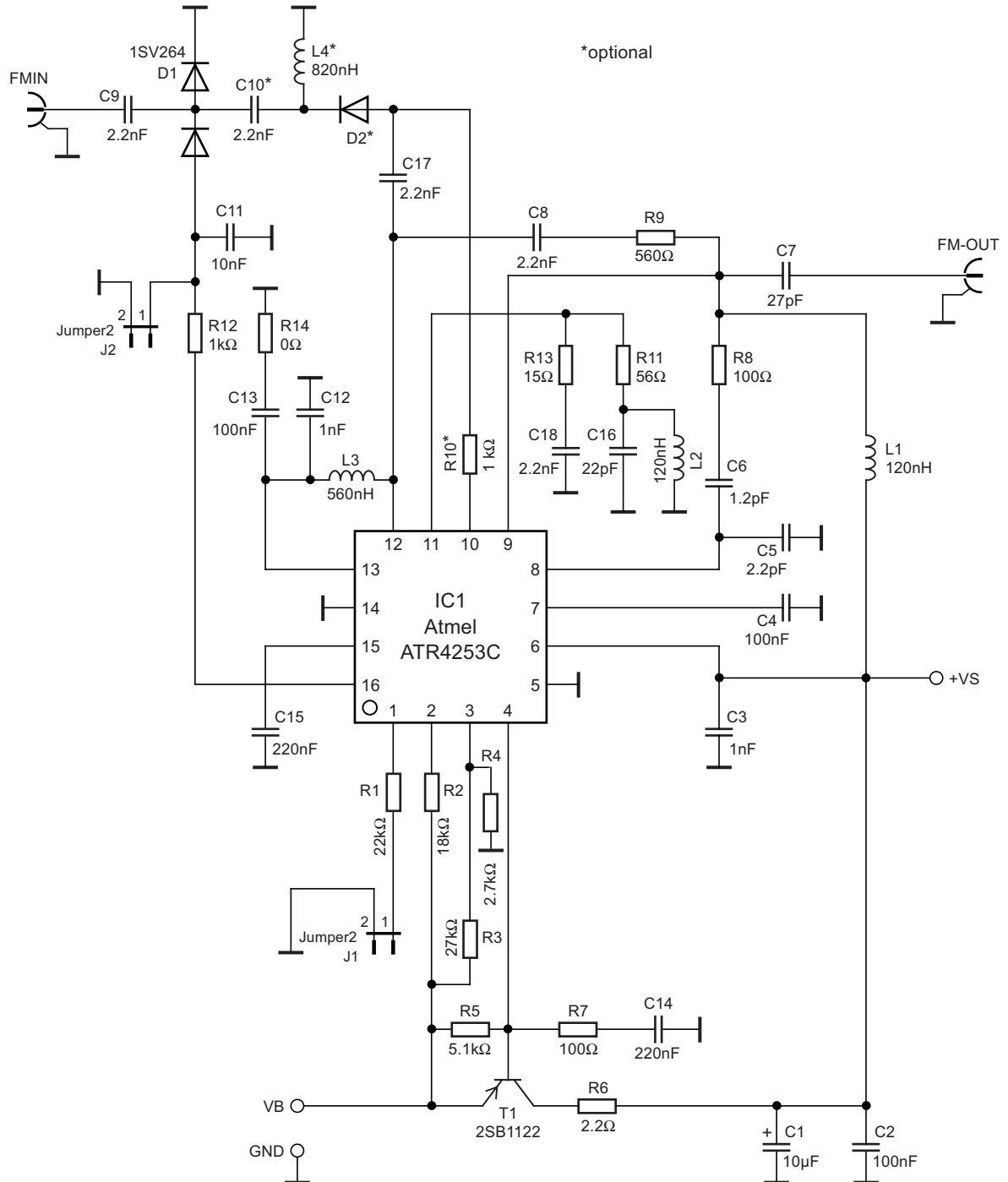
| No. | Parameters                           | Test Conditions                               | Pin        | Symbol               | Min.   | Typ. | Max.    | Unit            | Type* |
|-----|--------------------------------------|---|------------|----------------------|--------|------|---------|-----------------|-------|
| 3.6 | Input resistance                     |   | DET        | $R_{DET}$            | 17     |      | 25      | $k\Omega$       | C     |
| 3.7 | Input capacitance                    | $f = 100MHz$                                  | DET        | $C_{DET}$            | 1.5    |      | 2.0     | pF              | C     |
| 3.8 | IP3 Pin 8 FM                         | 100MHz + 105MHz,<br>$V_{DET} = 120dB\mu V$    | DET        |                      |        | 150  |         | $dB\mu V$       | C     |
| 3.9 | Transconductance                     | $dI_{FMTc} / dV_{FMDet}$                      | TC<br>DET  | $dI_{TC} / dV_{DET}$ | 0.35   | 0.5  | 0.8     | $mA/V$<br>(rms) | B     |
| 4   | Voltage Regulator / Monitor          |   |            |                      |        |      |         |                 |       |
| 4.1 | Output voltage of regulator          | Battery voltage<br>$V_B = 14V$                | VS         |                      | 9.5    | 10   | 10.5    | V               | A     |
| 4.2 | Ripple rejection of regulator        | 100Hz, $V_B > V_S + 1V$                       | VB, RF OUT |                      | 40     | 50   |         | dB              | C     |
| 4.3 | Threshold for over-voltage detection |   | OVDET      |                      | 1.6    |      | 1.8     | V               | A     |
| 4.4 | Hysteresis of overvoltage detection  |   | OVDET      |                      |        | 5    |         | %               | C     |
| 5   | Antenna Sensor                       |   |            |                      |        |      |         |                 |       |
| 5.1 | Antenna monitor range                | $R_{SENSE} = 22k\Omega$ ,<br>antenna detected | ANT SENS   |                      | 0 to 3 |      | 6 to 16 | V               | C     |

\*) Type means: A = 100% tested, B = 100% correlation tested, C = Characterized on samples, D = Design parameter

- Notes:
1. Current defined by  $R11 = 68\Omega$
  2. Current defined by  $R11 = 56\Omega$

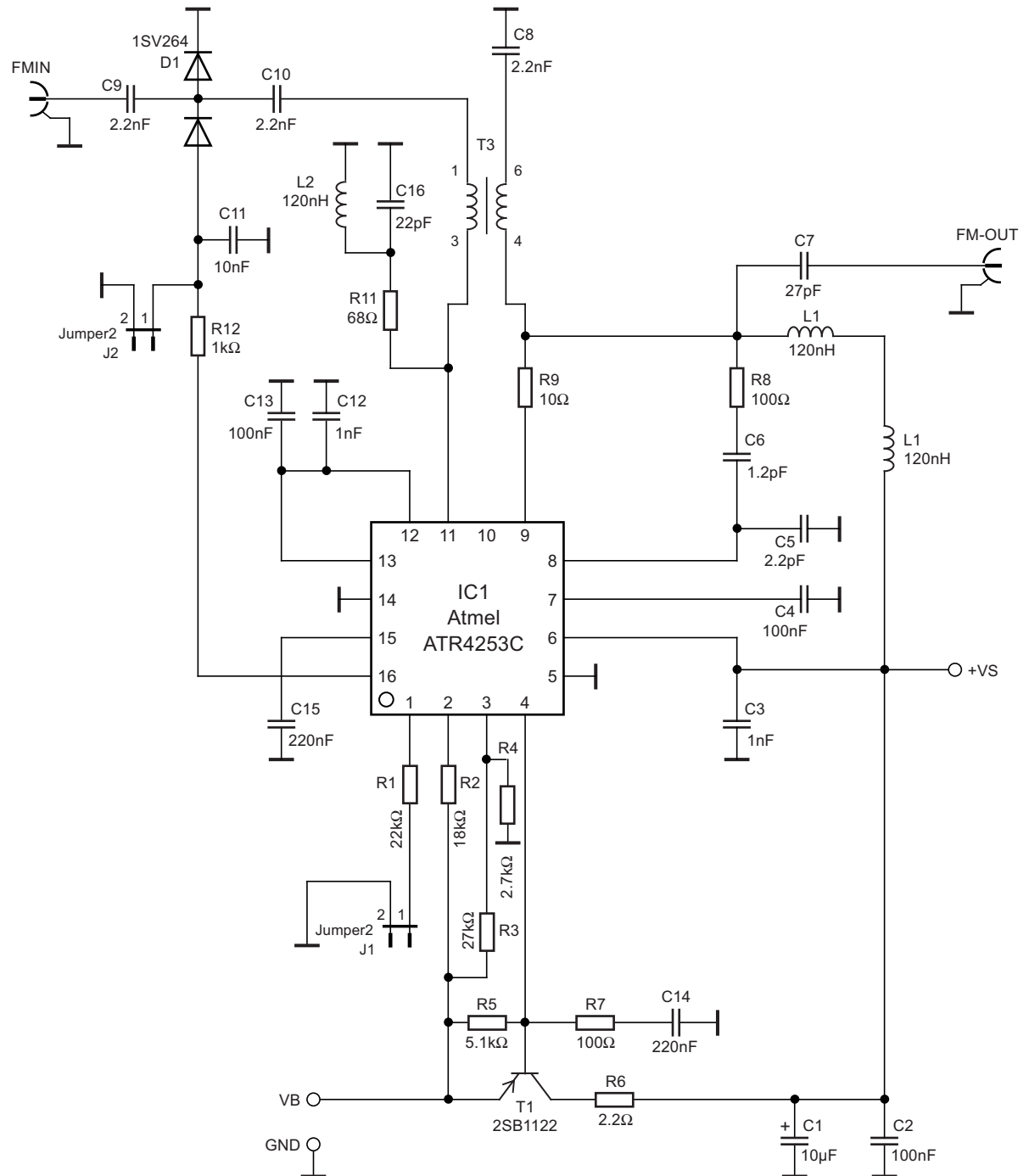
## 8. Application Circuits

Figure 8-1. Common Emitter Configuration

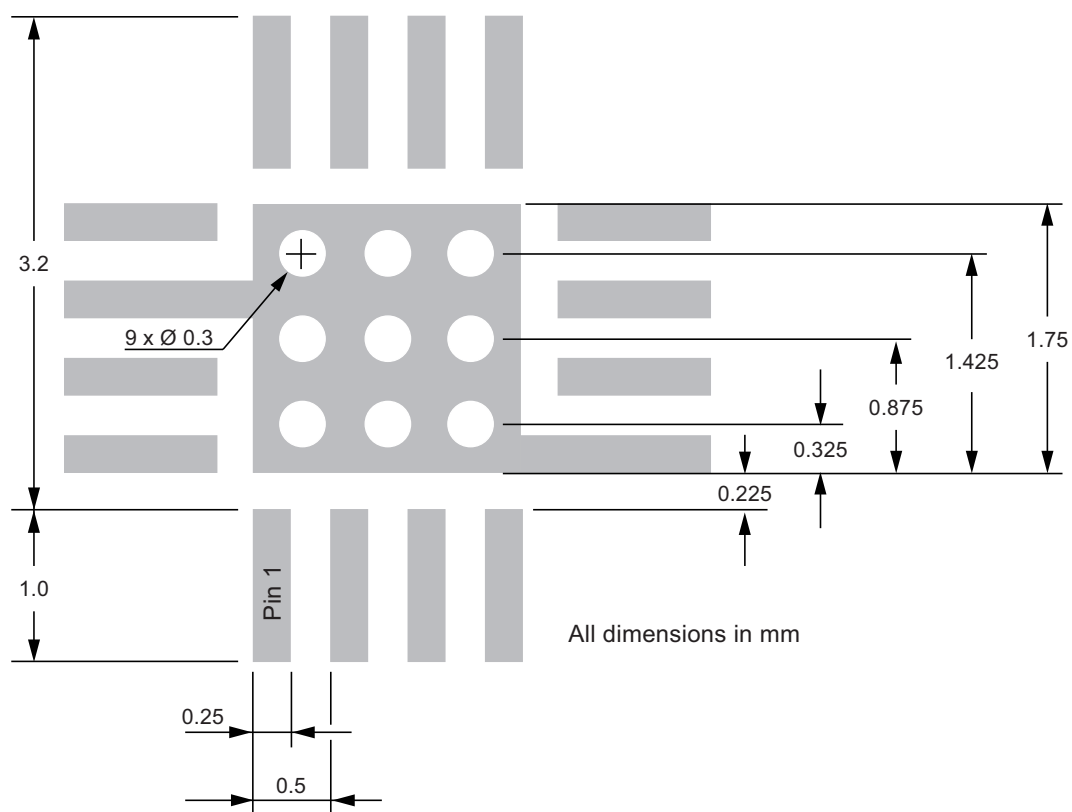




**Figure 8-2. Common Base Configuration**



### Figure 8-3. Recommended Footprint



## 9. Internal Circuitry

Table 9-1. Equivalent Pin Circuits (ESD Protection Circuits not Shown)

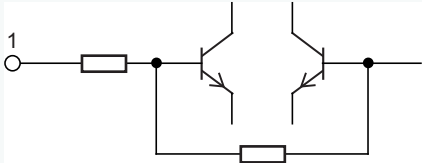
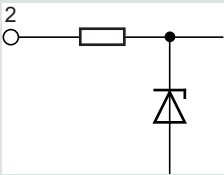
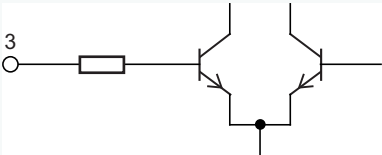
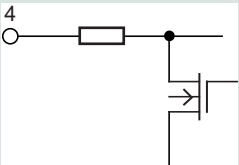

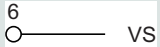
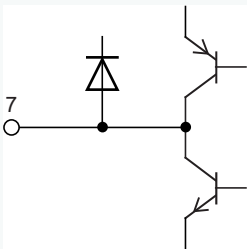
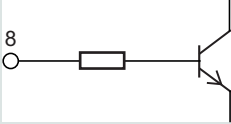
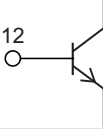
| Pin   | Symbol     | Function  |
|-------|------------|---|
| 1     | ANT SENSE  |     |
| 2     | VSTART     |     |
| 3     | OVDET      |     |
| 4     | VREGO      |   |
| 5, 14 | GND1, GND2 |  |
| 6     | VS         |   |
| 7     | TC         |   |

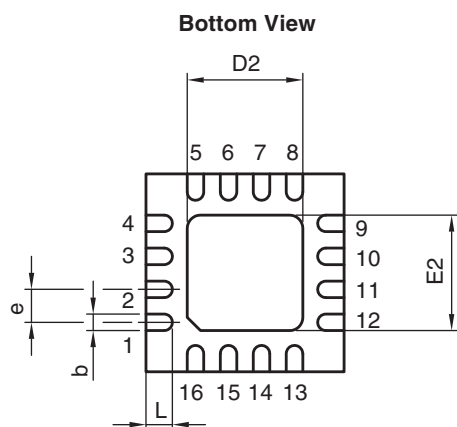
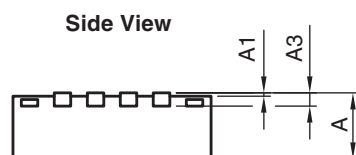
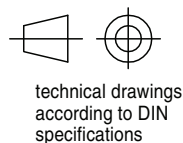
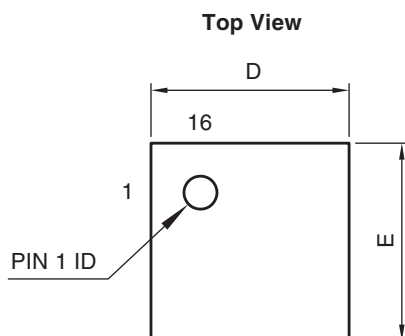
Table 9-1. Equivalent Pin Circuits (ESD Protection Circuits not Shown) (Continued)

| Pin    | Symbol    | Function  |
|--------|-----------|---|
| 8      | DET       |     |
| 9      | RFC       |    |
| 10, 16 | PD1, PD2  |     |
| 11, 13 | RFE, BIAS |   |
| 12     | RFB       |  |
| 15     | REF       |   |

## 10. Ordering Information

| Extended Type Number | Package        | Remarks                  |
|----------------------|----------------|--------------------------|
| ATR4253C-PVPW        | VQFN 3x3 / 16L | Taped on reel, 2k volume |
| ATR4253C-PVQW        | VQFN 3x3 / 16L | Taped on reel, 8k volume |

## 11. Package Information



| COMMON DIMENSIONS<br>(Unit of Measure = mm) |      |         |      |      |
|---|------|---------|------|------|
| Symbol                                      | MIN  | NOM     | MAX  | NOTE |
| A   | 0.8  | 0.9     | 1    |      |
| A1  | 0.0  | 0.02    | 0.05 |      |
| A3  | 0.15 | 0.2     | 0.25 |      |
| D   | 2.9  | 3       | 3.1  |      |
| D2  | 1.7  | 1.75    | 1.8  |      |
| E   | 2.9  | 3       | 3.1  |      |
| E2  | 1.7  | 1.75    | 1.8  |      |
| L   | 0.3  | 0.4     | 0.5  |      |
| b   | 0.18 | 0.25    | 0.32 |      |
| e   |      | 0.5 BSC |      |      |

11/11/09



**Package Drawing Contact:**  
packagedrawings@atmel.com

**TITLE**  
**Package: VQFN\_3x3\_16L**  
Exposed pad 1.75 x 1.75

**DRAWING NO.**  
6.543-5164.01-4

**REV.**  
1



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