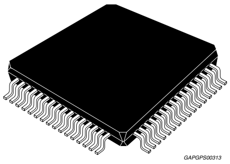
# TDA7786
# TDA7786M

## ELITE automotive tuners for AM/FM car-radio

**Datasheet - production data**



**LQFP64**

## Features

- AEC-Q100 qualified
- FM, AM and weather band reception
- Fully integrated VCO for world tuning
- High performance PLL for fast RDS system
- Integrated AM LNA and PIN diodes
- Automatic self alignment for FM front-end pre-selection filter and image rejection
- Integrated IF filters with high selectivity, dynamic range and adaptive bandwidth control
- Drift-free Digital-IF signal processing with high performance
- RDS demodulation with group and block synchronization
- High performance stereo decoder with noise-blanker
- Digital interface for HD Radio™ reception with digital audio blending
- I$^2$C bus-controlled
- I$^2$S input/output digital audio interfaces
- Single 5 V supply
- LQFP64 package
- MuSICA (multipath noise reduction) algorithm available for premium version of the device

## Description

The TDA7786x (ELITE) tuner is an optimized high-performance AM/FM tuner IC family for car-radio applications, suitable also (in combination with an external baseband decoder) for HD Radio™ reception.

Its members integrate mixers and IF amplifiers for AM, FM and WX, fully integrated VCO and PLL synthesizer, IF- processing including adaptive bandwidth control, stereo decoder, RDS decoder, and digital interfaces for external HD Radio™ decoding on a single IC.

AM/FM IBOC base band filtering is available in parallel to standard analog reception.

The utilization of digital signal processing results in numerous advantages: very low number of external components, very small space occupation and easy application, very high selectivity due to digital filters, high customization possibility through software control, automatic alignment and a powerful DSP for custom processing.

Two versions of the device cover different application/performance requirements:

**TDA7786:** entry-level, high-performance tuner;

**TDA7786M:** tuner with enhanced behavior in case of FM multipath, thanks to the proprietary MuSICA algorithm.

Both versions are HW- and SW-compatible.

**Table 1. Device summary**

| Order code | Package | Packing |
|---|---|---|
| TDA7786 | LQFP64 (10x10x1.4mm) | Tray |
| TDA7786M | | |

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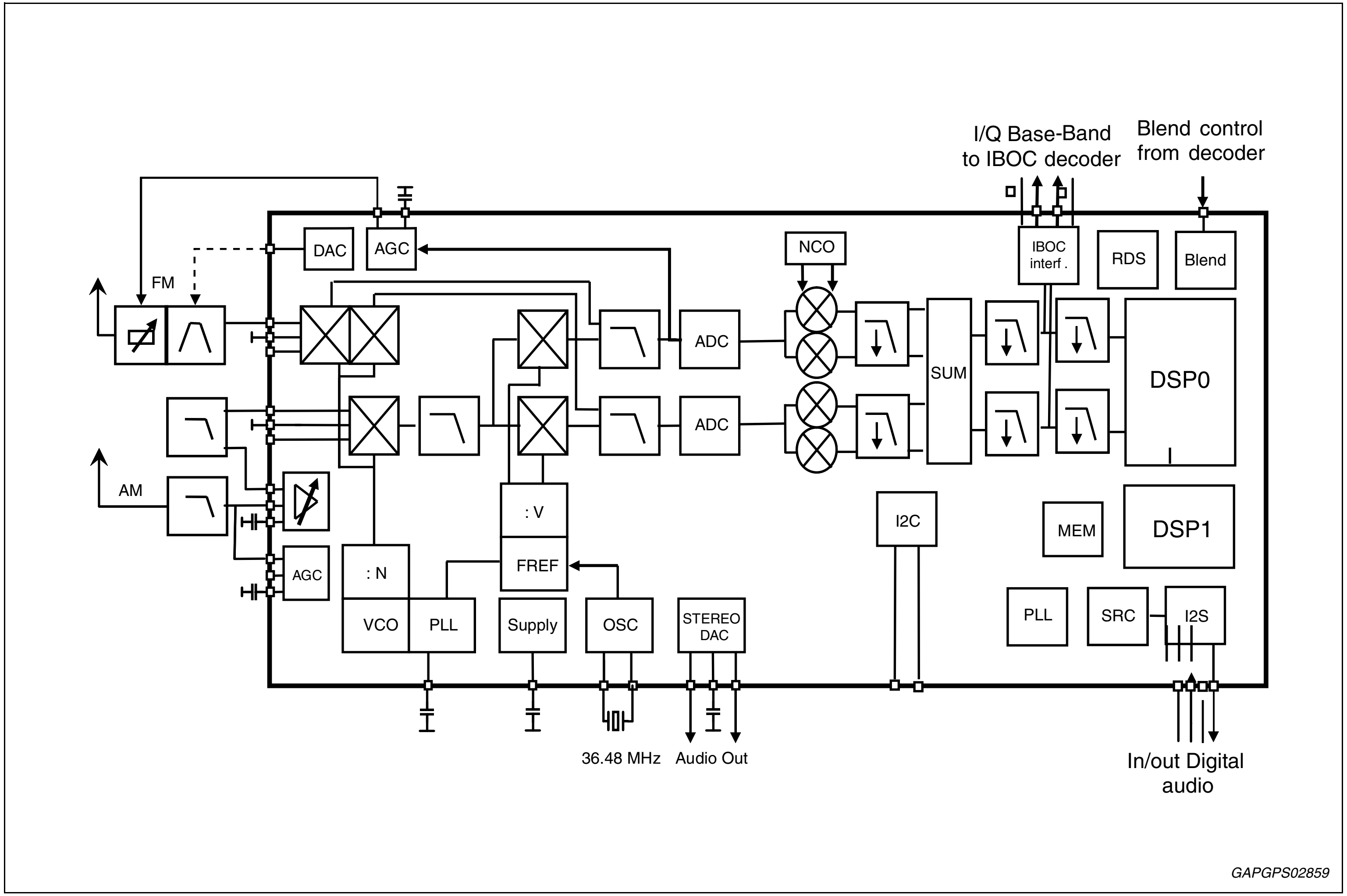
# 1 Block diagram and pin description

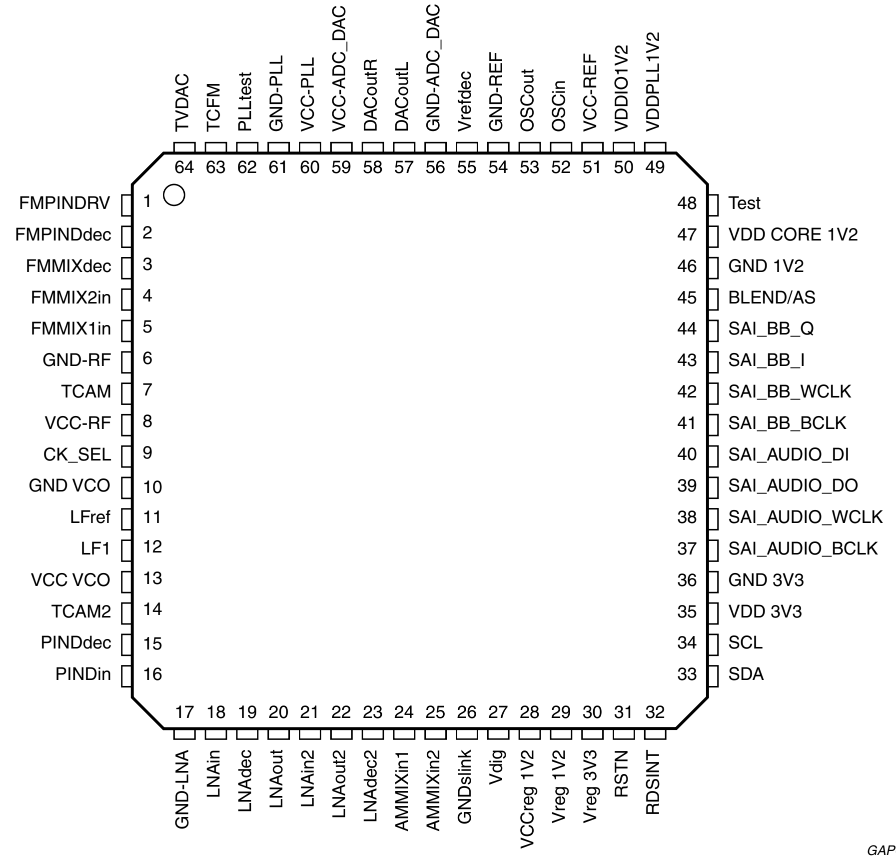
## 1.1 Block diagram

Figure 1. Functional block diagram



## 1.2 Pin description

**Figure 2. Pin connection (top view)**



GAPGPS02860

**Table 2. Pin description**

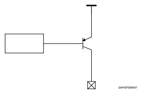
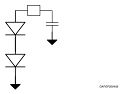
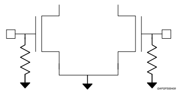
| Pin | Pin name | I/O | Function | Description | Equivalent circuit |
|---|---|---|---|---|---|
| 1 | FMPINDRV | Out | FM | FM PIN diode driver output |  |
| 2 | FMPINDdec | In | | Integrated FM PINdiode decoupling |  |
| 3 | FMMIXdec | - | | FM RF signal ground | |
| 4 | FMMIXin2 | In | | FM mixer input 2 |  |
| 5 | FMMIXin1 | In | | FM mixer input 1 | |
| 6 | GNDRF | - | - | RF power ground | - |

**Table 2. Pin description (continued)**

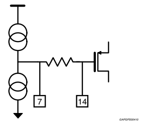
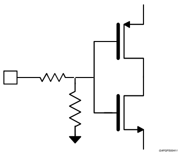
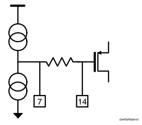
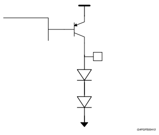
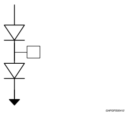
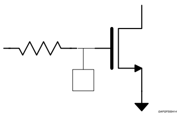
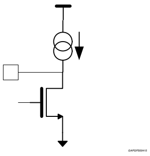
| Pin | Pin name | I/O | Function | Description | Equivalent circuit |
|---|---|---|---|---|---|
| 7 | TCAM | - | - | AM AGC time constant |  |
| 8 | VCCRF | In | - | RF 5 V supply | - |
| 9 | CK_SEL | In | - | Master/Slave clock operation select |  |
| 10 | GNDVCO | - | VCO | VCO ground | - |
| 11 | LFref | - |  | Loop filter reference | - |
| 12 | LF1 | - |  | Loop filter output | - |
| 13 | VCCVCO | In |  | VCO 5V supply | - |
| 14 | TCAM2 | - |  | AM AGC $2^{nd}$ order time constant |  |
| 15 | PINDdec | - | AM pin diode | AM AGC internal PIN diode decoupling |  |
| 16 | PINDin | - |  | AM AGC internal PIN diode input |  |
| 17 | GNDLNA | - | AM LNA | AM LNA ground | - |
| 18 | LNAin | In |  | AM LNA input |  |
| 19 | LNAdec | - |  | AM LNA decoupling |  |
| 20 | LNAout | Out |  | AM LNA output | - |
| 21 | LNAin2 | - |  | AM LNA input $2^{nd}$ stage | - |

Table 2. Pin description (continued)

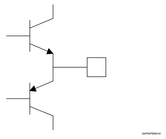
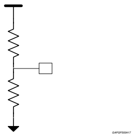
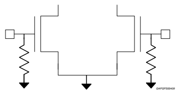
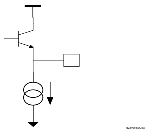
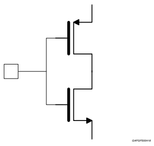
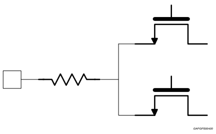
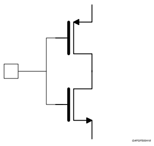
| Pin | Pin name | I/O | Function | Description | Equivalent circuit |
|---|---|---|---|---|---|
| 22 | LNAout2 | - | AM LNA | AM LNA output 2nd stage |  |
| 23 | LNAdec2 | - | | AM LNA decoupling 2nd stage |  |
| 24 | AMMIXin1 | In | AM mixer inputs | AM mixer input 1 |  |
| 25 | AMMIXin2 | In | | AM mixer input 2 | |
| 26 | GNDSLINK | - | Supply, ground and reset | Internal inter-IC communication bus ground | - |
| 27 | Vdig | In | | Front-end digital 5 V supply | - |
| 28 | VCCreg1V2 | In | | Internal 1.2 V regulator 5 V supply | - |
| 29 | REG1V2 | Out | | Internal 1.2 V regulator output |  |
| 30 | Vreg3v3 | Out | | Internal 3.3 V regulator output | |
| 31 | RSTN | In | | Reset (low active)<br>Pull-up 50 kΩ to 3.3 V IO supply |  |
| 32 | RDSINT | Out | | RDS interrupt output<br>Pull-down 50 kΩ to ground | - |
| 33 | SDA | In/Out | I$^2$C interface | I$^2$C bus data<br>Pull-up 50 kΩ to 3.3 V IO supply |  |
| 34 | SCL | In | | I$^2$C bus clock<br>Pull-up 50 kΩ to 3.3 V IO supply |  |
| 35 | VDD3V3 | In | - | IO ring (3.3 V) supply | - |
| 36 | GND3V3 | - | - | IO ring (3.3 V) supply | - |

Table 2. Pin description (continued)

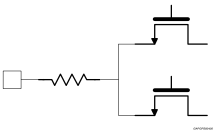
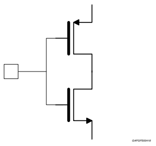
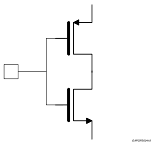
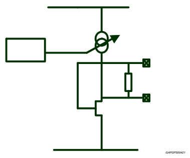
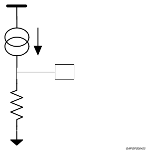
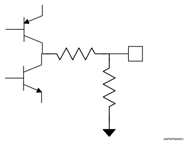
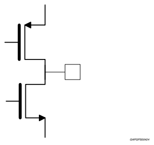
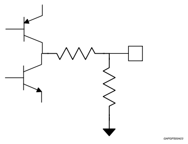
| Pin | Pin name | I/O | Function | Description | Equivalent circuit |
|---|---|---|---|---|---|
| 37 | SAI_AUDIO_BCLK | In/Out | HD Radio™ connectivity/ Audio output I2S interface | SAI clk<br>Pull-down 50 kΩ to ground, SINE_3V3_LIN pad |  |
| 38 | SAI_AUDIO_WCLK | In/Out | | Audio SAI word-select<br>Pull-down 50 kΩ to ground, SINE_3V3_LIN pad | |
| 39 | SAI_AUDIO_DO | Out | | Audio SAI data output<br>Pull-down 50 kΩ to ground, SINE_3V3_LIN pad | |
| 40 | SAI_AUDIO_DO | In | | Audio SAI data-input<br>Pull-down 50 kΩ to ground, SINE_3V3_LIN pad | |
| 41 | SAI_BB_BCLK | In/Out | | SAI Base-Band clock<br>Pull-down 50 kΩ to ground, SINE_3V3_LIN pad | |
| 42 | SA_BB_WCLK | In/Out | | SAI Base-Band word-select<br>Pull-down 50 kΩ to ground, SINE_3V3_LIN pad | |
| 43 | SAI_BB_I | Out | | SAI Base-Band I data<br>Pull-down 50 kΩ to ground, SINE_3V3_LIN pad | |
| 44 | SAI_BB_Q | Out | | SAI Base-Band Q data<br>Pull-down 50 kΩ to ground, SINE_3V3_LIN pad | |
| 45 | BLEND/AS | In | | HD blend input<br>Pull-down 50 kΩ to ground |  |
| 46 | GND1V2 | - | - | DSP core ground | - |
| 47 | VDD core 1V2 | In | - | DSP core 1.2 V supply | - |
| 48 | Test | In | - | Test Mode<br>Pull-down 50 kΩ to ground |  |
| 49 | VDDPLL1V2 | In | - | Digital PLL 1.2 V supply | - |
| 50 | VDDIO1V2 | In | - | Internal inter-IC communication 1.2 V supply | - |
| 51 | VCC-REF | In | - | Front-end reference frequency and regulator 5 V supply | - |

Table 2. Pin description (continued)

| Pin | Pin name | I/O | Function | Description | Equivalent circuit |
|---|---|---|---|---|---|
| 52 | OSCin | In | Oscillator | Crystal oscillator input | - |
| 53 | OSCout | Out |  | Crystal oscillator output |  |
| 54 | GND-REF | - | - | Front-end reference frequency and regulator ground | - |
| 55 | Vrefdec | - | - | 3.3 V Bias generation decoupling |  |
| 56 | GND-ADC_DAC | - | DAC | IFADC and audio DAC ground | - |
| 57 | DACoutL | Out |  | Audio output left |  |
| 58 | DACoutR | Out |  | Audio output right |  |
| 59 | VCC-ADC_DAC | In |  | IFADC and audio DAC 5 V supply | - |
| 60 | VCC-PLL | In | PLL | Tuning PLL 5 V supply | - |
| 61 | GND-PLL | - |  | Tuning PLL ground | - |
| 62 | PLLtest | Out |  | PLL Test output |  |
| 63 | TCFM | - | - | FM AGC time constant |  |
| 64 | TVDAC | Out | - | Tuning voltage output | - |

# 2 Function description

## 2.1 FM - mixers

The FM Image Rejection mixer has two single ended inputs, selectable through software. They are designed to achieve best performance both in case of a passive tuned preselection and of a passive fixed band-pass preselection without tuning for lower cost applications.

The input frequency is down-converted to very low IF with high image rejection.

The tuned application is supported by an 8-bit tuning DAC. The alignment of the DAC is performed automatically on-chip.

## 2.2 FM - AGC

The programmable RFAGC senses the mixer input to avoid overload.

When the RFAGC threshold is reached, the PIN diode output is activated in order to attenuate the incoming RF signal

The PIN diode driver is able to drive external PIN diodes with up to 15 mA current.

The time constant of the FM AGC is defined by the combination of an external capacitor and internal currents. There are two programmable attack and decay time constants.

## 2.3 AM - LNA

The integrated AM LNA feature is integrated with low-noise and high IIP2 and IIP3. The gain of the LNA is controlled by the AGC. The maximum gain is set with an external resistor, typically 26 dB with 470 Ω.

## 2.4 AM - AGC

The programmable AM RFAGC senses the mixer inputs and controls the internal PIN diodes and LNA gains.

Firstly the LNA gain is reduced by about 10 dB, and then the PIN diodes are activated to further attenuate the signal.

The time constant of the 2$^{nd}$ order AM AGC LPF is defined by both external components and programmable internal currents.

## 2.5 AM - Mixers

The image rejection mixer has two AM inputs selectable via software. It easily supports low-cost applications for extended frequency bands like short-waves.

The input frequency is converted to low IF with high image rejection.

## 2.6 IF A/D converters

A high performance IQ-IFADC converts the IF signal to the digital domain for subsequent digital signal processing.

Two fully differential, continuous-time Sigma-Delta (ΣΔ) IF-ADCs are used for both the 'I' path and the 'Q' path. For each IFADC, two fully differential input nodes are fed with an input signal having a bandwidth up to 325 kHz. This fully differential design provides good suppression of even-order harmonics. For complex filtering, the input signals of the 'I' path and the 'Q' path have a 90 degree phase shift. The IFADC sampling frequency is 36.48 MHz.

## 2.7 Audio D/A converters

A CD-quality (>100dB DR) stereo DAC provides the left/right audio signals after IF processing and stereo-decoding by the DSP. In presence of an external HD Radio™ decoder the DAC delivers the high quality audio resulting from the decoding of the HD Radio™ transmissions.

## 2.8 VCO

The VCO is fully integrated without any external tuning component. It covers all the FM frequency bands including EU, US, Japan, East-Europe, Weather-Band and the AM bands including LW, MW and SW. Its center frequency is approximately 2.7 GHz.

## 2.9 PLL

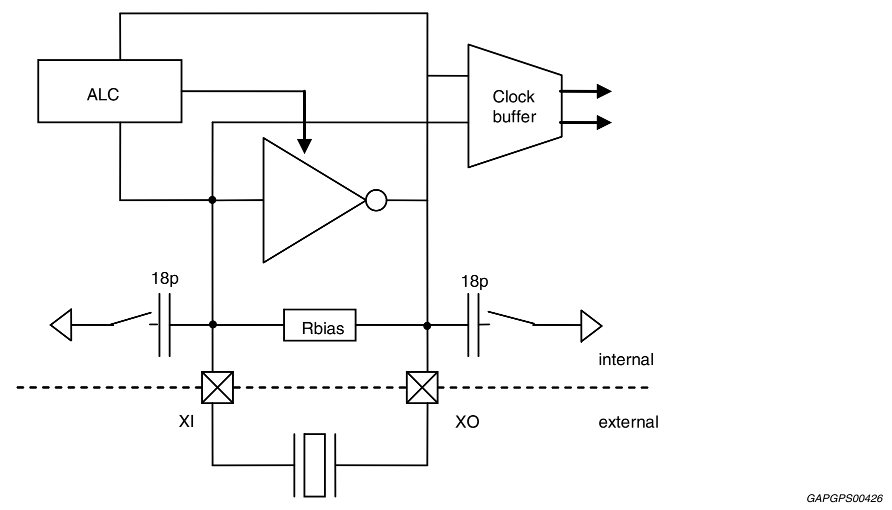
### 2.9.1 Tuner PLL

The very high-speed tuning PLL is able to settle within about 100 µs for fast RDS applications. The frequency step can be as low as 5 kHz in FM and 500 Hz in AM.

## 2.10 Crystal oscillator

The device works with a 36.48 MHz fundamental tone crystal. The oscillator block diagram is shown in *Figure 3*. On the PCB the crystal must be connected as close as possible to the chip oscillator input and output pins of the chip. The internal load capacitance together with pin and pad capacitance is optimized for fundamental tone crystal units at 36.48 MHz. It is not recommended to put any additional external load capacitors. By suitably configuring pin #9 (CK_SEL), the device can be operated as either a clock master or a clock slave. If pin 9 is left open or tied to GND, the device is configured as clock master (typical operation mode). In case the device is configured as clock slave, pin 9 needs to be connected to 5 V. Then the crystal oscillator is switched off and the device expects a crystal equivalent signal on the OSCout/OSCin pins.

**Figure 3. Crystal oscillator block diagram**



## 2.11 DSP and digital hardware accelerators

The TDA7786x embeds two DSP cores for high computational power and achievable customization. The DSP cores, in combination with the hardware accelerators, take care of all the tuner digital signal processing. The main program is fixed in ROM. Control parameters are copied to RAM and are accessible and modifiable there, thus allowing a parametric performance optimization. The operations performed by the DSP cores and HW accelerators are:

- digital down-conversion of IF
- bandwidth selection with variable controlled bandwidth
- FM and AM noise blanking
- FM/AM demodulation with soft-mute, high-cut, weak signal processing and quality detection
- FM stereo decoding with stereo-blend
- RDS demodulation including error correction and block synchronization with generation of an RDS interrupt for the main µP
- Autonomous control of RDS-AF tests
- Self-alignment of pre-selection tuning

## 2.12 Digital high speed IO interface pins

The IC has several IOs tasked for connectivity to an external HD Radio™ decoder and/or to $I^2S$ audio sources and destinations (pins 37 to 44).

These pins are driven by a special buffer that has been developed to reduce disturbance originating from activity on the digital lines. This bidirectional buffer is based on a TTL Schmitt trigger receiver and a slew-rate controlled driver with programmable cut-off frequency and current capability.

Typical configurations of these IOs for both analog and digital-HD reception are indicated in *Table 3*; for the suggested configuration all the slew-rate controlled pads are programmed with a 10 MHz cut-off frequency:

**Table 3. Suggested GPIO direction and driving capability**

| Pin | Use case: HD reception | Use case: digital audio out | Driving capability | |
|---|---|---|---|---|
| | | | 10 pF | 5 pF |
| 37 | IN | OUT | | X |
| 38 | IN | OUT | | X |
| 39 | OUT | OUT | | X |
| 40 | IN | IN | | X |
| 41 | OUT | - | X | |
| 42 | OUT | - | | X |
| 43 | OUT | - | X | |
| 44 | OUT | - | X | |

In case a different GPIO configuration is used, it is recommended to connect the TDA7786x to an externally regulated 3.3 V source.

## 2.13 Multipath reduction

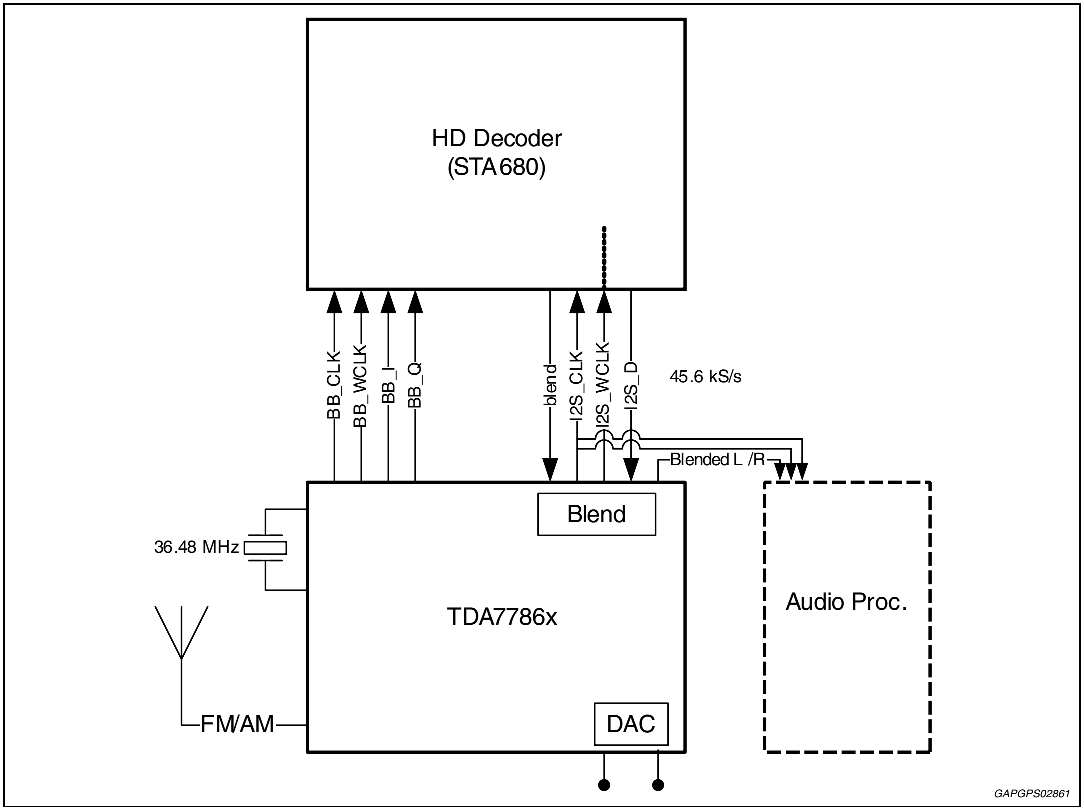
The TDA7786 is equipped with a basic FM multipath noise reduction system in addition to the traditional weak signal processing. The algorithm, called DANCE, assures an improved performance in presence of in-band interference (such as in case of multipath).

The premium version of the ELITE family, the TDA7786M is equipped with a superior algorithm, called MuSICA, to further enhance the reception quality even in presence of strong multipath.

## 2.14 HD Radio™ connectivity

The ELITE complies with HD Radio™ interface specifications as per Ibiquity's 'RX_SSS_1108 HD Radio™ power efficient RF-IF and peripheral processing (power RIPP) specification', thus providing an external HD Radio™ decoder with I/Q base-band signals and receiving the decoded digital audio from it, as shown in *Figure 4*.

**Figure 4. HD Radio™ system architecture example**



The complex baseband signal of an IBOC transmission is sent to the external decoder using the dedicated digital output interface SAI_BB. The SAI_BB supports the modes shown in both *Figure 5* and *Figure 6*. Timing information for the protocols shown is detailed in *Table 4* and *Table 5*.

Figure 5. SAI_BB waveforms (normal mode)

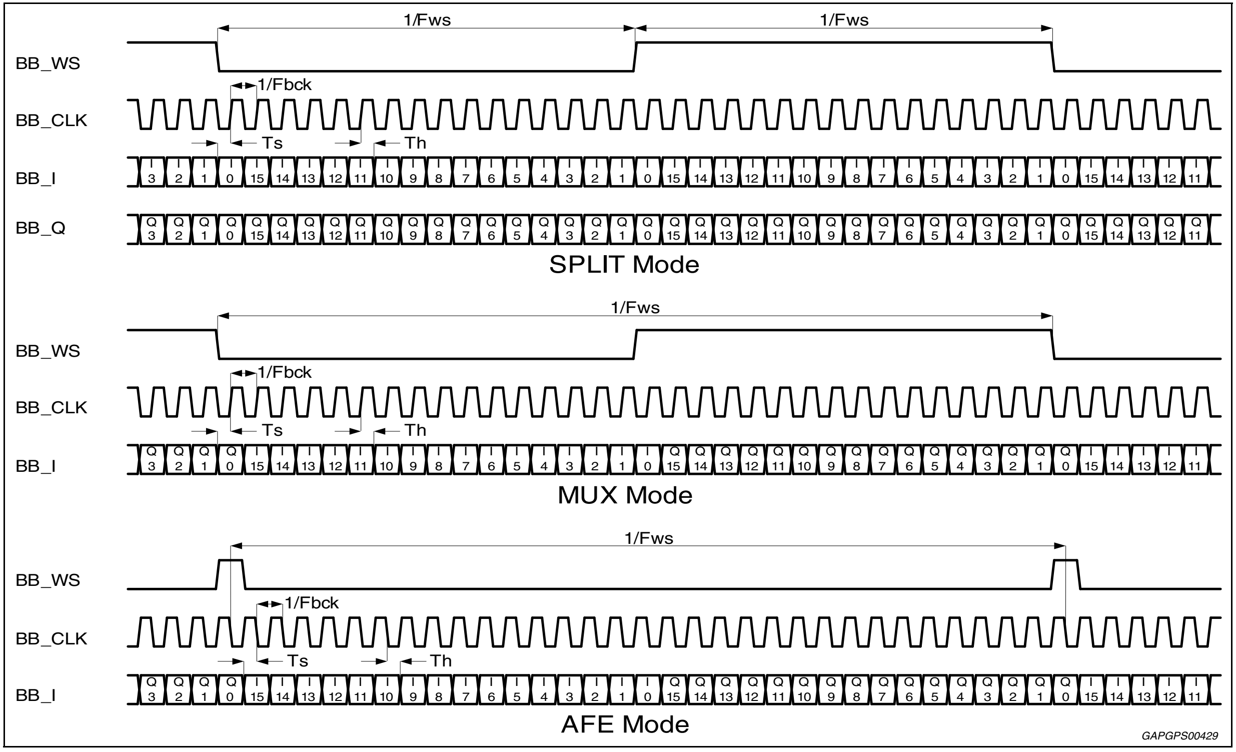


Table 4. SAI_BB timing values (normal mode)

| Symbol | Parameter | Rate | | | | | Unit |
|---|---|---|---|---|---|---|---|
| Fpll | PLL clock | 332.8 | 345.6 | 451.584 | 466.944 | 245.76 | MHz |
| Fws | Word strobe | 650<br>(332.8/512) | 675<br>(345.6/512) | 882<br>(451.582/512) | 912<br>(466.944/512)) | 48<br>(245.76/5120) | KHz |
| Fbclk | Bit clock in SPLIT mode | 10.4<br>(332.8/32) | 10.8<br>(345.6/32) | 14.112<br>(451.584/32) | 14.592<br>(466.944/32) | 0.768<br>(245.76/320) | MHz |
| Fbclk | Bit clock in MUX mode | 20.8<br>(332.8/16) | 21.6<br>(345.6/16) | 28.224<br>(451.584/16) | 29.184<br>(466.944/16) | 1.536<br>(245.76/160) | MHz |
| Fbclk | Bit clock in AFE mode | 20.8<br>(332.8/16) | 21.6<br>(345.6/16) | 28.224<br>(451.584/16) | 29.184<br>(466.944/16) | 1.536<br>(245.76/160) | MHz |
| Ts | Data setup time (min) | 5 | 5 | 5 | 5 | 5 | ns |
| Th | Data hold time (min) | 5 | 5 | 5 | 5 | 5 | ns |

Figure 6. SAI_BB waveforms (burst mode)

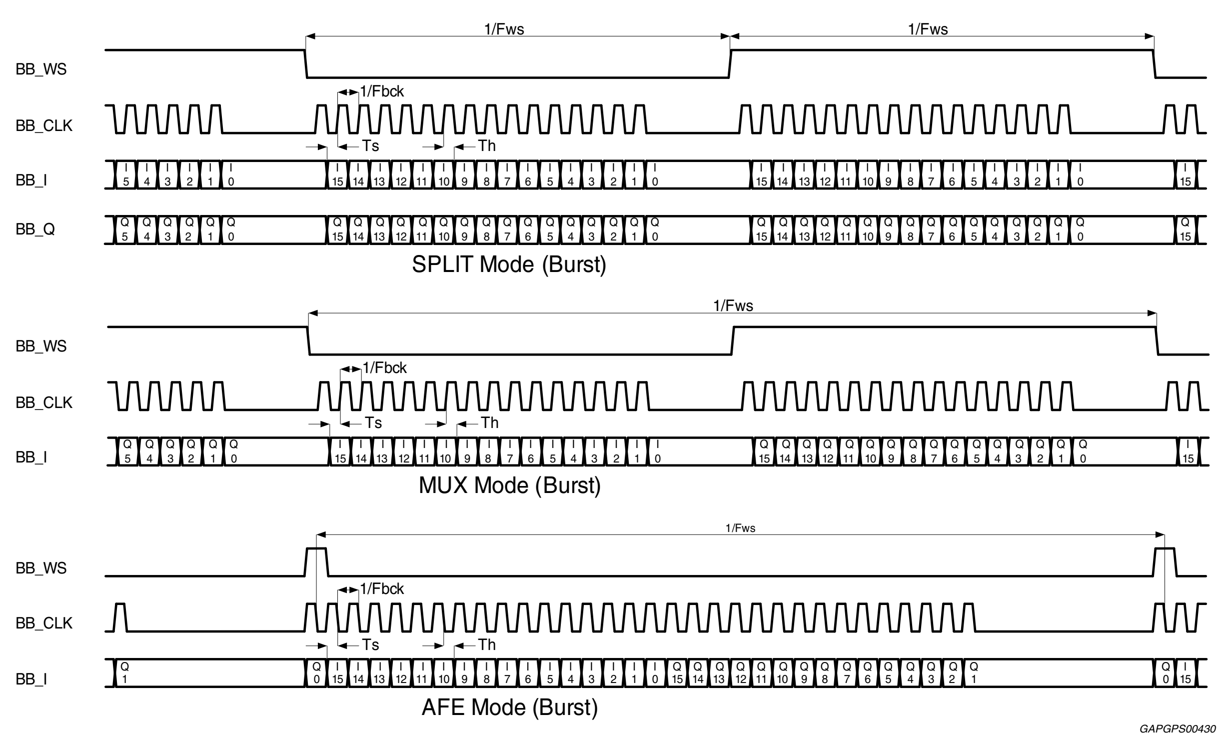


Table 5. SAI_BB timing values (burst mode)

| Symbol | Parameter | Rate | | | | | Unit |
|---|---|---|---|---|---|---|---|
| Fpll | PLL clock | 332.8 | 345.6 | 451.584 | 466.944 | 245.76 | MHz |
| Fws | Word strobe | 650<br>(332.8/512) | 675<br>(345.6/512) | 882<br>(451.582/512) | 912<br>(466.944/512)) | 48<br>(245.76/5120) | KHz |
| Fbclk | Bit clock in SPLIT mode | 332.8/n<br>(n=16/32) | 345.6/n<br>(n=16/32) | 451.584/n<br>(n=16/32) | 466.944/n<br>(n=16/32) | 245.76/n<br>(n=160/320) | MHz |
| Fbclk | Bit clock in MUX mode | 332.8/n<br>(n=8/16) | 345.6/n<br>(n=8/16) | 451.584/n<br>(n=8/16) | 466.944/n<br>(n=8/16) | 245.76/n<br>(n=80/160) | MHz |
| Fbclk | Bit clock in AFE mode | 332.8/n<br>(n=8/16) | 345.6/n<br>(n=8/16) | 451.584/n<br>(n=8/16) | 466.944/n<br>(n=8/16) | 245.76/n<br>(n=80/160) | MHz |
| Ts | Data setup time (min) | 5 | 5 | 5 | 5 | 5 | ns |
| Th | Data hold time (min) | 5 | 5 | 5 | 5 | 5 | ns |

## 2.15 I$^2$S - serial audio interface

The audio SAI serves as stereo input/output audio bus interface (e.g. to an external audio processor, or from an external HD decoder) using the I$^2$S protocol. The latter calls for a bit clock line, a word select line and data lines; the SAI interface on the TDA7786x has one input data line and one output data line.

The audio SAI lines are: SAI_AUDIO_CLK (pin 37, bit clock line), SAI_AUDIO_WCLK (pin 38, word select (frame) clock line), SAI_AUDIO_DO (pin 39, data output line), SAI_AUDIO_DI (pin 40, data input line). In master mode SAI_AUDIO_BCLK and SAI_AUDIO_WCLK are outputs, in slave mode these pins are inputs.

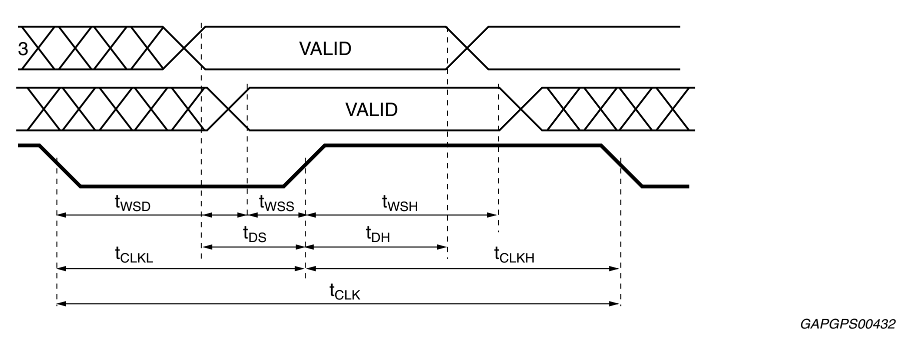
The input and output data lines are operated at the same sampling frequency.

The bit clock has one pulse for each discrete bit of data on the data lines. The bit clock operates at a frequency which is a multiple of the sample rate, and is equal to the sampling frequency times the number of bits per word times two.

**Table 6. Audio I$^2$S configuration overview**

| Name | Channels | World length | Valid Bits | Pins | Formats | Master/Slave mode | Input Rate/ksps | Output Rate /ksps | Max. bit clock frequency |
|---|---|---|---|---|---|---|---|---|---|
| SAI | 1x2 In and 1x2 Out | 16/32 | 16/24 | 4 | I$^2$S | M/S | 32-48 | 32-48 | 12.288 MHz |

**Figure 7. I$^2$S interface timing (receiver)**

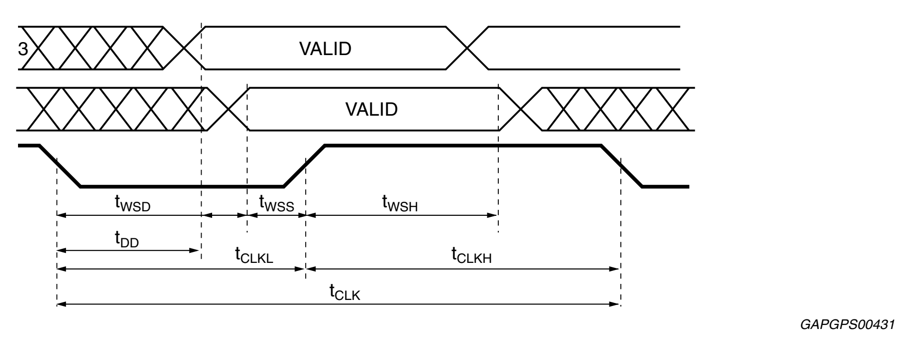


*Note: The polarity of the signals and the data bit-shift direction can be selected by configuration bits.*

Table 7. I$^2$S interface timing (receiver)

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $t_{CLK}$ | Minimum Clock Cycle (CLK) | - | 50 | - | - | ns |
| $t_{CLKH}$ | Minimum bit clock high time | - | 25 | - | - | ns |
| $t_{CLKL}$ | Minimum bit clock low time | - | 25 | - | - | ns |
| $t_{WSS}$ | Word-select setup time | slave mode | 5 | - | - | ns |
| $t_{WSH}$ | Word-select hold time | slave mode | 3 | - | - | ns |
| $t_{WSD}$ | Word-select delay | master mode | 4 | - | - | ns |
| $t_{DS}$ | Data setup time | - | 5 | - | - | ns |
| $t_{DH}$ | Data_hold time | - | 5 | - | - | ns |

Figure 8. I$^2$S interface timing (transmitter)



*Note: The polarity of the signals and the data shift direction can be selected by configuration bits.*

Table 8. I$^2$S interface timing (transmitter)

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $t_{CLK}$ | Minimum Clock Cycle (CLK) | - | 50 | - | - | ns |
| $t_{CLKH}$ | Minimum bit clock high time | - | 25 | - | - | ns |
| $t_{CLKL}$ | Minimum bit clock low time | - | 25 | - | - | ns |
| $t_{WSS}$ | Word-select setup time | slave mode | 5 | - | - | ns |
| $t_{WSH}$ | Word-select hold time | slave mode | 5 | - | - | ns |
| $t_{WSD}$ | Word-select delay | master mode | 5 | - | - | ns |
| $t_{DD}$ | Data delay | - | 5 | - | - | ns |

The audio SAI can be configured via software to be operating either in master or in slave mode. The frame length is selectable as 16/32 bits per word, with 16/24 valid bits. *Figure 9* shows the default setting of SAI for the 16-bit mode. Different settings of clock polarity, word clock polarity, transmission mode (I$^2$S mode) and data direction (either MSB or LSB first transmission) are possible, and they can be changed through software. Supported configurations are shown in *Figure 10*. Timing information for the protocols is detailed in *Figure 10*.

**Figure 9. I²S interface 16-bit**

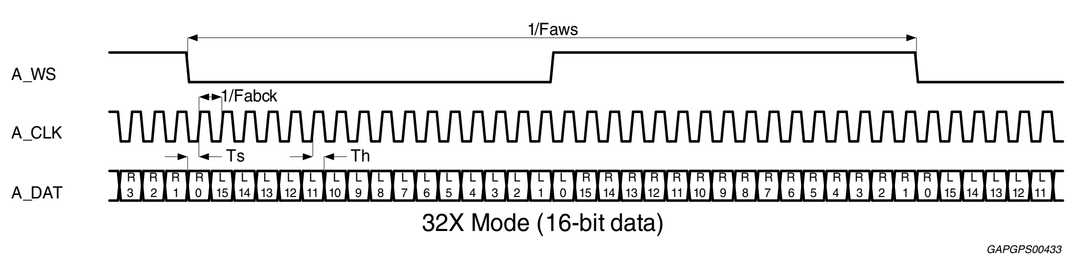
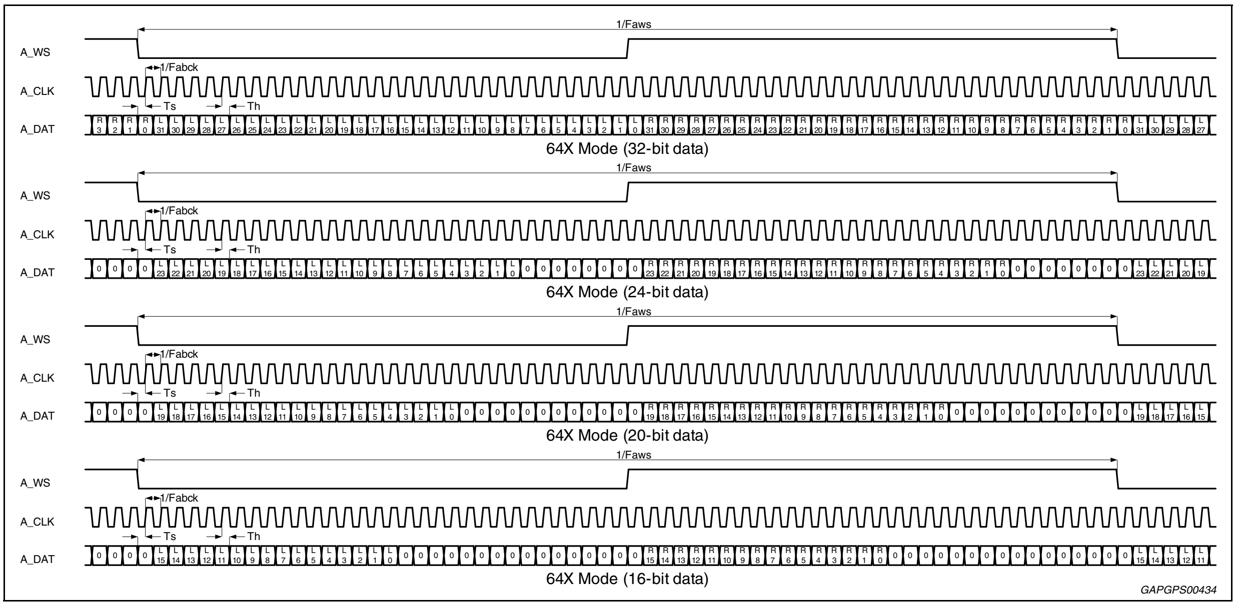


**Figure 10. I²S interface 32/24/20/16-bit**



## 2.16 Audio sample rate converter

The TDA7786x is equipped with internal sample rate converters (SRC) that can be configured to modify the sampling frequency of outgoing and incoming digital audio both in the master and in the slave SAI mode (the native audio sampling frequency of the TDA7786x is 45.6 kHz).

The SRC is able to automatically detect the input and output sampling rates and includes a sample clock jitter rejection function which can be enabled separately. The input signal word-width is 20 bits, while the output signal word width can be selected as 20 bits or 16 bits. In order to properly assist in the conversion, the SRC is coupled to self-adjusting low-pass filters.

## 2.17 Serial control interface

The device is controlled via $I^2C$.

Through serial bus the processing parameters can be modified and the signal quality parameters and the RDS information can be read out.

The operation of the device is handled mainly through high level commands sent by the car-radio microprocessor through the serial interface, which allows simplification of the operations carried out in the microprocessor itself. The high level commands include among others:

- change frequency (which allows to avoid computing the PLL divider factors)
- change band;
- start seek (the seek operation can be carried out by the TDA7786x in a completely autonomous fashion);
- RDS seek/search (jumps to AF and quality measurements are automatically sequenced).

### 2.17.1 Serial interface / boot mode

The device possesses two different I2C addresses: 0xC2/C3 and 0xC8/C9. The configuration is chosen by applying the proper voltage at the exit from reset to the pins indicated in *Table 9*. The configuration is latched (e.g. made effective) when the RSTN line transitions from low to high (when RSTN is low, the IC is in reset mode).

The voltage level forced to the boot pins must be released to start the system operation a suitable time after the RSTN line has gone high. The list of configurations is shown in the following table:

**Table 9. 64-pin package boot mode configuration**

| **SAI_AUDIO_DO** pin 39 | **RDS INT pin 32** | **BUS mode** |
|---|---|---|
| 0 | 0 | $I^2C$ Address = 0xC2 |
| 0 | 1 | $I^2C$ Address = 0xC8 |

The status of these pins during the reset phase can be set to:

- High: through external <10 kΩ resistors tied to 3.3V
- Low: by not forcing any voltage on them from outside, as 50 kΩ internal pull-down resistors are present inside the device.

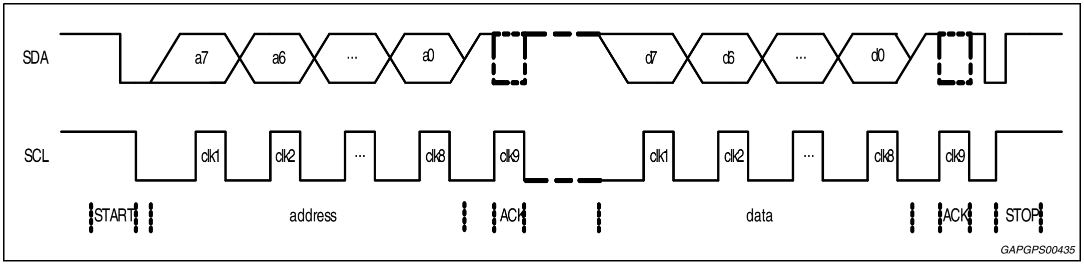
To make sure the $I^2C$ address is correctly latched up at start-up, it is advisable to keep the RSTN line low until the IC supply pins have reached their steady state, and further keep it low for an additional time Treset.

### 2.17.2 $I^2C$ bus protocol

The $I^2C$ communication requires two signals: clock (SCL) and data (SDA - bidirectional). The protocol requires an acknowledge signal after any 8-bit transmission.

A "write" communication example is shown in the figure below, for an unspecified number of data bytes (see the relevant technical documentation for frame structure description):

**Figure 11. $I^2C$ "write" sequence**

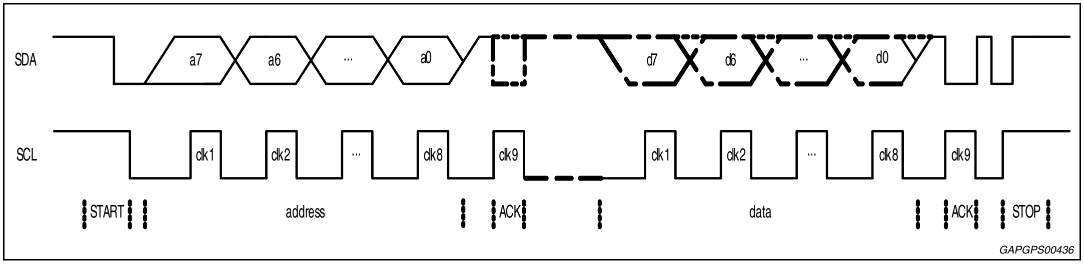


The sequence consists of the following phases:

1. START: SDA line transitioning from H to L with SCL fixed H. This indicates that a new transmission is starting;
2. DATA LATCHING: on the rising SCL edge. The SDA line can vary only when SCL is low (otherwise its transitions are interpreted as either a START or a STOP transition);
3. ACKNOWLEDGE: on the 9th SCL pulse the microprocessor keeps the SDA line H, and the TDA7786x pulls it down in case the communication has been successful. Lack of the acknowledge pulse generation from the TDA7786x indicates a communication failure; the chip-address byte must be sent at the beginning of the transmission. The value can be 0xC2 or 0xC8 (according to the mode chosen at start-up) for "write"; as many data bytes as needed can follow the address before the communication is terminated. See the next section for details on the frame format;
4. STOP: SDA line transitioning from L to H with SCL H. This signifies the end of the transmission.

Dashed lines represent transmissions from the TDA7786x to the microprocessor. A communication example is shown in the figure below, for an unspecified number of data bytes (see later on for frame structure description):

**Figure 12. $I^2C$ "read" sequence**



The "read" sequence is similar to the "write" and it has the same constraints for start, stop, data-latching and the following differences:

- the chip address must always be sent by the microprocessor to the TDA7786x; the address must be 0xC3 (if C2 had been selected at boot) or 0xC9 (if 0xC8 had been selected at boot);
- the header is transmitted after the chip address (the same happens for "write") before data are transferred from the TDA7786x to the microprocessor. See the relevant technical documentation for details on the frame format;
- when data are transmitted from the TDA7786x to the µP, the latter keeps the SDA line H;
- the acknowledge pulse is generated by the µP for those data bytes that are sent by the TDA7786x to the µP. Failure of the µP to generate an ACK pulse on the 9th CLK pulse has the same effect on the TDA7786x as a STOP.

The maximum clock speed is 500 kbit/s.

**Warning: When the TDA7786x is not powered on, the internal ESD protection diodes act as a pull-down keeping the I$^2$C lines voltage below 2 V. This implies that the I$^2$C bus connected to the TDA7786x may not be used to drive other devices when the TDA7786x is powered off.**

## 2.18 Digital-down-converter (DDC)

The complex digital mixer in the DDC performs mixing of the IF signal to zero IF. The internal sample rate for FM/AM processing is 456 kS/s and the sample rate for FM/AM IBOC is 912 kS/s. AM IBOC require additional filtering implemented in software.

Figure 13. Digital-down-converter simplified block diagram

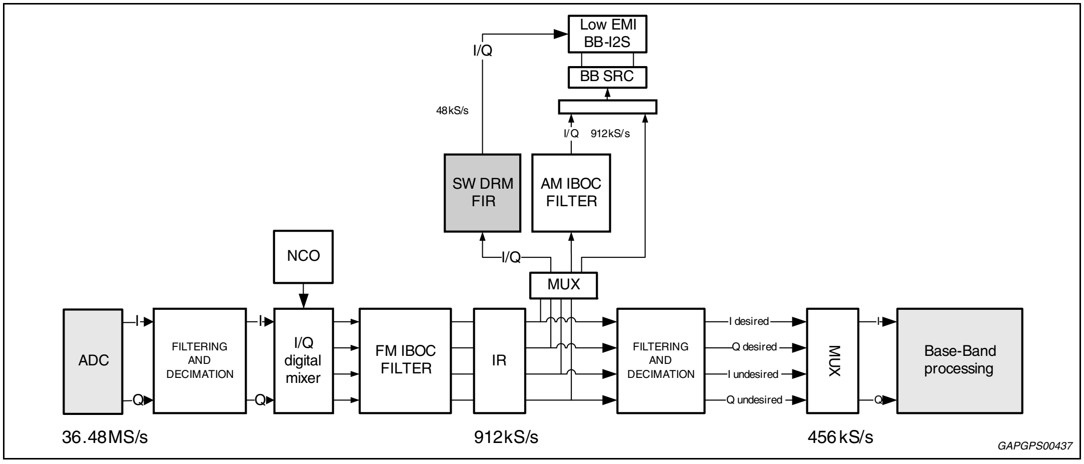


Figure 14. Cumulative transfer function at output of IBOC_FM filter

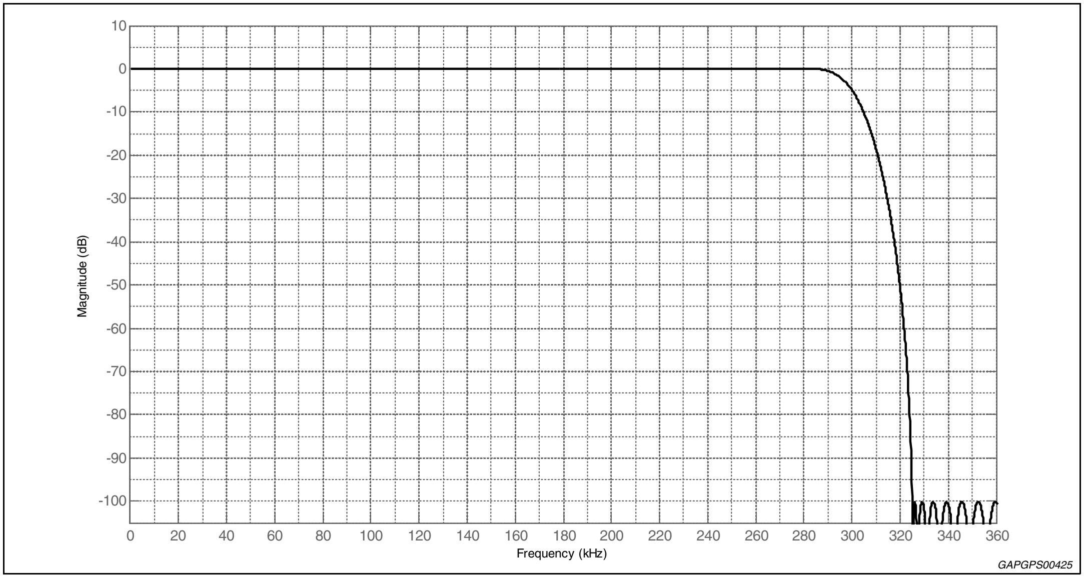
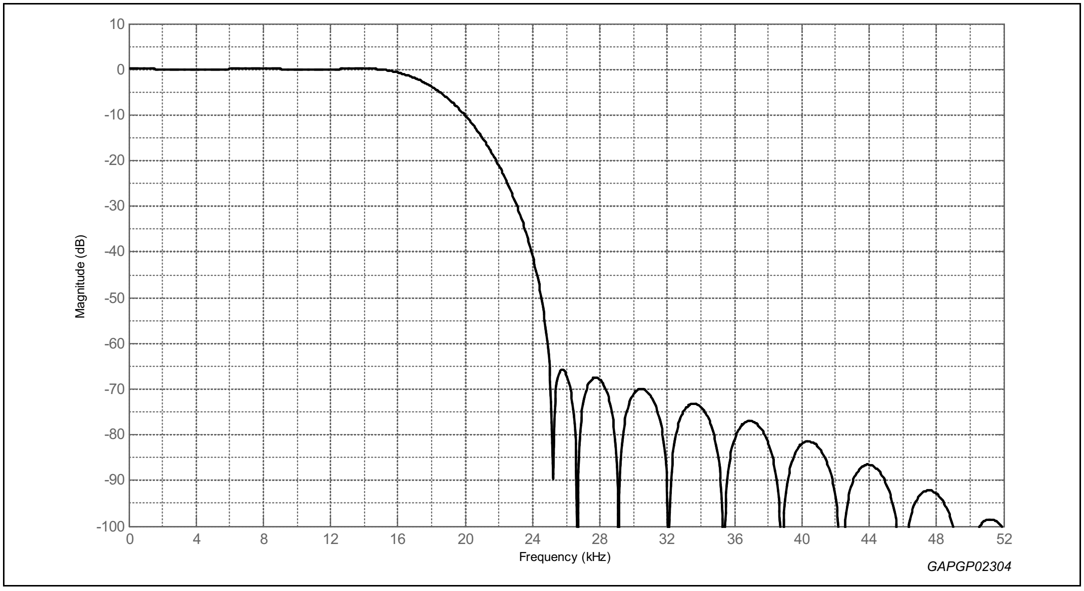


Table 10. Overall filter characteristics for IBOC_FM filter

| Item | Value | Unit |
|---|---|---|
| Pass-band edge | 282 | kHz |
| Stop-band edge | 325 | kHz |
| In-band ripple (0 kHz to 282 kHz) | <0.002 | dB |
| Anti-alias band range | [-500 +500] | kHz |
| Anti-alias Attenuation | 100 | dB |

### Figure 15. Cumulative transfer function at output of IBOC_AM filter



### Table 11. Overall filter characteristics at output of IBOC_AM filter

| \|Item | Value | Unit |
|---|---|---|
| Pass-band edge | 15 | kHz |
| Stop-band edge | 25 | kHz |
| In-band ripple | <0.34 | dB |
| Anti-alias Attenuation | >100 | dB |

### Figure 16. Cumulative digital-down-converter transfer function for FM

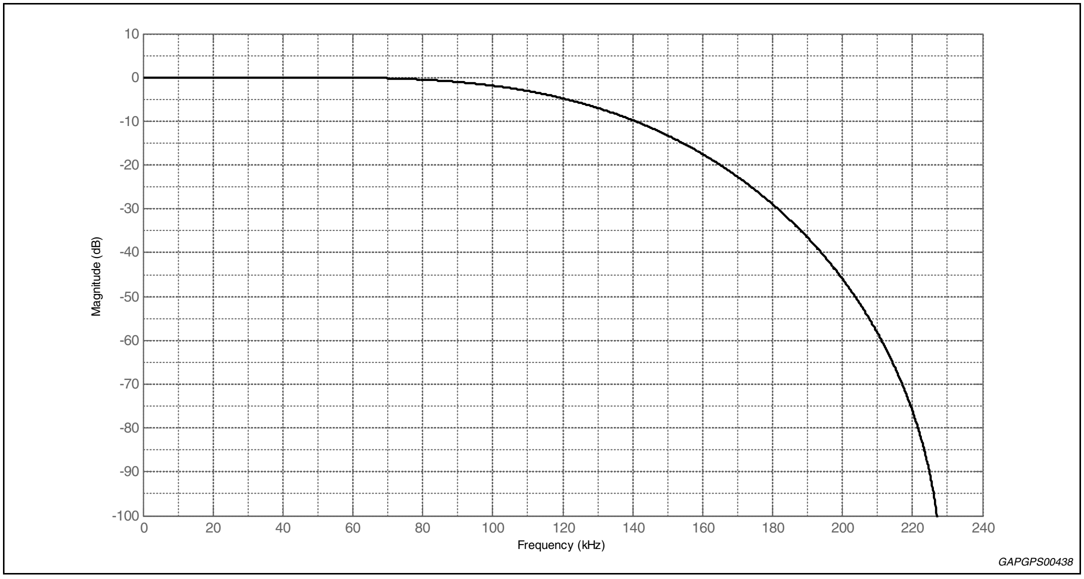


Table 12. Overall filter characteristics for FM (not including DISS filter)

| \|Item | Value | Unit |
|---|---|---|
| Pass-band edge | 45.8 | kHz |
| Stop-band edge | 228 | kHz |
| In-band ripple | <0.003 | dB |
| Anti-alias Attenuation | >100 | dB |

Figure 17. Cumulative digital-down-converter transfer function for AM

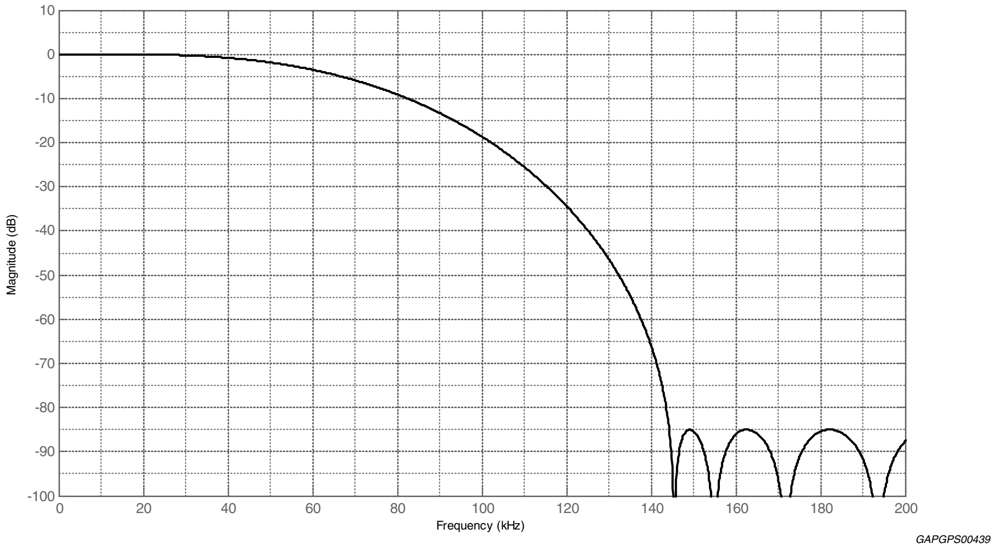


Table 13. Overall filter characteristics for AM

| \|Item | Value | Unit |
|---|---|---|
| Pass-band edge | 20 | kHz |
| Stop-band edge | 300 | kHz |
| In-band ripple | <0.051 | dB |
| Anti-alias Attenuation | >100 | dB |

# 3 Electrical specifications

## 3.1 Absolute maximum ratings

**Table 14. Absolute maximum ratings**

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_{CC}$ | Abs. supply voltage | - | -0.5 | - | 5.5 | V |
| $T_{stg}$ | Storage temperature | - | -55 | - | 150 | °C |
| $V_{ESD}$ | ESD absolute minimum withstand voltage | Human Body model | >\|±2000\| | | | V |
| | | Charged device model | >\|±400\| | | | |
| | | Charged device mode, corner pins | >\|±750\| | | | |
| - | Max. input at any pin (latch-up characteristic) | $I_{INMAX}$ | ±100 | | | mA |

Note: *For all pins 37-44, when set as input, injecting current cannot exceed 20 mA as it would lead to voltage at the pin above the abs max.*

## 3.2 Thermal data

**Table 15. Thermal data**

| Symbol | Parameter | Test condition | Value | Units |
|---|---|---|---|---|
| $R_{th}$ | Thermal resistance | LQFP64 10x10, JEDEC 2s1p PCB | 55 | °C/W |

## 3.3 General key parameters

**Table 16. General key parameters**

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_{CC}$ | 5 V supply voltage | see note (1) | 4.7 | 5 | 5.2 | V |
| $I_{CC}$ | supply current @ 5 V | | - | 175 | 225 | mA |
| $T_{amb}$ | Ambient temperature range | - | -40 | - | 85 | °C |
| $T_j$ | Operating junction temperature | - | - | - | 150 | °C |
| $V_{VCCREG12}$ | VCCREG12 supply voltage | see note (2) | 2.3 | - | 5.2 | V |
| $V_{1V2}$ | Digital core 1.2 V supply voltage | when supplied externally<br>see note (3) | 1.14 | 1.2 | 1.3 | V |
| $I_{1V2}$ | Digital core 1.2 V supply current | $V_{1V2}$ = 1.2V<br>see note(3) | - | 55 | 80 | mA |
| $V_{3V3}$ | Digital IO 3.3 V supply voltage | when supplied externally<br>see note(4) | 3.0 | - | 3.6 | V |

**Table 16. General key parameters (continued)**

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $I_{3V3}$ | Digital IO 3.3 V supply current | Maximum current specified only in case generated from Internal supply only | - | - | 10 | mA |

1. FM functional test from antenna mixer input to audio output.
2. In the typical application supplied from 5 V with a 27 Ω series resistor.
   Test condition: maximum current load for minimum value, unloaded for maximum value.
3. When the 1.2 V supply is applied externally, and not using the internal 1.2 V regulator.
   Test condition: FM functional test from antenna mixer input to audio output.
4. When the 3.3 V supply is applied externally, and not using the internal 3.3 V regulator.

## 3.4 Electrical characteristics

$V_{CC}$ = 4.7 V to 5.25 V; $T_{amb}$ = -40 °C to +85 °C; unless otherwise specified.

### 3.4.1 FM - section

**Table 17. FM - section**

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| **FM IMR Mixer** | | | | | | |
| RF Gain | Voltage gain (mix in -> s.e. test output) | RF gain 0 | 33 | 35 | 37 | dB |
| | | RF gain 1[(1)] | 36 | 38 | 40 | |
| | | RF gain 2 | 37 | 39 | 41 | |
| | | RF gain 3 | 39 | 41 | 43 | |
| Vnoise low gain | Input noise voltage (RF gain 0) | Rsource=1.25 kΩ, noiseless | - | 2.3 | 2.9 | nV/√Hz |
| | | Rsource=0 | - | 2.1 | 2.6 | |
| Vnoise high gain | Input noise voltage (RF gain 3) | Rsource=1.25 kΩ, noiseless | - | 1.9 | 2.4 | nV/√Hz |
| | | Rsource=0 | - | 1.6 | 2.0 | |
| IIP3 | $3^{rd}$ order intercept point | RF gain 0, up to Vin/tone = 92 dBμV<br>RF gain 3, up to Vin/tone = 86 dBμV | 124<br>119 | 127<br>122 | - | dBμV |
| **FM AGC** | | | | | | |
| RFAGC-Thr | RFAGC threshold, referred to mixer input;<br>RF level | min setting, reg8<14> =1 | 85.4 | 88.4 | 91.4 | dBμV |
| | | max setting, reg8<14>=1 | 89 | 92 | 95 | |
| | | min setting, reg8<14>=0 | 88.4 | 91.4 | 94.4 | |
| | | max setting, reg8<14>=0 | 92 | 95 | 98 | |
| | Threshold steps | - | 1.3 | 1.8 | 2.3 | dB |
| | Threshold error | @ $T_{amb}$ | -1.5 | - | 1.5 | dB |
| | Threshold temperature drift | - | - | 0.016 | - | dB/K |

**Table 17. FM - section (continued)**

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| IFAGC-Thr | IFAGC threshold | min setting | 120 | 122 | 124 | dBµV |
| | | max setting | 126 | 128 | 130 | dBµV |
| | Threshold steps | - | 1.5 | 2 | 2.5 | dB |
| | Threshold error | @ $T_{amb}$ | -1.5 | - | 1.5 | dB |
| | Threshold temperature drift | - | - | 0.016 | - | dB/K |
| Time constant | I attack | Slow attack | 10 | 20 | 30 | µA |
| | | Fast attack | 100 | 200 | 300 | |
| | I decay | Slow decay | 1 | 2 | 5 | |
| | | Fast decay | 10 | 20 | 30 | |
| - | PIN diode source current | @ $T_{amb}$ (2) | -15 | - | - | mA |
| - | PIN diode sink current | - | 3 | - | 20 | µA |
| - | PIN diode source current in constant current mode | @ $T_{amb}$ | -0.9 | - | - | mA |

1. The gain is internally 6 dB higher than what measured at the test output. This is due to the differential to single-ended conversion used for the test output.
2. The current is generated by a PTAT (proportional to absolute temperature) source, and has therefore a temperature dependency described by: ΔI/Io = ΔT/To, with Io being the current at ambient temperature (25 °C) and To the ambient temperature (25 °C) expressed in Kelvin, that is 298K.

### 3.4.2 AM - section

**Table 18. AM - section**

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| **AM IMR Mixer** | | | | | | |
| Gain | Voltage gain (mix in -> s.e. test output)(1) | normal | 20 | 22 | 24 | dB |
| | | reduced | 17 | 19 | 21 | |
| Rin | Input resistance | - | 20 | 30 | 45 | kΩ |
| Vnoise | Input noise voltage | Mix 1, 2<br>$R_{source}$ = 1 kΩ, noise-less | - | 7.5 | 9 | nV/√Hz |
| IIP3 | 3rd order intercept point | Mix1, 2<br>up to Vin/tone = 90 dBµV | 128 | 132 | - | dBµV |
| IIP2 | 2nd order intercept point | Mix1, 2<br>up to Vin/tone = 90 dBµV | 152 | 158 | - | dBµV |
| LO hsupp | LO harmonic suppression | - | 80 | - | - | dB |
| **AM LNA** | | | | | | |
| Gain | Voltage gain | Max gain, $R_{ext}$ = 470 Ω | 24 | 28 | 32 | dB |
| | | Min gain (AGC controlled) | 8 | 12 | 16 | |
| $R_{in}$ | Input resistance | - | 600 | 950 | 1300 | kΩ |
| $C_{in}$ | input capacitance | - | - | 20 | - | pF |

Table 18. AM - section (continued)

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_{noise}$ | Input noise voltage | - | - | 0.7 | 1.0 | nV/√Hz |
| IIP3 | $3^{rd}$ order intercept point | @ maximum LNA gain | 116 | 120 | - | dBµV |
| IIP2 | $2^{rd}$ order intercept point | @ maximum LNA gain | 121 | 127 | - | dBµV |
| **AM PIN diode** | | | | | | |
| IIP2 | $2^{rd}$ order intercept point | Full attenuation,<br>Csource = 80 pF, f = 1 MHz | 134 | 140 | - | dBµV |
| Res | Minimum resistance | - | - | 5 | 15 | Ω |
| Cin | Input capacitance | High ohmic | - | 2 | - | pF |
| **AM AGC** | | | | | | |
| AGC-Thr | Referred to mixer input; RF level | Mix 1,2 min setting | 80 | 83 | 86 | dBµV |
| | | Mix 1,2 max setting | 92.6 | 95.6 | 98.6 | |
| Thr-steps | Threshold steps | - | 1.3 | 1.8 | 2.3 | dB |
| - | Threshold error | @ $T_{amb}$ | -2.5 | - | 2.5 | dB |
| - | Threshold temperature drift | - | -3 | - | 3 | dB |
| - | PIN diode source current | @ $T_{amb}$ See note(2) | -10 | - | - | mA |
| - | PIN diode sink current | - | 15 | 30 | 45 | µA |
| - | PIN diode source current in constant current mode | @ $T_{amb}$ See note(2) | -1 | - | - | mA |

1. The gain is internally 6 dB higher than what measured at the test output. This is due to the differential to single-ended conversion used for the test output.
2. The current is generated by a PTAT (proportional to absolute temperature) source, and has therefore a temperature dependency described by: ΔI/Io = ΔT/To, with Io being the current at ambient temperature (25 °C) and To the ambient temperature (25 °C) expressed in Kelvin, that is 298K.

### 3.4.3 VCO

Table 19. VCO

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $fvco_{,min}$ | Minimum VCO oscillation frequency (1) | - | - | - | 2.34 | GHz |
| $fvco_{,max}$ | Maximum VCO oscillation frequency (2) | | 3.025 | - | - | GHz |
| PN | Phase noise of LO | Locked VCO;<br>values referred @ 100MHz<br>@ 100 Hz<br>@ 1 kHz<br>@ 10 kHz | - | -105<br>-115<br>-115 | - | dBc/Hz |
| dev | deviation error (RMS) | FM reception, deemphasis 50 µs, $f_{audio}$=20 Hz...20 kHz | - | 5 | 8 | Hz |

1. Limited by application Firmware to 2.1 GHz.
2. Limited by application Firmware to 3.1 GHz.

### 3.4.4 Phase locked loop

Table 20. Phase locked loop

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $T_{settle}$ | Settling time FM | Δf < 10 kHz | - | 100 | 140 | µs |
| FM step | FM Frequency step | - | - | 5 | - | kHz |
| AM step | AM frequency step | - | - | 500 | - | Hz |

### 3.4.5 Tuning DAC

Table 21. Tuning DAC

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $R_{es}$ | Resolution | 8 bit | 14 | 18 | 22 | mV |
| $V_{outmin}$ | Min output voltage | - | - | 0.6 | 0.75 | V |
| $V_{outmax}$ | Max output voltage | - | VCC-0.25 | VCC-0.15 | - | V |
| $R_{out}$ | Output impedance | - | 1.5 | 2.5 | 3.5 | kΩ |
| DNL | Diff. Nonlinearity | - | - | - | 0.5 | LSB |
| $T_{conv}$ | Conversion time | Without capacitive load | - | 20 | - | µs |

### 3.4.6 IF ADC

Table 22. IF ADC

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $DR_{FM}$ | Dynamic range in FM | BW = ±100 kHz | 87 | 90 | - | dB |
| $vnoise_{FM}$ | Input noise referred to mixer input | RF gain 2 | 1.7 | 0.94 | - | nV/√Hz |
| $DR_{AM}$ | Dynamic range in AM | BW = ±3 kHz | 105 | 108 | - | dB |
| $vnoise_{AM}$ | Input noise referred to mixer input | normal gain | 6.3 | 3.2 | - | nV/√Hz |
| $DR_{FM\text{-}HD}$ | Dynamic range in FM-IBOC | BW = ±200 kHz | 82 | 85 | - | dB |
| $Vnoise_{FM\text{-}HD}$ | Input noise referred to mixer input | RF gain 2 | 2.3 | 1.2 | - | nV/√Hz |
| $DR_{AM\text{-}HD}$ | Dynamic range in AM-IBOC | BW = ±15 kHz | 97 | 100 | - | dB |
| $vnoise_{AM\text{-}HD}$ | Input noise referred to mixer input | normal gain | 5.6 | 2.9 | - | nV/√Hz |

### 3.4.7 Audio DAC

Table 23. Audio DAC

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_{out}$ | Max. output voltage | Full scale | 1.2 | 1.4 | - | Vrms |
| BW | Pass-band | 0.01dB attenuation | - | 20 | - | KHz |
| Rout | Output resistance | - | 100 | 150 | 200 | Ω |
| multipath | Output noise | - | - | 14 | 30 | μVrms |
| D | Distortion | -6 dBFS | - | 0.03 | 0.05 | % |

### 3.4.8 IO interface pins

Table 24. IO interface pins

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| - | High level output voltage | Unloaded | 2.9 | 3.2 | - | V |
| - | Low level output voltage | Unloaded | - | 0.1 | 0.3 | V |
| - | Input voltage range | - | 0 | - | 3.5 | V |
| - | High level input voltage | - | 2.0 | - | - | V |
| - | Low level input voltage | - | - | - | 0.8 | V |
| $T_{reset}$ | Reset time | Minimum time during which pin RSTN must be low so as to reset the device | 10 | - | - | μs |
| $T_{latch}$ | Boot mode configuration latch time | Minimum time during which the voltage applied at pins 32 and 39 must be driven in order to latch the correct control serial bus address configuration | 10 | - | - | μs |

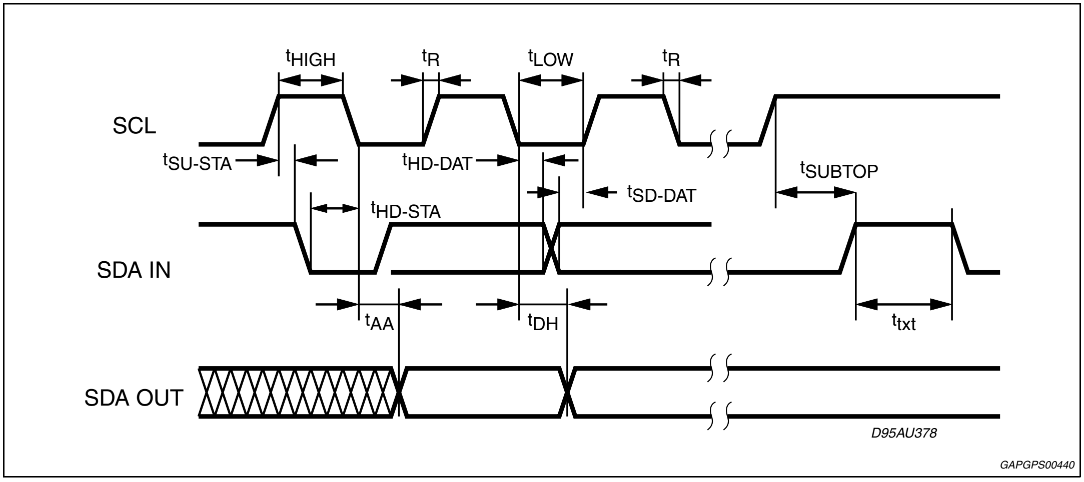
### 3.4.9 $I^2C$ interface

The $I^2C$ protocol serial bus communication parameters of the following table are defined as in *Figure 18*.

**Table 25. $I^2C$ interface**

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $f_{SCL}$ | SCL Clock frequency | - | - | - | 500 | kHz |
| $t_{AA}$ | SCL low to SDA data valid | - | 0.3 | - | - | µs |
| $t_{buf}$ | Time the bus must be kept free before a new transmission | - | 1.3 | - | - | µs |
| $t_{HD\text{-}STA}$ | START condition hold time | - | 0.6 | - | - | µs |
| $t_{LOW}$ | Clock low period | - | 1.3 | - | - | µs |
| $t_{HIGH}$ | Clock high period | - | 0.6 | - | - | µs |
| $t_{SU\text{-}SDA}$ | START condition setup time | - | 0.1 | - | - | µs |
| $t_{HD\text{-}DAT}$ | Data input hold time | - | 0 | - | 0.9 | µs |
| $t_{SU\text{-}DAT}$ | Data input setup time | - | 0.1 | - | - | µs |
| $t_R$ | SDA & SCL rise time | - | - | - | 0.3 | µs |
| $t_F$ | SDA & SCL full time | - | - | - | 0.3 | µs |
| $t_{SU\text{-}STOP}$ | Stop condition setup time | - | 0.6 | - | - | µs |
| $t_{DH}$ | Data out time | - | - | - | 0.3 | µs |

**Figure 18. $I^2C$ bus timing diagram**

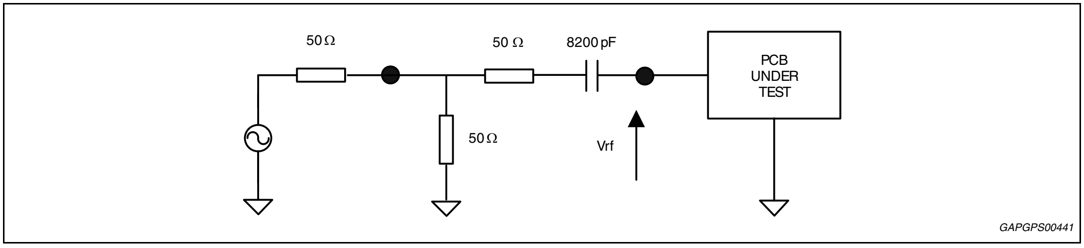


## 3.5 Overall system performance

### 3.5.1 FM overall system performance

Antenna level equivalence: 0 dBµV = 1 µVrms (Antenna terminal voltage with 75 Ω dummy load).

**Figure 19. FM input set-up**



Input level referred to 75 Ω antenna dummy output. $F_{rf}$ = 98.1 MHz, $V_{rf}$ = 60 dBµV, mono modulation, $f_{dev}$ = 40 kHz, $f_{audio}$ =1 kHz audio. De-emphasis = 50 µs. Wide-band, not-tuned pre-selection application, unless otherwise specified.

**Table 26. FM overall system performance**

| Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| Tuning range FM Eu | (can be modified by the user)<br>(automatic FE alignment available) | 87.5 | - | 108 | MHz |
| Tuning step FM Eu | (can be modified by the user) | - | 100 | - | kHz |
| Tuning range FM US | (can be modified by the user)<br>(automatic FE alignment available) | 87.5 | - | 107.9 | MHz |
| Tuning step FM US | (can be modified by the user) | - | 200 | - | kHz |
| Tuning range FM Jp | (can be modified by the user)<br>(automatic FE alignment available) | 76 | - | 90 | MHz |
| Tuning step FM Jp | (can be modified by the user) | - | 100 | - | kHz |
| Tuning range FM EEu | (can be modified by the user)<br>(automatic FE alignment not available) | 65 | - | 74 | MHz |
| Tuning step FM EEu | (can be modified by the user) | - | 100 | - | kHz |
| Sensitivity | S/N = 26 dB | - | -6 | -3 | dBµV |
| S/N | @ 10 dBµV, no high-cut, DISS BW = #4 | 49 | 52 | - | dB |
| Ultimate S/N | @ 60 dBµV, mono | 77 | 80 | - | dB |
| | @ 60 dBµV, Deviation = 75 kHz, mono | 82 | 85 | - | dB |
| | @ 60 dBµV, stereo | 67 | 70 | - | dB |

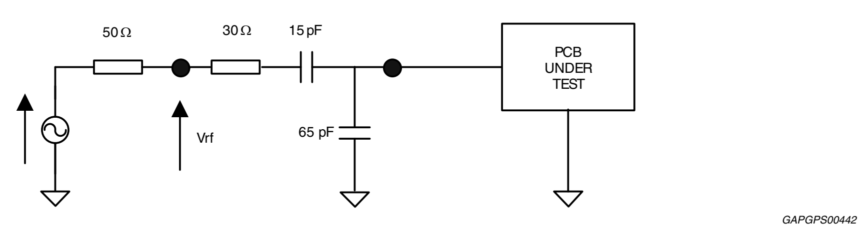
**Table 26. FM overall system performance (continued)**

| Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| Distortion | Deviation= 75 kHz | - | 0.05 | 0.1 | % |
| Max deviation | THD=3% | 150 | 166 | - | kHz |
| Adjacent channel Selectivity (D/U ratio) | ΔF =100 kHz, SINAD=30 dB<br>Desired 40 dBµV, dev = 40 kHz, 400 Hz undesired Dev=40 kHz, 1 kHz | 20 | 30 | - | dB |
| Alternate Channel Selectivity (D/U ratio) | ΔF = 200 kHz, SINAD=30 dB<br>Desired 40 dBµV, dev = 40 kHz, 400 Hz undesired Dev=40 kHz, 1 kHz | 52 | 62 | - | dB |
| Max. Strong Signal Interferer (D/U ratio) | Desired = 40 dBµV SINAD = 30 dB<br>Undesired ΔF = 1MHz | 75 | 80 | - | dB |
| 3 signal performance<br>(“wide-band”) application | Desired = 40 dBµV, dev = 40 kHz, 400 Hz, SINAD = 30 dB<br>Undesired1 = ± 400 kHz, dev = 40 kHz, 1 kHz<br>Undesired2 = ± 800 kHz, no mod | 101 | 106 | - | dBµV |
|  | Desired = 40 dBµV, dev = 40 kHz, 400 Hz, SINAD = 30 dB<br>Undesired1 = ±1 MHz, dev = 40 kHz, 1 kHz<br>Undesired2 =±2MHz, no mod | 105 | 110 | - | dBµV |
| AM suppression | m= 30 % | 60 | 70 | - | dB |
| Logarithmic field strength indicator | @40 dBµV<br>read “FM_Smeter_log” | -0.41<br>(equivalent to 37 dBµV) | -0.38 | -0.35<br>(equivalent to 43 dBµV) | - |

### 3.5.2 AM MW overall system performance

Antenna level equivalence: 0 dBμV = 1 μVrms

**Figure 20. AM MW input set-up**



Level referred to SG EMF output before antenna dummy; dummy antenna load as shown above $F_{rf}$ = 999 kHz (1000 kHz for US), $V_{rf}$ =74 dBμV, mod = 30 %, $f_{audio}$ =400 Hz, unless otherwise specified.

**Table 27. AM MW overall system performance**

| Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| Tuning range MW Eu/Jp | (can be modified by the user) | 531 | - | 1629 | kHz |
| Tuning step MW Eu/Jp | (can be modified by the user) | - | 9 | - | kHz |
| Tuning range MW US | (can be modified by the user) | 530 | - | 1710 | kHz |
| Tuning step MW US | (can be modified by the user) | - | 10 | - | kHz |
| Sensitivity | S/N = 20 dB | - | 25 | 28 | dBμV |
| Ultimate S/N | @ 80 dBμV | 67 | 72 | - | dB |
| AGC F.O.M. | Ref.=74 dBμV<br>-10dB drop point | (1) | 64 | - | dB |
| Distortion | M=80% | - | 0.1 | 0.2 | % |
| Adjacent channel selectivity | ΔF = 9 kHz, SINAD = 26 dB undesired M = 30 % 1 kHz | 44 | 47 | - | dB |
| Alternate channel selectivity | ΔF = 18 kHz, SINAD = 26 dB undesired M = 30 % 1 kHz | 48 | 51 | - | dB |
| Strong signal interferer (1) SNR | ΔF = ±40 kHz<br>desired = 40 dBμV<br>undesired = 110 dBμV, m = 30 % 1 kHz | 8 | 12 | - | dB |
| Strong signal interferer (1) suppression | ΔF = ±40 kHz<br>desired = 40 dBμV<br>undesired = 110 dBμV, m = 30 % 1 kHz | - | 10 | 15 | dB |
| Strong signal interferer (1) cross-modulation | ΔF = ±40 kHz<br>desired = 80 dBμV<br>undesired = 110 dBμV, m = 30 % 1 kHz<br>maximum SNR of undesired channel | - | 1 | 4 | dB |

Table 27. AM MW overall system performance (continued)

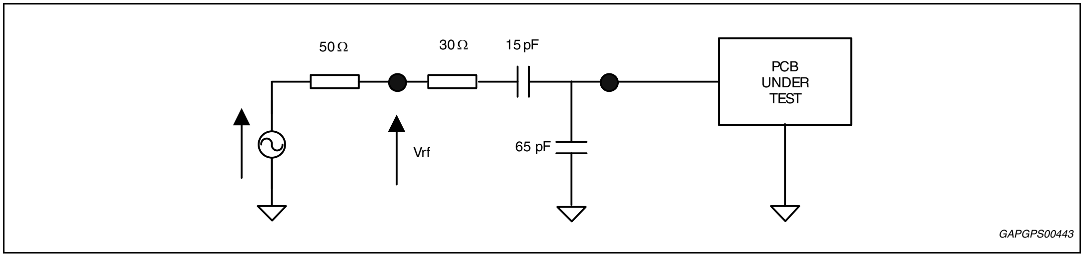
| Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| Strong signal interferer (2) SNR | ΔF = ±400 kHz<br>desired = 40 dBµV<br>undesired = 110 dBµV, m = 30 %, 1 kHz | 5 | 11 | - | dB |
| Strong signal interferer (2) suppression | ΔF = ±400 kHz<br>desired = 40 dBµV<br>undesired = 110 dBµV, m = 30 %, 1 kHz | - | 15 | 18 | dB |
| Strong signal interferer (2) cross-modulation | ΔF = ±400 kHz<br>desired = 80 dBµV<br>undesired = 110 dBµV, m = 30 %, 1 kHz<br>maximum SNR of undesired channel | - | 1 | 4 | dB |
| Max. strong signal interferer | Desired = 40 dBµV<br>SINAD = 26dB, blocking<6dB<br>Undesired ΔF = 400 kHz, m = 30 % (crossmod. Test) | 90 | 98 | - | dBµV |
| Image rejection | - | 60 | 80 | - | dB |
| Logarithmic field strength indicator | @60 dBµV read "AM_SMeter_log" | -0.47 (equivalent to 57 dBµV | -0.44 | -0.41 (equivalent to 63 dBµV) | - |

1. Programmable by software parameters.

### 3.5.3 AM LW overall system performance

Antenna level equivalence: 0 dBµV = 1 µVrms

**Figure 21. AM LW input set-up**



Level referred to SG EMF output before antenna dummy; dummy antenna load as shown above $F_{rf}$ =216 kHz, $V_{rf}$ =74 dBµV, mod = 30 %, $f_{audio}$ = 400 Hz, unless otherwise specified.

**Table 28. AM LW overall system performance**

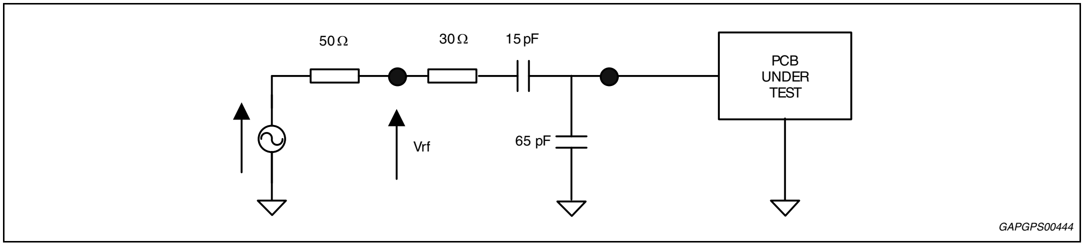
| Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| Tuning range LW | (can be modified by the user) | 144 | - | 288 | kHz |
| Tuning step LW | (can be modified by the user) | - | 1 | - | kHz |
| Sensitivity | S/N = 20 dB | - | 30 | 34 | dBµV |
| Ultimate S/N | @ 80 dBµV | 63 | 70 | - | dB |
| AGC F.O.M. | Ref. = 74 dBµV<br>-10dB drop point | (1) | 64 | - | dB |
| Distortion | M= 80 % | - | 0.1 | 0.2 | % |
| Image rejection | - | 60 | 80 | - | dB |

1. Programmable by software parameters.

### 3.5.4 AM SW overall system performance

Antenna level equivalence: 0 dBµV = 1 µVrms

**Figure 22. AM SW input set-up**



Level referred to SG EMF output before antenna dummy; dummy antenna load as shown above; $F_{rf}$ = 6000 kHz, $V_{rf}$ =74 dBµV, mod = 30 %, $f_{audio}$ = 400 Hz, unless otherwise specified.

**Table 29. AM SW overall system performance**

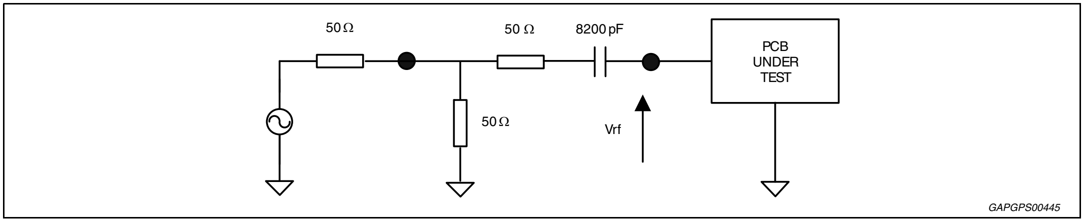
| Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| Tuning range SW | (can be modified by the user) | 2300 | - | 30000 | kHz |
| Tuning step SW | (can be modified by the user) | - | 1 | - | kHz |
| Sensitivity | S/N = 20 dB | - | 26 | 32 | dBµV |
| Ultimate S/N | @ 80 dBµV | 63 | 70 | - | dB |
| AGC F.O.M. | Ref.=74 dBµV<br>-10 dB drop point | (1) | 58 | - | dB |
| Distortion | M = 80% | - | 0.1 | 0.2 | % |
| Image rejection | - | 60 | 80 | - | dB |

1. Programmable by software parameters.

### 3.5.5 WX overall system performance

Antenna level equivalence: 0 dBµV = 1 µVrms (Antenna terminal voltage with 75Ω dummy load).

**Figure 23. WX input set-up**



Input level referred to 75 Ω dummy antenna output; antenna dummy as shown above. $F_{rf}$ = 162.475 MHz, $V_{rf}$ = 60 dBµV, mono modulation, $f_{dev}$ = 3 kHz, $f_{audio}$ = 400 Hz audio. De-emphasis = 75 µs. Application WX using mixer input 2.Unless otherwise specified.

**Table 30. WX overall system performance**

| Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| Sensitivity | S/N = 26 dB | - | -6 | -3 | dBµV |
| Ultimate S/N | @ 60 dBµV | 70 | 81 | - | dB |
| Distortion | Deviation= 4.5 kHz | - | 0.8 | 1 | % |
| Max deviation | THD = 3% | 5 | - | - | kHz |
| Adjacent channel Selectivity | ΔF = 25 kHz, SINAD = 30dB<br>desired 40 dBµV, dev = 2.0 kHz, 400 Hz undesired Dev = 2.0 kHz, 1 kHz | 60 | 70 | - | dB |
| Alternate Channel Selectivity | ΔF = 50 kHz, SINAD = 30dB<br>desired 40 dBµV, dev = 2.0 kHz, 400 Hz undesired Dev = 2.0 kHz, 1 kHz | 60 | 70 | - | dB |

# 4 Front-end registers

All the parameters in this section refer to the programmability of the FE part of the device (registers). The part of the registers that are not described here have either fixed values or values written by the tuner drivers, and are described in the proper technical documentation.

**Table 31. Register 0x00**

| Register number | | | | | | | | | | | | | | | | | | | | | | | | Register definition |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MSB | | | | | | | | | | | | | | | | | | | | | | | LSB | |
| 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | |
| | | | | | | | | | | | | | | | | | | | | | | | | **AM mixer input selector** |
| | | | | | | | | | | | | | | | | | | | | | | 0 | 1 | Input #1 |
| | | | | | | | | | | | | | | | | | | | | | | 1 | 0 | Input #2 |
| | | | | | | | | | | | | | | | | | | | | | | | | **AM PIN diode** |
| | | | | | | | | | | | 0 | | | | | | | | | | | | | Internal |
| | | | | | | | | | | | 1 | | | | | | | | | | | | | External |
| | | | | | | | | | | | | | | | | | | | | | | | | **AM AGC mode** |
| | | | | | | | | | | 0 | | | | | | | | | | | | | | LNA and PIN diode |
| | | | | | | | | | | 1 | | | | | | | | | | | | | | PIN diode only |
| | | | | | | | | | | | | | | | | | | | | | | | | **AM AGC time constant** |
| | | | | | | | | 0 | 0 | | | | | | | | | | | | | | | Slow (125 ms with 1 µF) |
| | | | | | | | | 0 | 1 | | | | | | | | | | | | | | | Medium (25ms with 1 µF) |
| | | | | | | | | 1 | 1 | | | | | | | | | | | | | | | Fast (5ms with 1 µF) |
| | | | | | | | | | | | | | | | | | | | | | | | | **AM AGC thresholds @ mixin** |
| | | | | | 0 | 0 | 0 | | | | | | | | | | | | | | | | | 90.2 dBµV @ mixin |
| | | | | | 0 | 0 | 1 | | | | | | | | | | | | | | | | | 92.0 dBµV @ mixin |
| | | | | | 0 | 1 | 0 | | | | | | | | | | | | | | | | | 93.8 dBµV @ mixin |
| | | | | | 0 | 1 | 1 | | | | | | | | | | | | | | | | | 95.6 dBµV @ mixin |
| | | | | | 1 | 0 | 0 | | | | | | | | | | | | | | | | | 88.4 dBµV @ mixin |
| | | | | | 1 | 0 | 1 | | | | | | | | | | | | | | | | | 86.6 dBµV @ mixin |
| | | | | | 1 | 1 | 0 | | | | | | | | | | | | | | | | | 84.8 dBµV @ mixin |
| | | | | | 1 | 1 | 1 | | | | | | | | | | | | | | | | | 83 dBµV @ mixin |
| | | | | | | | | | | | | | | | | | | | | | | | | **AM AGC attack time constant** |
| | | | 0 | | | | | | | | | | | | | | | | | | | | | Normal |
| | | | 1 | | | | | | | | | | | | | | | | | | | | | Fast |

Table 32. Register 0x01

| Register number | | | | | | | | | | | | | | | | | | | | | | | | Register definition |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MSB | | | | | | | | | | | | | | | | | | | | | | | LSB | |
| 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | |
| | | | | | | | | | | | | | | | | | | | | | | | | **FM mixer RF-gain** |
| | | | | | | | | | | | | | | | | | | | | 0 | 0 | | | 35 dB |
| | | | | | | | | | | | | | | | | | | | | 0 | 1 | | | 38 dB |
| | | | | | | | | | | | | | | | | | | | | 1 | 0 | | | 39 dB |
| | | | | | | | | | | | | | | | | | | | | 1 | 1 | | | 41 dB |
| | | | | | | | | | | | | | | | | | | | | | | | | **FM mixer input** |
| | | | | | | | | | 0 | 1 | | | | | | | | | | | | | | Input #1 (single-ended) |
| | | | | | | | | | 1 | 0 | | | | | | | | | | | | | | Input #2 (single-ended) |
| | | | | | | | | | 1 | 1 | | | | | | | | | | | | | | Input #1/2 (differential) |
| | | | | | | | | | | | | | | | | | | | | | | | | **FM AGC output mode** |
| 0 | 0 | | | | | | | | | | | | | | | | | | | | | | | Normal |
| 0 | 1 | | | | | | | | | | | | | | | | | | | | | | | Constant 15mA |
| 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | Constant 1mA |

Table 33. Register 0x02

| Register Number | | | | | | | | | | | | | | | | | | | | | | | | Register Definition | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MSB | | | | | | | | | | | | | | | | | | | | | LSB | | | | |
| 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | | |
| | | | | | | | | | | | | | | | | | | | | | | | | **FM RF AGCThresholds@ mixin** | |
| | | | | | | | | | | | | | | | | | | | | | | 0 | 0 | 88.4 dBµV | Reg 0x008<14> = 1 |
| | | | | | | | | | | | | | | | | | | | | | | 0 | 1 | 90.2 dBµV | |
| | | | | | | | | | | | | | | | | | | | | | | 1 | 0 | 92.0 dBµV | |
| | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | 93.8 dBµV | |
| | | | | | | | | | | | | | | | | | | | | | | 0 | 0 | 91.4 dBµV | Reg 0x008<14> = 0 |
| | | | | | | | | | | | | | | | | | | | | | | 0 | 1 | 93.2 dBµV | |
| | | | | | | | | | | | | | | | | | | | | | | 1 | 0 | 95.0 dBµV | |
| | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | 96.8 dBµV | |
| | | | | | | | | | | | | | | | | | | | | | | | | **FM IFAGC threshold@IFADCin** | |
| | | | | | | | | | | | | | | | | | | | | 0 | 0 | | | 122 dBµV | |
| | | | | | | | | | | | | | | | | | | | | 0 | 1 | | | 124 dBµV | |
| | | | | | | | | | | | | | | | | | | | | 1 | 0 | | | 126 dBµV | |
| | | | | | | | | | | | | | | | | | | | | 1 | 1 | | | 128 dBµV | |
| | | | | | | | | | | | | | | | | | | | | | | | | **FMAGC attack time constant** | |
| | | | | | | | | | | | | | | | | | | | 0 | | | | | slow | |
| | | | | | | | | | | | | | | | | | | | 1 | | | | | fast | |
| | | | | | | | | | | | | | | | | | | | | | | | | **FMAGC decay time constant** | |
| | | | | | | | | | | | | | | | | | | 0 | | | | | | slow | |
| | | | | | | | | | | | | | | | | | | 1 | | | | | | fast | |
| | | | | | | | | | | | | | | | | | | | | | | | | **FM DAC** | |
| | | | | | | | | | | | | | | | | | 0 | | | | | | | off | |
| | | | | | | | | | | | | | | | | | 1 | | | | | | | on | |
| | | | | | | | | | | | | | | | | | | | | | | | | **FM DAC VALUE** | |
| | | | | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | | 0 | |
| | | | | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | | | | | | | | 1 | |
| | | | | | | | | | … | … | … | … | … | … | … | … | | | | | | | | … | |
| | | | | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | 255 | |

### Table 34. Register 0x05

| Register Number | | | | | | | | | | | | | | | | | | | | | | | | Register Definition |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MSB | | | | | | | | | | | | | | | | | | | | | LSB | | | |
| 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | |
| | | | | | | | | | | | | | | | | | | | | | | | | **GPODATA** |
| | | | | | | | | | | | | | | | | | | | | | | | 0 | low |
| | | | | | | | | | | | | | | | | | | | | | | | 1 | high |

### Table 35. Register 0x08

| Register number | | | | | | | | | | | | | | | | | | | | | | | | Register definition |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MSB | | | | | | | | | | | | | | | | | | | | | | | LSB | |
| 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | |
| | | | | | | | | | | | | | | | | | | | | | | | | **FMAGC gain select** |
| | | | | | | | | | 0 | | | | | | | | | | | | | | | FM AGC thresholds high |
| | | | | | | | | | 1 | | | | | | | | | | | | | | | FM AGC thresholds down |

# 5 Weak signal processing

All the parameters in this section refer to the programmability of the DSP part of the device. The typical values are those set by default parameters (start-up without parametric change from main microprocessor); the max and the min values refer to the programmability range. The values are referred to the typical application (‘wide-band’ in FM). Wherever the possible values are a discrete set, all the possible programmable values are displayed.

## 5.1 FM IF-processing

### 5.1.1 Dynamic channel selection filter (DISS)

Table 36. Dynamic channel selection filter (DISS) - discrete set

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| DISS BW | IF filter #10 | response: - 3dB | - | ±150 | - | kHz |
| | IF filter #9 | | - | ±120 | - | kHz |
| | IF filter #8 | | - | ±100 | - | kHz |
| | IF filter #7 | | - | ±85 | - | kHz |
| | IF filter #6 | | | ±75 | - | kHz |
| | IF filter #5 | | | ±65 | - | kHz |
| | IF filter #4 | | | ±60 | - | kHz |
| | IF filter #3 | | | ±55 | - | kHz |
| | IF filter #2 | | - | ±45 | - | kHz |
| | IF filter #1 | | - | ±35 | - | kHz |
| | IF filter #0 | | - | ±25 | - | kHz |

### 5.1.2 Soft mute

Table 37. Soft mute - continuous set

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| SMsp | Start point vs. field strength | audio atten = 1 dB<br>read “FM_SoftMute”<br>no adjacent channel present | 0 | 6 | 20 | dBµV |
| SMep | End point vs. field strength | audio atten = SMd + 1 dB<br>read “FM_SoftMute”<br>no adjacent channel present | -6 | -6 | 10 | dBµV |
| SMd | Depth | | -30 | -15 | 0 | dB |
| SMtauatt | Field strength LPF cut-off frequency for soft mute activation | | 0.1 | 100 | 4000 | Hz |
| SMtaurel | Field strength LPF cut-off frequency for soft mute release | | 0.1 | 1 | 4000 | Hz |

### 5.1.3 Adjacent channel mute

**Table 38. Adjacent channel mute - continuous set**

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| ACMd | Depth | - | SMd | 0 | 0 | dB |

### 5.1.4 Stereo blend

**Table 39. Stereo blend - continuous set**

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| MaxSep | Maximum stereo separation | field strength = 80 dBµV, pilot deviation = 6.75 kHz | 0 | 40 | 50 | dB |
| SBFSsp | Start point vs. field strength | separation = MaxSep - 1 dB<br>no multipath present | 20 | 50 | 60 | dBµV |
| SBFSep | End point vs. field strength | separation = 1 dB<br>no multipath present | 20 | 30 | 60 | dBµV |
| SBFStM2S | Field strength-related transition time from mono to stereo | $V_{rf}$ step-like variation from 20 dBµV to 80 dBµV | 0.001 | 3 | 20 | s |
| SBFStS2M | Field strength-related transition time from stereo to mono | $V_{rf}$ step-like variation from 80 dBµV to 20 dBµV | 0.001 | 0.5 | 20 | s |
| SBMPsp | Start point vs. multipath | separation = MaxSep - 1 dB<br>equivalent 19 kHz AM modulation depth;<br>field strength = 80 dBµV | 5 | 10 | 80 | % |
| SBMPep | End point vs. multipath | separation = 1 dB<br>equivalent 19 kHz AM modulation depth;<br>field strength = 80 dBµV | 5 | 30 | 80 | % |
| SBMPtM2S | Multipath-related transition time from mono to stereo | $V_{rf}$ step-like variation from 20 dBµV to 80 dBµV | 0.001 | 1 | 20 | s |
| SBMPtS2M | Multipath-related transition time from stereo to mono | $V_{rf}$ step-like variation from 80 dBµV to 20 dBµV | 0.001 | 0.001 | 20 | s |
| Pil ThrM2S | Pilot detector stereo threshold | Threshold on pilot tone deviation for mono-stereo transition | 0.8 | 2.74 | - | kHz |
| Pil ThrHyst | Pilot detector threshold hysteresis | Difference in Pil. det. deviation threshold for stereo to mono transition compared to PilThrM2S | - | 0.01 | - | kHz |

### 5.1.5 High cut control

Table 40. High cut control - continuous set

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| HCFSsp | Start point vs. field strength | minimum RF level for widest HC filter (filter # 7)<br>no multipath present | 0 | 50 | 50 | dBµV |
| HCFSep | End point vs. field strength | maximum RF level for narrowest HC filter (filter # 0)<br>no multipath present | 0 | 30 | 40 | dBµV |
| HCFStW2N | Field strength-related transition time from wide to narrow band | $V_{rf}$ step-like variation from 60 dBµV to 10 dBµV | (1) | | | - |
| HCFStN2W | Field strength-related transition time from narrow to wide band | $V_{rf}$ step-like variation from 0 dBµV to 60 dBµV | (1) | 14 | 100 | s |
| HCMPsp | Start point vs. multipath | minimum RF level for widest HC filter (filter # 7)<br>equivalent 19 kHz AM modulation depth;<br>field strength = 80 dBµV | 5 | 10 | 150 (2) | % |
| HCMPep | End point vs. multipath | maximum RF level for narrowest HC filter (filter # 0)<br>equivalent 19 kHz AM modulation depth;<br>field strength = 80 dBµV | 5 | 30 | 150 (2) | % |
| HCMPtN2W | Multipath-related transition time from narrow to wide band | $V_{rf}$ step-like variation from 20 dBµV to 80 dBµV | 0.001 | 0.001 | 20 | s |
| HCMPtW2N | Multipath-related transition time from wide to narrow | $V_{rf}$ step-like variation from 80 dBµV to 20 dBµV | 0.001 | 0.001 | 20 | s |
| HCmaxBW | Maximum cut-off frequency of high cut filter bank | Filter #7, -3 dB response frequency, input signal with pre-emphasis | HCminBW | 14 | 18 | kHz |
| HCminBW | Minimum cut-off frequency of high cut filter bank | Filter #0, -3 dB response frequency, input signal with pre-emphasis | 0.1 | 3 | HCmaxBW | kHz |
| HCnumFilt | Number of discrete HC filters | - | - | 8 (3) | - | - |

1. Depends only on field strength filter time constant.
2. Means that 100% equivalent 19 kHz AM modulation depth will not achieve full band narrowing.
3. Intermediate filters (#6 - #1) cut-off frequencies exponentially spaced between HCmaxBW and HCminBW.

**Table 41. De-emphasis filter - continuous set**

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| DEtc | De-emphasis time constant 1 | - | - | 50 | - | µs |
| | De-emphasis time constant 2 | - | - | 75 | - | |

### 5.1.6 Stereo decoder

**Table 42. Stereo decoder - continuous set**

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| PilSup | Pilot signal suppression | Pilot 9%, 19 kHz, ref = 40 kHz | - | 60 | - | dB |
| SubcSup | Subcarrier suppression | f = 38 kHz | - | 70 | - | dB |
| | | f = 57 kHz | - | 70 | - | dB |
| | | f = 76 kHz | - | 80 | - | dB |

## 5.2 AM IF-processing

### 5.2.1 Channel selection filter

**Table 43. Channel selection filter**

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| CSF BW | Channel selection filter BW | response: - 3dB | - | ±3.7 | - | kHz |

### 5.2.2 Soft mute

**Table 44. Soft mute - continuous set**

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| SMsp | Start point vs. field strength | audio atten = 1 dB<br>read “FM_SoftMute”<br>no adjacent channel present | 0 | 25 | 40 | dBµV |
| SMep | End point vs. field strength | audio atten = SMd + 1 dB<br>read “FM_SoftMute”<br>no adjacent channel present | 0 | 0 | 30 | dBµV |
| SMd | Depth | - | -40 | -24 | 0 | dB |
| SMtauatt | Transition time for field strength-dependent soft mute activation | - | 0.001 | 0.1 | 10 | s |
| SMtaurel | Transition time for field strength-dependent soft mute release | - | 0.001 | 3 | 10 | s |

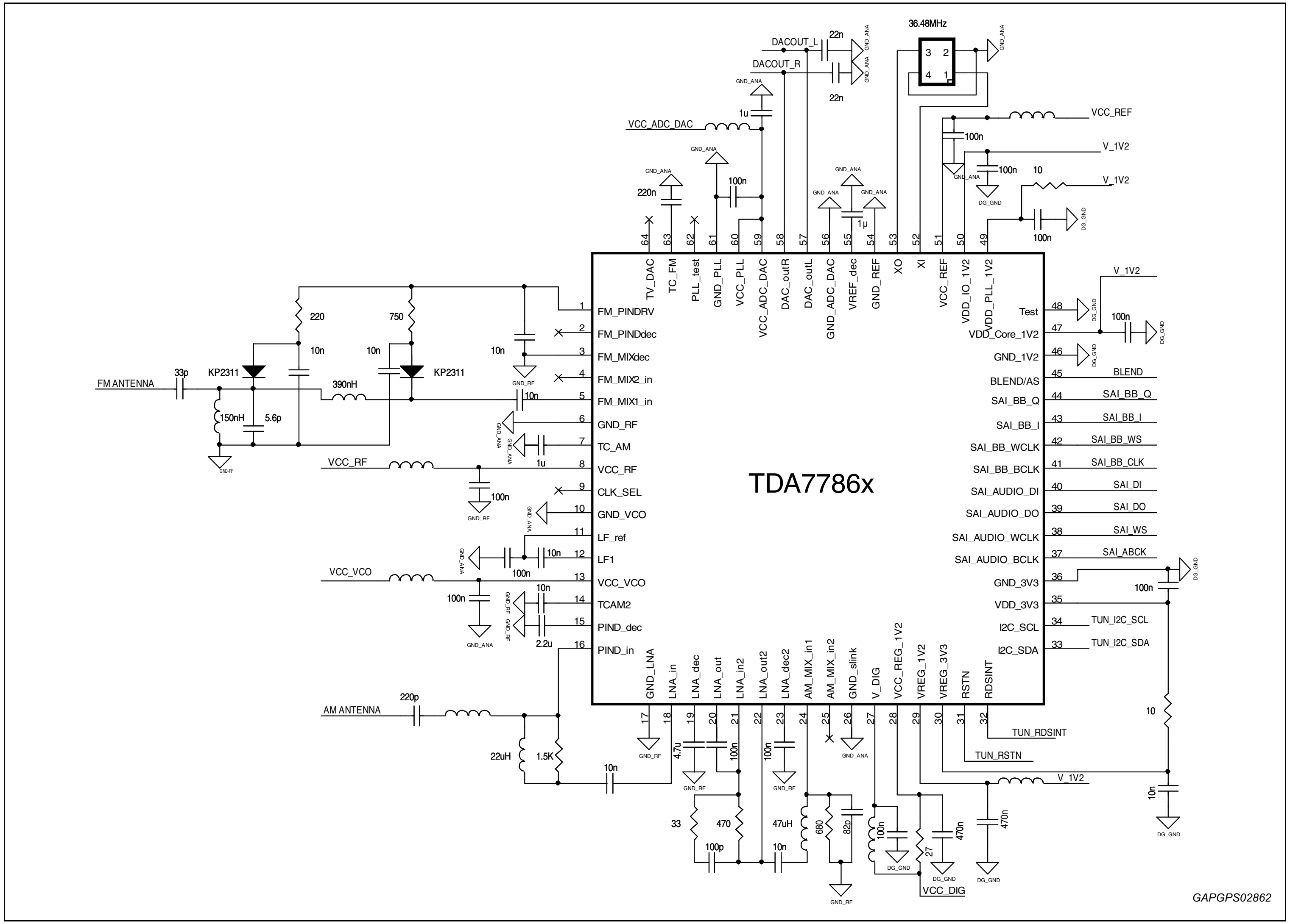
### 5.2.3 High cut control

**Table 45. High cut control - continuous set**

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| HCFSsp | Start point vs. field strength | minimum RF level for widest HC filter (filter # 7)<br>no multipath present | 0 | 40 | 50 | dBµV |
| HCFSep | End point vs. field strength | maximum RF level for narrowest HC filter (filter # 0)<br>no multipath present | 0 | 30 | 50 | dBµV |
| HCFStW2N | Field strength-related transition time from wide to narrow band | $V_{rf}$ step-like variation from 60 dBµV to 10 dBµV | 0.001 | 0.2 | 20 | s |
| HCFStN2W | Field strength-related transition time from narrow to wide band | $V_{rf}$ step-like variation from 0 dBµV to 60 dBµV | 0.001 | 10 | 20 | s |
| HCmaxBW | Maximum cut-off frequency of high cut filter bank | Filter #7, -3 dB response frequency, input signal with pre-emphasis | HCmin BW | 14 | 18 | kHz |
| HCminBW | Minimum cut-off frequency of high cut filter bank | Filter #0, -3 dB response frequency, input signal with pre-emphasis | 1 | 3 | HCma xBW | kHz |
| HCnumFilt | Number of discrete HC filters | - | - | 8 | - | - |

# 6 Basic application schematic

Figure 24. FM wide-band application



# 7 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: *www.st.com*.

ECOPACK® is an ST trademark.

## 7.1 LQFP64 (10x10x1.4 mm) package information

**Figure 25. LQFP64 (10x10x1.4 mm) package outline**

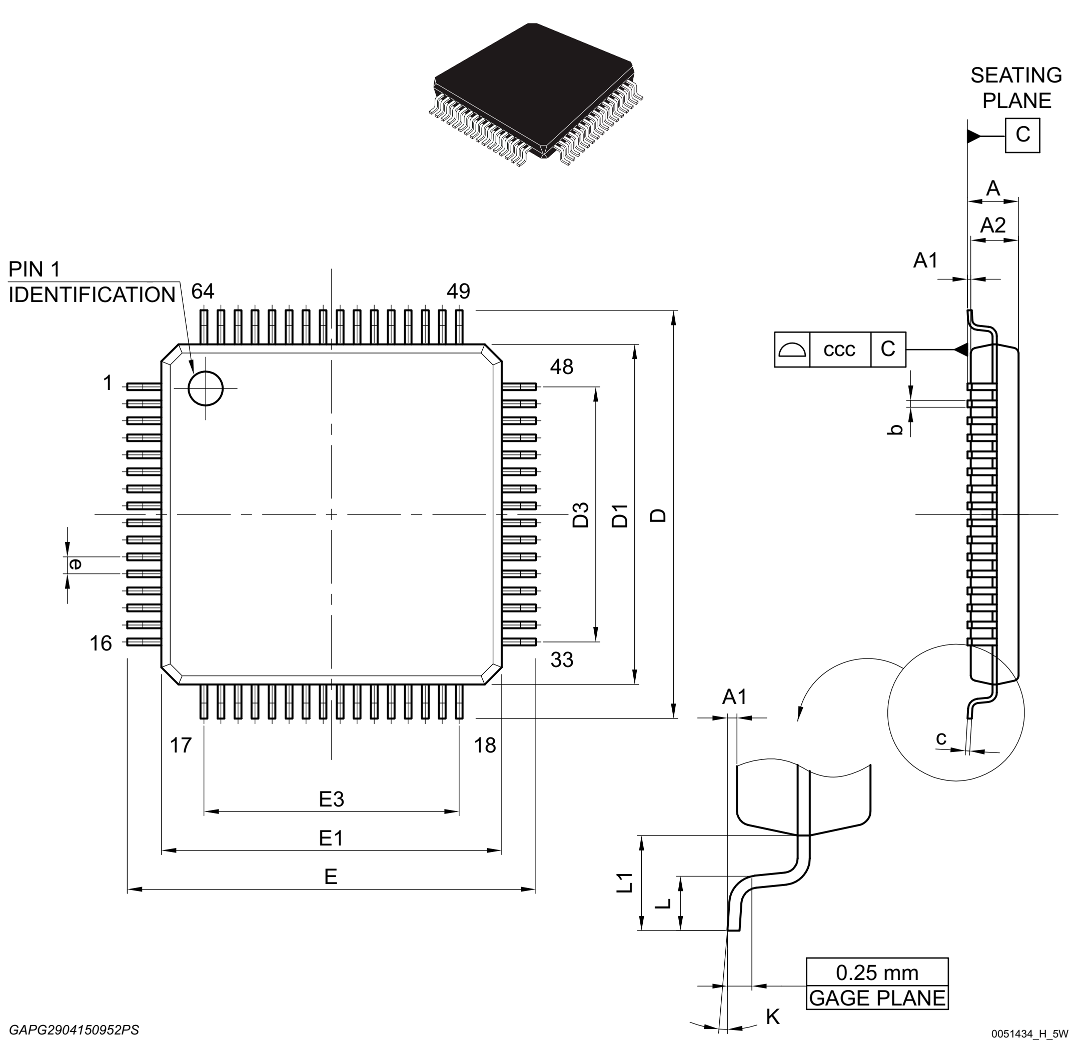


**Table 46. LQFP64 (10x10x1.4 mm) package mechanical data**

| Ref | Dimensions | | | | | |
|---|---|---|---|---|---|---|
| | Millimeters | | | Inches[1] | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | - | - | 1.60 | - | - | 0.0630 |
| A1 | 0.05 | - | 0.15 | 0.0020 | - | 0.0059 |
| A2 | 1.350 | 1.40 | 1.45 | 0.0531 | 0.0551 | 0.0571 |
| b | 0.17 | 0.22 | 0.27 | 0.0067 | 0.0087 | 0.0106 |
| c | 0.09 | - | 0.20 | 0.0035 | - | 0.0079 |
| D | 11.80 | 12.00 | 12.20 | 0.4646 | 0.4724 | 0.4803 |
| D1 | 9.80 | 10.00 | 10.20 | 0.3858 | 0.3937 | 0.4016 |
| D3 | - | 7.50 | - | - | 0.2953 | - |
| E | 11.80 | 12.00 | 12.20 | 0.4646 | 0.4724 | 0.4803 |
| E1 | 9.80 | 10.00 | 10.20 | 0.3858 | 0.3937 | 0.4016 |
| E3 | - | 7.50 | - | - | 0.2953 | - |
| e | - | 0.50 | - | - | 0.0197 | - |
| L | 0.45 | 0.60 | 0.75 | 0.0177 | 0.0236 | 0.0295 |
| L1 | - | 1.00 | - | - | 0.0394 | - |
| K | 0° (min.), 3.5° (typ.) 7° (max.) | | | | | |
| ccc | - | - | 0.08 | - | - | 0.0031 |

1. Values in inches are converted from mm and rounded to 4 decimal digits.

# 8 Revision history

Table 47. Document revision history

| Date | Revision | Changes |
|---|---|---|
| 24-Mar-2014 | 1 | Initial release. |
| 29-May-2014 | 2 | Updated *Table 3: Suggested GPIO direction and driving capability on page 15*. |
| 23-Feb-2016 | 3 | Document status promoted from preliminary data to production data.<br>Added '$T_j$' parameter in *Table 16: General key parameters on page 28*, and changed in note 2 the value of resistance from 15 to 27 Ω.<br>Updated:<br>– *Figure 24: FM wide-band application on page 50* (pin 28 - from 15 to 27 Ω);<br>– *Section 7: Package information*. |
| 27-May-2016 | 4 | Updated:<br>– Title in cover page;<br>– *Features on page 1* and added new bullet "AEC-Q100 qualified";<br>– *Description on page 1*;<br>– *Table 1: Device summary on page 1*;<br>– *Table 2: Pin description*;<br>– *Section 2.7: Audio D/A converters*<br>– *Section 2.12: Digital high speed IO interface pins*<br>– *Section 2.13: Multipath reduction*;<br>– *Section 2.14: HD Radio™ connectivity*;<br>– *Section 2.18: Digital-down-converter (DDC)*<br>Removed section 2.14 Antenna switching. |
| 05-Oct-2016 | 5 | The publication scope change from internal to public document, no content change. |