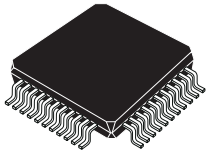
# TDA7703R

## Highly integrated tuner for AM/FM car radio

## Features

- Fully integrated VCO for world tuning
- High performance PLL for fast RDS system
- AM/FM mixers with high image rejection
- Integrated AM-LNA and AM-PINDIODE
- Automatic self alignment for image rejection
- Digital IF signal processing, high performance and drift-free
- Integrated IF-filters with high selectivity, high dynamic range and FM adaptive bandwidth control
- RDS demodulation with group and block synchronization
- High performance stereodecoder with noiseblanker
- $I^2C$ bus controlled
- Single 5 V supply
- LQFP44 package



**LQFP44**

## Description

The TDA7703R highly integrated tuner (HIT44) is part of a family of tuners for carradio applications.

It contains mixers and IF amplifiers for AM and FM, fully integrated VCO and PLL synthesizer, IF-processing including adaptive bandwidth control (FM), stereo decoder and RDS decoder on a single chip.

The utilization of digital signal processing results in numerous advantages against today's tuners:

- Very low number of external components
- Very small space occupation and easy application
- Very high selectivity due to digital filters
- High flexibility by software control
- Automatic image rejection alignment.

**Table 1. Device summary**

| Order code | Package | Packing |
|---|---|---|
| TDA7703R | LQFP44 (10x10x1.4mm) | Tray |
| TDA7703RTR | LQFP44 (10x10x1.4mm) | Tape and reel |

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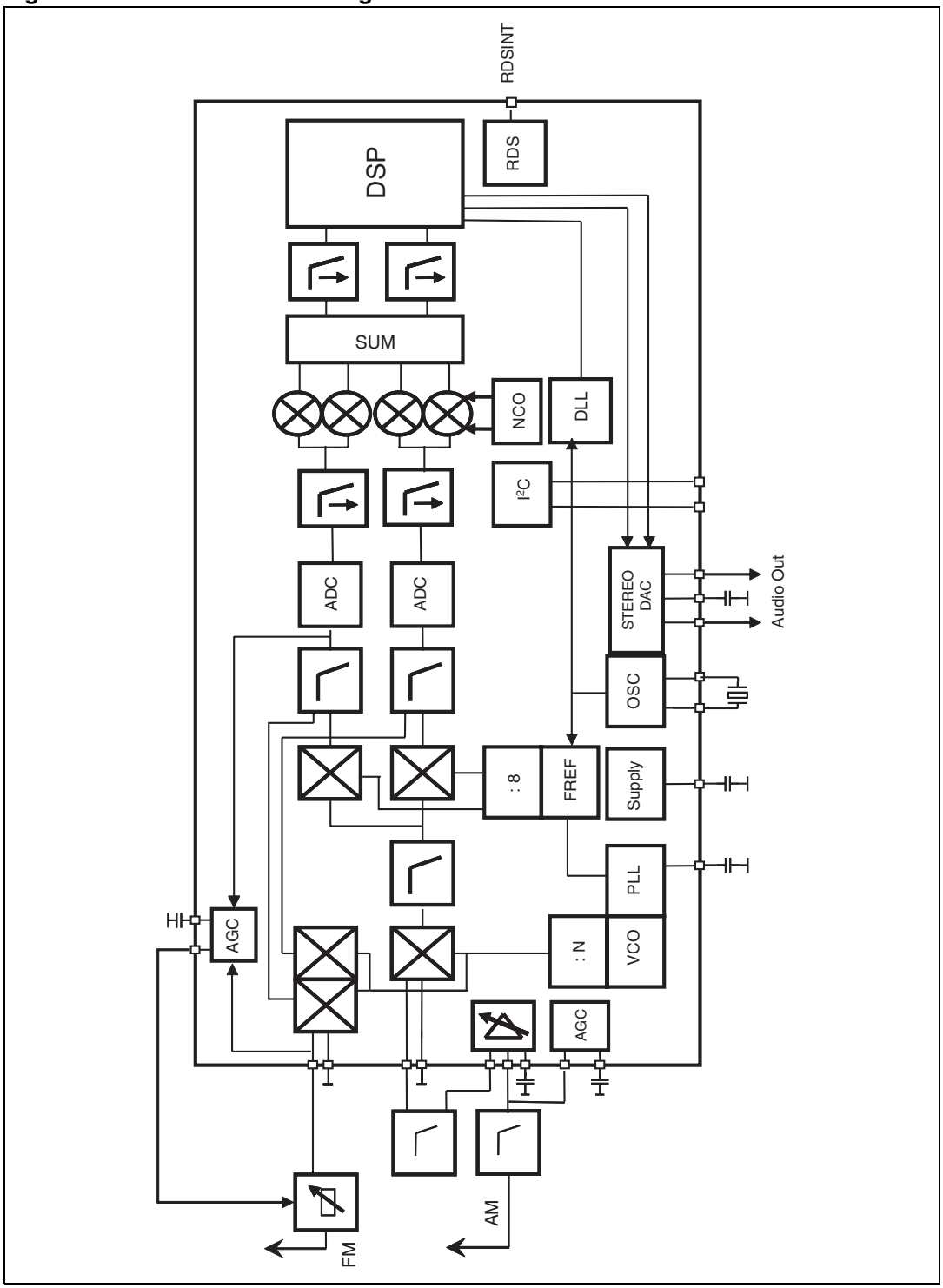
# 1 Block diagram and pin description

## 1.1 Block diagram

**Figure 1. Functional block diagram**



## 1.2 Pin description

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

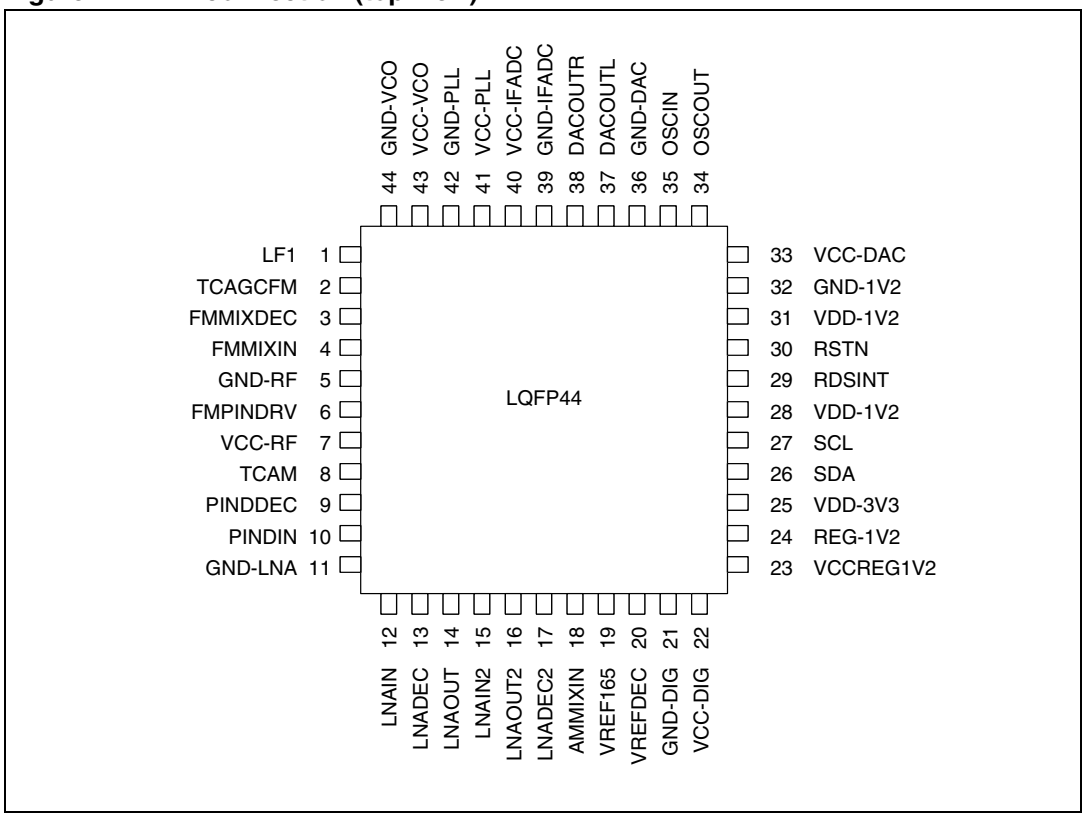



**Table 2. Pin description**

| Pin # | Pin name | Description |
|---|---|---|
| 1 | LF1 | PLL loopfilter output |
| 2 | TCAGCFM | FM AGC time constant |
| 3 | FMMIXDEC | FM mixer decoupling |
| 4 | FMIXIN | FM mixer input |
| 5 | GND-RF | RF Ground |
| 6 | FMPINDRV | FM AGC PIN diode driver |
| 7 | VCC-RF | 5 V supply for RF section |
| 8 | TCAM | AM AGC time constant |
| 9 | PINDDEC | AM AGC internal PIN diode decoupling |
| 10 | PINDIN | AM AGC internal PIN diode input |
| 11 | GND-LNA | GND of AM LNA, AM internal PIN diode , AM mixer, IF |
| 12 | LNAIN | AM LNA input |
| 13 | LNADEC | AM LNA decoupling |
| 14 | LNAOUT | AM LNA output first stage |

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

| Pin # | Pin name | Description |
|---|---|---|
| 15 | LNAIN2 | AM LNA input 2nd stage |
| 16 | LNAOUT2 | AM LNA output |
| 17 | LNADEC2 | AM LNA decoupling 2nd stage |
| 18 | AMMIXIN | AM mixer input |
| 19 | VREF165 | 1.65 V reference voltage decoupling |
| 20 | VREFDEC | 3.3 V reference voltage decoupling |
| 21 | GND-DIG | Digital GND |
| 22 | VCC-DIG | 5 V supply for digital logic |
| 23 | VCCREG1V2 | VCC of 1.2 V regulator |
| 24 | REG1V2 | 1.2 V regulator output |
| 25 | VDD-3V3 | 3.3 V VDD output / decoupling |
| 26 | SDA | $I^2C$ bus data |
| 27 | SCL | $I^2C$ bus clock |
| 28 | VDD-1V2 | 1.2 V DSP supply |
| 29 | RDSINT | RDS interrupt |
| 30 | RSTN | Reset pin (active low) |
| 31 | VDD-1V2 | 1.2 V DSP supply |
| 32 | GND-1V2 | Digital GND for 1.2 V VDD |
| 33 | VCC-DAC | 5 V supply of audio DAC |
| 34 | OSCOUT | Xtal osc output |
| 35 | OSCIN | Xtal osc input |
| 36 | GND-DAC | Audio DAC GND |
| 37 | DACOUTL | Audio output left |
| 38 | DACOUTR | Audio output right |
| 39 | GND-IFADC | IF ADC GND |
| 40 | VCC-IFADC | 5 V supply of IF ADC |
| 41 | VCC-PLL | 5 V supply of PLL |
| 42 | GND-PLL | PLL GND |
| 43 | VCC-VCO | 5 V supply of VCO |
| 44 | GND-VCO | VCO GND |

# 2 Function description

## 2.1 FM - mixer

The FM image-rejection mixer is optimized for best performance with a passive wide-band prestage.

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

## 2.2 FM - AGC

The programmable RFAGC senses the mixer input whereas the IFAGC senses the IFADC input to avoid overload.

The PIN diode driver is able to drive external PIN diodes with a current value as high as 15mA.

The time constant of the FM-AGC is defined by an external capacitor.

## 2.3 AM - LNA

The AM-LNA 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 28 dB with 1.5 kΩ.

## 2.4 AM - AGC

The programmable AM-RF-AGC senses the mixer inputs and controls the internal PIN diode and LNA gain.

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

The time constant of the AM-AGC is defined with an external capacitor and programmable internal currents.

## 2.5 AM - mixer

The AM mixer converts RF to low IF with high image rejection.

## 2.6 IF A/D converters

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

## 2.7 Audio D/A converters

A stereo DAC provides the left / right audio signals after IF-processing and stereodecoding by the DSP.

## 2.8 VCO

The VCO is fully integrated without any external tuning component. It covers all FM frequency bands including EU, US, Japan, EastEU and AM-bands including LW and MW.

## 2.9 PLL

The high speed tuning PLL is able to settle within about 300 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 37.05 MHz fundamental tone crystal, and can be used also with a 3$^{rd}$ overtone 37.05 MHz crystal.

## 2.11 DSP

The DSP and its hardware accelerators perform all the digital signal processing. The main program is fixed in ROM. Control parameters are copied in RAM and are accessible and modifiable there, thus allowing parametric performance optimization.

It performs:

- digital down-conversion of IF
- bandwidth selection with variable controlled bandwidth
- FM noiseblanking
- FM/AM demodulation with softmute, 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

## 2.12 IO interface pins

The TDA7703R has the following IO pins:

| | | |
|---|---|---|
| SDA | pin 26 | serial communication with µP |
| SCL | pin 27 | serial communication with µP |
| RDSINT | pin 29 | RDS interrupt line towards µP |
| RSTN | pin 30 | reset pin driven by µP |

All the inputs are voltage-tolerant up to 3.5 V . The outputs can drive currents up to 0.5 mA from the internal 3.3 V supply line.

## 2.13 Serial interface

The device is controlled with a standard $I^2C$ bus interface.

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

The operation of the device is handled through high level commands sent by the main car-radio µP through the serial interface, which allow to simplify the operations carried out in the main µP. The high level commands include among others:

- set frequency (which allows to avoid computing the PLL divider factors);
- start seek (the seek operation can be carried out by the TDA7703R in a completely autonomous fashion);
- RDS seek/search (jumps to AF and quality measurements are automatically sequenced).

The serial bus communication configuration is set by forcing pin 29 (RDSINT) to ground when the RSTN line transitions from low to high (when RSTN is low, the IC is in reset mode).

The voltage level forced to pin 29 must be released to start the system operation a suitable time after the RSTN line has gone high. The $I^2C$ address is 0xC2 (write) / 0xC3 (read).

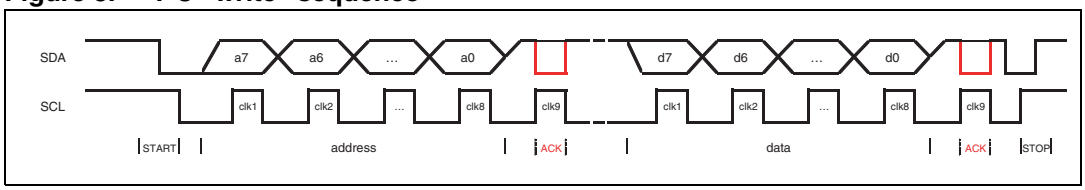
The status of pin 29 during the reset phase can be set to low by not forcing any voltage on it from outside, as a 50 kΩ internal pull-down resistors is present.

To make sure the boot mode 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 then for an additional time $T_{reset}$ (see *Section 3.4.6*).

$I^2C$ requires two signals: clock (SCL) and data (SDA - bidirectional). The protocol requires an acknowledge 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 3. $I^2C$ "write" sequence**



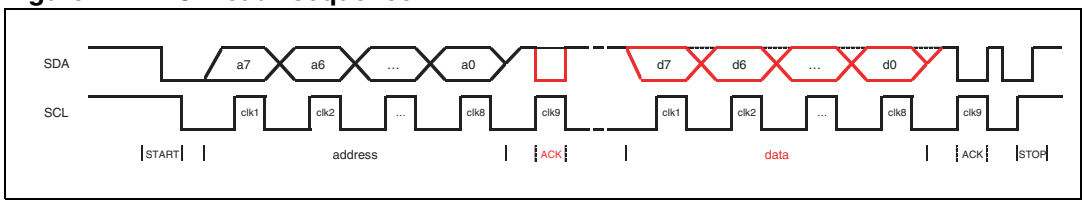
The sequence consists of the following phases:

- START: SDA line transitioning from H to L with SCL fixed H. This signifies a new transmission is starting;
- data latching: on the rising SCL edge. The SDA line can transition only when SCL is low (otherwise its transitions are interpreted as either a START or a STOP transition);
- ACKnowledge: on the 9$^{th}$ SCL pulse the µP keeps the SDA line H, and the TDA7703R pulls it down if communication has been successful. Lack of the acknowledge pulse generation from the TDA7703R means that the communication has failed;
- a chip address byte must be sent at the beginning of the transmission. The value is C2 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;
- STOP: SDA line transitioning from L to H with SCL H. This signifies the end of the transmission.

Red lines represent transmissions from the TDA7703R to the µP.

A "read" communication example is shown in the figure below, for an unspecified number of data bytes (see later on for frame structure decription):

**Figure 4. I$^2$C "read" sequence**




The sequence is very similar to the "write" one and has the same constraints for start, stop, data latching. The differences follow:

- a chip address must always be sent by the µP to the TDA7703R; the address must be C3;
- a header is transmitted after the chip address (the same happens for "write") before data are transferred from the TDA7703R to the µP. See the relevant technical documentation for details on the frame format;
- when data are transmitted from the TDA7703R to the µP, the µP keeps the SDA line H;
- the ACKnowledge pulse is generated by the µP for those data bytes that are sent by the TDA7703R to the µP. Failure of the µP to generate an ACK pulse on the 9$^{th}$ CLK pulse has the same effect on the TDA7703R as a STOP.

The max. clock speed is 500 kbit/s.

# 3 Electrical specifications

## 3.1 Absolute maximum ratings

**Table 3. Absolute maximum ratings**

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_{CC}$ | Supply voltage | | | | 5.5 | V |
| $T_{stg}$ | Storage temperature | | -55 | | 150 | °C |

## 3.2 Thermal data

**Table 4. Thermal data**

| Symbol | Parameter | Test condition | Value | Units |
|---|---|---|---|---|
| $R_{Th\ j\text{-}amb}$ | Thermal resistance junction to ambient | LQFP44 10x10, double-layer JEDEC PCB | 55 | °C/W |

## 3.3 General key parameters

**Table 5. General key parameters**

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_{CC}$ | 5 V supply voltage | | 4.7 | 5 | 5.25 | V |
| $I_{CC}$ | Supply current @ 5 V | | | 220 | 295 | mA |
| $T_{amb}$ | Ambient temperature range | | -30 | | 75 | °C |
| $V_{VCCREG12}$ | VCCREG12 supply voltage | see note(1) | 2 | | | V |
| $V_{1V2}$ | Digital core 1.2V supply voltage | when supplied externally see note (2) | 1.08 | 1.2 | 1.32 | V |
| $I_{1V2}$ | Digital core 1.2 V supply current | $V_{1V2}$ = 1.08 V see note (2) | | | 120 | mA |
| | | $V_{1V2}$ = 1.2 V see note (2) | | 80 | 135 | mA |
| | | $V_{1V2}$ = 1.32 V see note (2) | | | 150 | mA |

1. In the typical application supplied from 5V with a series resistor.
2. When the 1.2 V supply is applied externally, and not using the internal 1.2 V regulator.

## 3.4 Electrical characteristics

$V_{CC}$ = 5 V; $T_{amb}$ = 27 °C; unless otherwise specified.

### 3.4.1 FM - section

**Table 6. FM - section**

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| **FM IMR mixer** | | | | | | |
| $R_{in}$ | Input resistance | | 90 | 130 | 170 | kΩ |
| IIP3 | 3rd order intercept point | up to $V_{in/tone}$ = 85 dBµV | | 121 | | dBµV |
| **FM AGC** | | | | | | |
| RFAGC-Thr | RFAGC threshold, referred to mixer input; RF level | min setting | | 85 | | dBµV |
| | | max setting | | 91 | | |
| | Threshold steps | | | 2 | | dB |
| | Threshold error | | -1.5 | | 1.5 | dB |
| | Threshold temperature drift | | | 0.016 | | dB/K |
| IFAGC-Thr | IFAGC threshold, referred to mixer input; at tuned frequency RF level | min setting | | 77 | | dBµV |
| | | max setting | | 81 | | |
| | Threshold steps | | | 2 | | dB |
| | Threshold error | | -1.5 | | 1.5 | dB |
| | Threshold temperature drift | | | 0.016 | | dB/K |
| | Pin diode source current | see note(1) | 12 | | | mA |
| | Pin diode sink current | | 3 | | 20 | µA |
| | Pin diode source current in constant current mode | see note(1) | 0.4 | | | mA |

1. 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 298 K.

### 3.4.2 AM - section

**Table 7. AM - section**

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| **AM IMR Mixer** | | | | | | |
| $R_{in}$ | Input resistance | | 20 | 30 | 45 | kΩ |
| IIP3 | 3rd order intercept point | up to $V_{in/tone}$ = 90 dBµV | | 129 | | dBµV |
| IIP2 | 2nd order intercept point | up to $V_{in/tone}$ = 90 dBµV | | 158 | | dBµV |
| LO hsupp | LO harmonic suppression | N=2,3,4,5,6 | | 100 | | dB |
| | | N=7,9 | | 85 | | |
| **AM LNA** | | | | | | |
| Gain | Voltage gain | Max Gain, $R_{ext}$ = 1.5 kΩ | 24 | 28 | 31 | dB |
| | | Min Gain (AGC controlled) | | 12 | | |
| $R_{in}$ | Input resistance | | | 1000 | | kΩ |
| $C_{in}$ | Input capacitance | | | 20 | | pF |
| IIP3 | 3rd order intercept point | @ maximum LNA gain | | 125 | | dBµV |
| IIP2 | 2nd order intercept point | @ maximum LNA gain | | 143 | | dBµV |
| **AM PIN diode** | | | | | | |
| IIP2 | 2nd order intercept point | Full attenuation, $C_{source}$ = 80 pF, f=1 MHz | | 140 | | dBµV |
| $R_{min}$ | Minimum resistance | | | 50 | 80 | Ω |
| $C_{in}$ | Input capacitance | High ohmic | | 12 | | pF |
| **AM AGC** | | | | | | |
| AGC-Thr | Referred to mixer input RF level | min setting | | 87 | | dBµV |
| | | max setting | | 93 | | |
| Thr-steps | Threshold steps | | | 1 | | dB |
| | Threshold error | | -2.5 | | 2.5 | |
| | Threshold temperature drift | | -3 | | 3 | |

### 3.4.3 VCO

**Table 8. VCO**

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $F_{VCO}$ | Frequency range VCO | | 1100 | | 1550 | MHz |
| PN | Phase noise of LO | Locked VCO;<br>values referred @ 100MHz<br>@ 100 Hz<br>@ 1 kHz<br>@ 10 kHz | | <br><br>-100<br>-115<br>-115 | | dBc/Hz |
| dev | Deviation error (rms) | FM reception, deemphasis 50µs, $f_{audio}$=20Hz...20kHz | | 5 | | Hz |

### 3.4.4 Phase locked loop

**Table 9. Phase locked loop**

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $T_{settle}$ | Settling time FM | $\Delta f$ < 10 kHz | | 300 | | µs |
| FM step | FM frequency step | | | 5 | | kHz |
| AM step | AM frequency step | | | 500 | | Hz |

### 3.4.5 Audio DAC

**Table 10. Audio DAC**

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_{out}$ | Output voltage | AM 90% modulation;<br>FM 75 kHz deviation.<br>400 Hz audio frequency | | 300 | | mVrms |
| BW | Bandwidth | 1 dB attenuation | | 15 | | KHz |
| $R_{out}$ | Output resistance | | 600 | 750 | 900 | Ω |

### 3.4.6 IO interface pins

**Table 11. IO interface pins**

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| | High level output voltage | $I_{out}$ = 500µA | 2.9 | 3.2 | | V |
| | Low level output voltage | $I_{out}$ = -1mA | | 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 pin 29 must be kept in order to latch the correct boot mode (serial bus configuration) | 10 | | | µs |

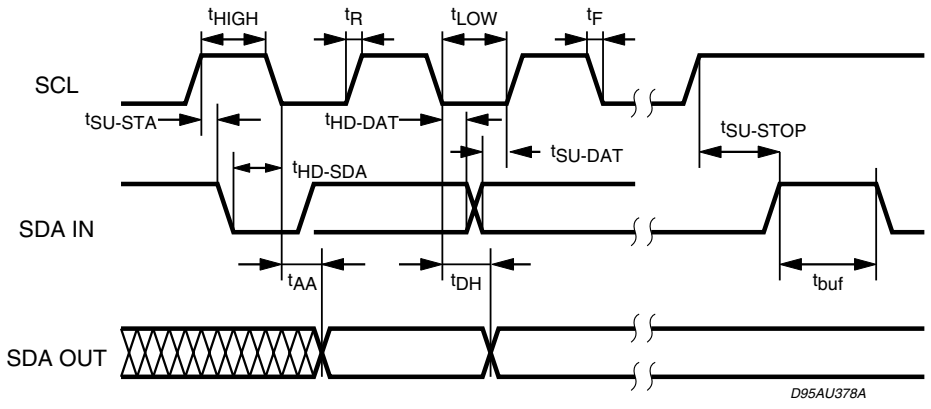
### 3.4.7 I²C interface

The parameters of the following table are defined as in *Figure 5*.

**Table 12. I²C 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 transmisison | | 1.3 | | | µs |
| $t_{HD-STA}$ | START condition hold time | | 0.6 | | | µs |
| $t_{LOW}$ | Clock low period | | 1.3 | | | µs |
| $t_{HIGH}$ | Clock high period | | 0.6 | | | µs |
| $t_{SU-SDA}$ | START condition setup time | | 0.1 | | | µs |
| $t_{HD-DAT}$ | Data input hold time | | 0 | | 0.9 | µs |
| $t_{SU-DAT}$ | Data input setup time | | 0.1 | | | µs |
| $t_R$ | SDA & SCL rise time | | | | 0.3 | µs |
| $t_F$ | SDA & SCL fall time | | | | 0.3 | µs |
| $t_{SU-STOP}$ | Stop condition setup time | | 0.6 | | | µs |
| $t_{DH}$ | Data out time | | | | 0.3 | µs |

**Figure 5. I²C bus timing diagram**



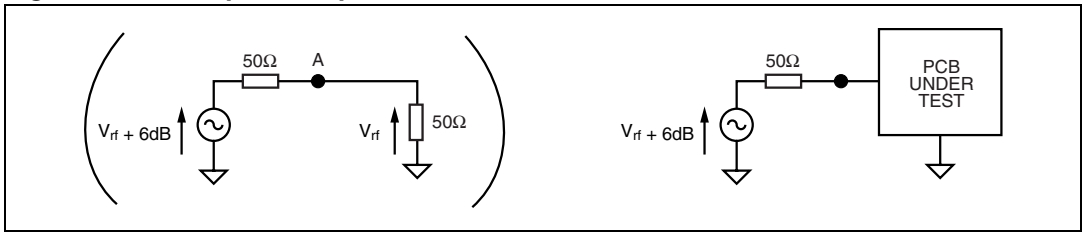
## 3.5 Overall system performance

All measurements obtained with application of *Figure 9* unless otherwise specified.

### 3.5.1 FM overall system performance

Antenna level equivalence: 0 dBµV = 1 $\mu V_{rms}$ (Antenna terminal voltage with 50 Ω source).

**Figure 6. FM input set-up**




Input level referred to signal generator loaded with 50 Ω ($V_{rf}$, node 'A'); no antenna dummy; AM input not connected. $F_{rf}$ = 98.1 MHz, $V_{rf}$ = 60 dBµV, mono modulation, $f_{dev}$ = 40 kHz, $f_{audio}$ = 1 kHz. De-emphasis = 50 µs. Unless otherwise specified

**Table 13. FM overall system performance**

| Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| Tuning range FM Eu | (can be modified by the user) | 87.5 | | 108 | MHz |
| Tuning step FM Eu | | | 100 | | kHz |
| Tuning range FM US | | 87.5 | | 107.9 | MHz |
| Tuning step FM US | | | 200 | | kHz |
| Tuning range FM Jp | | 76 | | 90 | MHz |
| Tuning step FM Jp | | | 100 | | kHz |
| Tuning range FM EEu | | 65 | | 74 | MHz |
| Tuning step FM EEu | | | 100 | | kHz |
| Sensitivity | S/N =26dB | | -3 | 0 | dBµV |
| Ultimate S/N | @ 60 dBµV, mono | 72 | 75 | | dB |
| | @ 60 dBµV, Deviation = 75 kHz, mono | 77 | 80 | | dB |
| | @ 60 dBµV, stereo | 70 | 73 | | dB |
| Distortion | Deviation= 75 kHz | | 0.15 | | % |
| Max deviation | THD=3% | 120 | | | kHz |
| Adjacent channel selectivity ($V_u/V_d$) | ΔF=100 kHz, SINAD=30 dB desired 40 dBµV, dev=40kHz, 400Hz undesired. dev=40kHz, 1KHz | | 13 | | dB |
| Alternate channel selectivity ($V_u/V_d$) | ΔF=200 kHz, SINAD=30 dB desired 40 dBµV, dev=40 kHz, 400 Hz undesired. dev=40kHz, 1kHz | | 62 | | dB |

**Table 13. FM overall system performance (continued)**

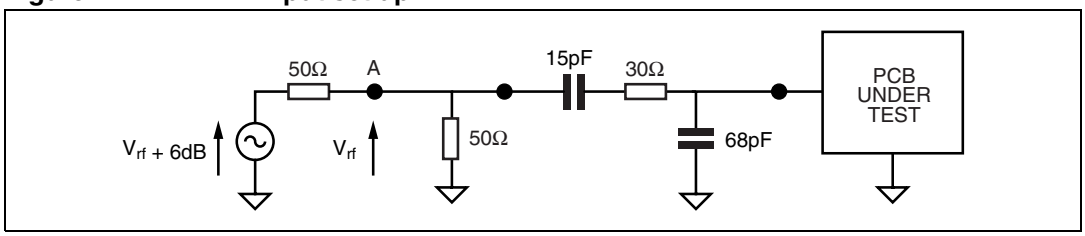
| Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| Max. strong signal interferer ($V_u/V_d$) | Desired = 40 dBµV<br>SINAD = 30dB<br>Undesired ΔF = 5MHz<br>dev = 40kHz, 1kHz | | 75 | | dB |
| 3 signal performance ($V_{u1}$ & $V_{u2}/V_d$)(1) | Desired = 40 dBµV, dev=40kHz, 400Hz, SINAD=30dB<br>Undesired1 =±400kHz, dev=40kHz, 1 kHz<br>Undesired2=±800kHz, no mod | | 62 | | dB |
| | Desired = 40 dBµV, dev=40kHz, 400Hz, SINAD=30dB<br>Undesired1 =±1MHz, dev=40kHz, 1 kHz<br>Undesired2=±2MHz, no mod | | 65 | | dB |
| AM suppression | m=30% | | 70 | | dB |
| Image rejection | | | 80 | | dB |
| Logarithmic field strength indicator | @40 dBµV<br>read “FM_Smeter_log” | -0.33 (equiv. to 37 dBµV) | -0.3 | -0.27 (equiv. to 43 dBµV) | - |

1. Signal levels referred to combiner output.

### 3.5.2 AM MW overall system performance

Antenna level equivalence: 0 dBµV = 1 $\mu V_{rms}$.

**Figure 7. AM MW input set up**




Level referred to SG output before antenna dummy ($V_{rf}$, node 'A'); capacitive dummy 15pF+68pF, FM input not connected. $F_{rf}$ = 999 kHz (1000 kHz for US), $V_{rf}$ =74 dBµV, mod = 30%, $f_{audio}$ =400 Hz, unless otherwise specified.

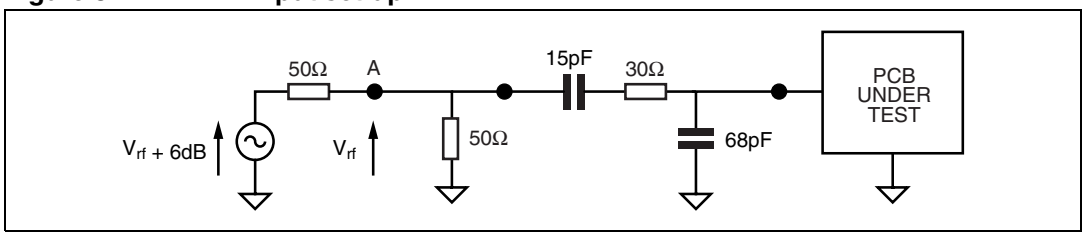
**Table 14. AM MW overall system performance**

| 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 | | 29 | 32 | dBµV |
| Ultimate S/N | @ 80 dBµV | 63 | 66 | | dB |
| AGC F.O.M. | Ref.=74 dBµV<br>-10dB drop point | 50 | 62 | 65 | dB |
| Distortion | m = 80 % | | 0.1 | | % |
| Adjacent channel selectivity | ΔF=9 kHz, $V_{audio}$ = -10 dBr (relative to ΔF = 0 kHz), m=30%, 1 kHz | | 97 | | dB |
| Alternate channel selectivity | ΔF=18 kHz, $V_{audio}$ = -10 dBr (relative to ΔF = 0 kHz), m=30%, 1kHz | | 97 | | dB |
| Image rejection | | | 80 | | dB |
| Logarithmic field strength indicator | @60 dBµV<br>read “AM_Smeter_log” | 0.50 (equiv. to 57 dBµV) | 0.47 | 0.43 (equiv. to 63 dBµV) | - |

### 3.5.3 AM LW overall system performance

Antenna level equivalence: 0dBµV = 1µ$V_{rms}$

**Figure 8. AM LW input set-up**




Level referred to SG output before antenna dummy ($V_{rf}$, node 'A'); capacitive dummy 15pF+68pF; FM input not connected. $F_{rf}$ = 216 kHz, $V_{rf}$ =74 dBµV, mod = 30 %, $f_{audio}$ = 400 Hz, unless otherwise specified.

**Table 15. 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 =20dB | | 31 | 34 | dBµV |
| Ultimate S/N | @ 80 dBµV | 63 | 66 | | dB |
| AGC F.O.M. | Ref.=74 dBµV<br>-10dB drop point | 50 | 62 | 65 | dB |
| Distortion | m = 80 % | | 0.1 | | % |
| Image rejection | | | 80 | | dB |

# 4 Front-end processing

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 16. 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 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 (25 ms with 1 µF) |
| | | | | | | | | 1 | 1 | | | | | | | | | | | | | | | fast (5 ms with 1 µF) |
| | | | | | | | | | | | | | | | | | | | | | | | | **AM AGC threshold** @ mixin |
| | | | | | 0 | 0 | 0 | | | | | | | | | | | | | | | | | 90 dBµV |
| | | | | | 0 | 0 | 1 | | | | | | | | | | | | | | | | | 91 dBµV |
| | | | | | 0 | 1 | 0 | | | | | | | | | | | | | | | | | 92 dBµV |
| | | | | | 0 | 1 | 1 | | | | | | | | | | | | | | | | | 93 dBµV |
| | | | | | 1 | 0 | 0 | | | | | | | | | | | | | | | | | 90 dBµV |
| | | | | | 1 | 0 | 1 | | | | | | | | | | | | | | | | | 89 dBµV |
| | | | | | 1 | 1 | 0 | | | | | | | | | | | | | | | | | 88 dBµV |
| | | | | | 1 | 1 | 1 | | | | | | | | | | | | | | | | | 87 dBµV |
| | | | | | | | | | | | | | | | | | | | | | | | | **AM AGC attack time constant** |
| | | | 0 | | | | | | | | | | | | | | | | | | | | | normal |
| | | | 1 | | | | | | | | | | | | | | | | | | | | | fast |

**Table 17. 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 gain** |
| | | | | | | | | 0 | | | | | | | | | | | | | | | | high |
| | | | | | | | | 1 | | | | | | | | | | | | | | | | low |
| | | | | | | | | | | | | | | | | | | | | | | | | **FM AGC time constant** |
| | | 0 | | | | | | | | | | | | | | | | | | | | | | normal |
| | | 1 | | | | | | | | | | | | | | | | | | | | | | fast |
| | | | | | | | | | | | | | | | | | | | | | | | | **FM AGC output mode** |
| 0 | 0 | | | | | | | | | | | | | | | | | | | | | | | normal |
| 0 | 1 | | | | | | | | | | | | | | | | | | | | | | | constant 15 mA |
| 1 | 0 | | | | | | | | | | | | | | | | | | | | | | | constant 1 mA |

**Table 18. 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 AGC threshold @** mixin |
| | | | | | | | | | | | | | | | | | | | | | | 0 | 0 | 87 dBµV |
| | | | | | | | | | | | | | | | | | | | | | | 0 | 1 | 89 dBµV |
| | | | | | | | | | | | | | | | | | | | | | | 1 | 0 | 91 dBµV |
| | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | 93 dBµV |
| | | | | | | | | | | | | | | | | | | | | | | | | **FM iF AGC threshold @** IFADC in |
| | | | | | | | | | | | | | | | | | | | | 0 | 0 | | | 120 dBµV |
| | | | | | | | | | | | | | | | | | | | | 0 | 1 | | | 122 dBµV |
| | | | | | | | | | | | | | | | | | | | | 1 | 0 | | | 124 dBµV |

# 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 µP); the max and the min values refer to the programmability range. The values are referred to the typical application. 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 19. Dynamic channel selection filter (DISS)**
(discrete set)

| Symbol | Parameter | Test condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| DISS BW | IF filter #2 | response: - 3dB | - | ±80 | - | kHz |
| | IF filter #1 | | - | ±60 | - | kHz |
| | IF filter #0 | | - | ±40 | - | kHz |

### 5.1.2 Soft mute

**Table 20. 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 21. 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 22. 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 | 7 | 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 23. 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 | 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 | 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 24. 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 25. Stereo decoder**

| 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 26. 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 27. 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 |

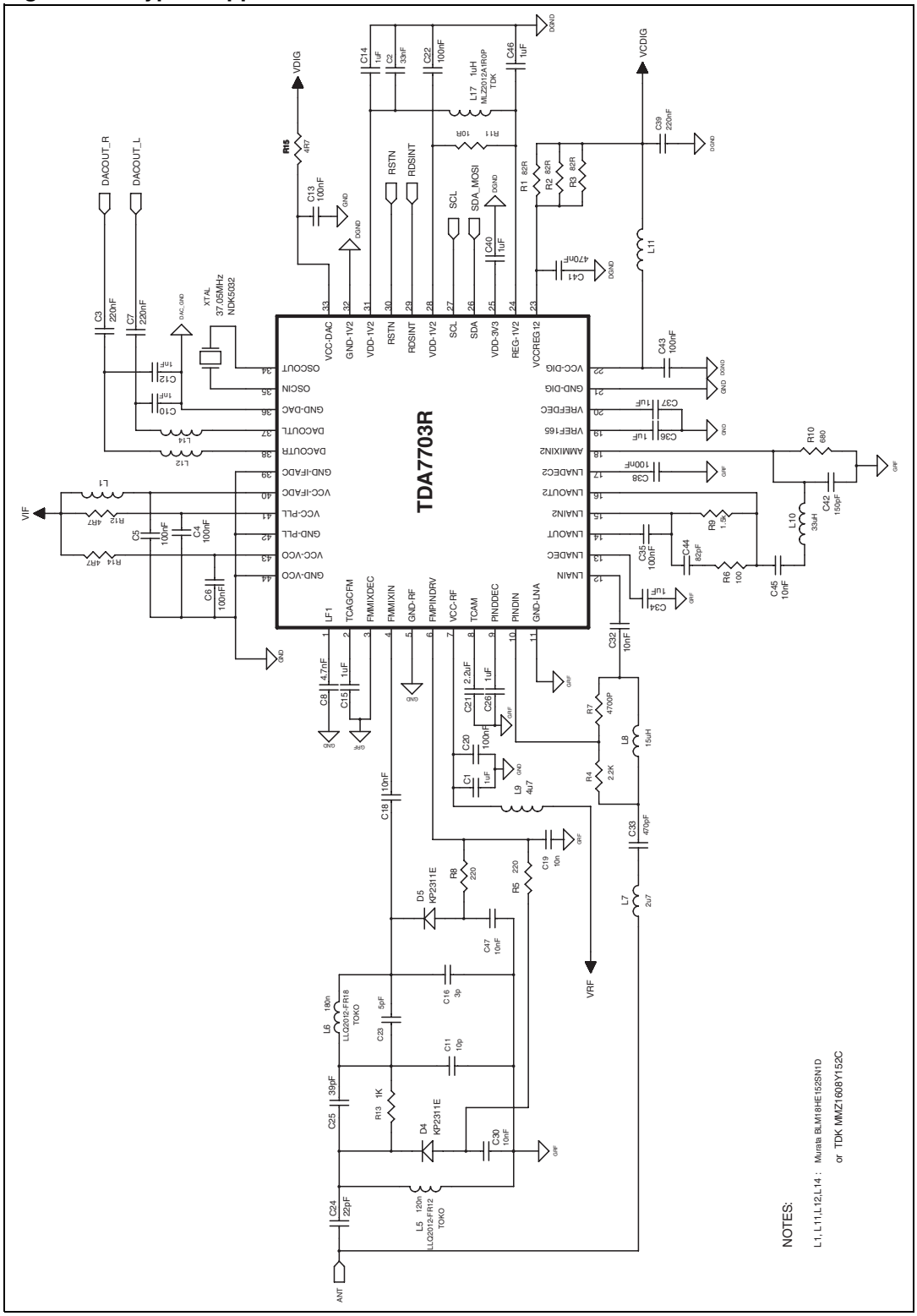
### 5.2.3 High cut control

**Table 28. 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) no multipath present | 0 | 40 | 50 | dBµV |
| HCFSep | End point vs. field strength | maximum RF level for narrowest HC filter (filter # 0) 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 |
| HCnumFilt | Number of discrete HC filters | | - | 8 | - | - |

# 6 Application schematic

**Figure 9. Typical application schematic**



# 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*.

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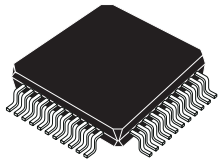
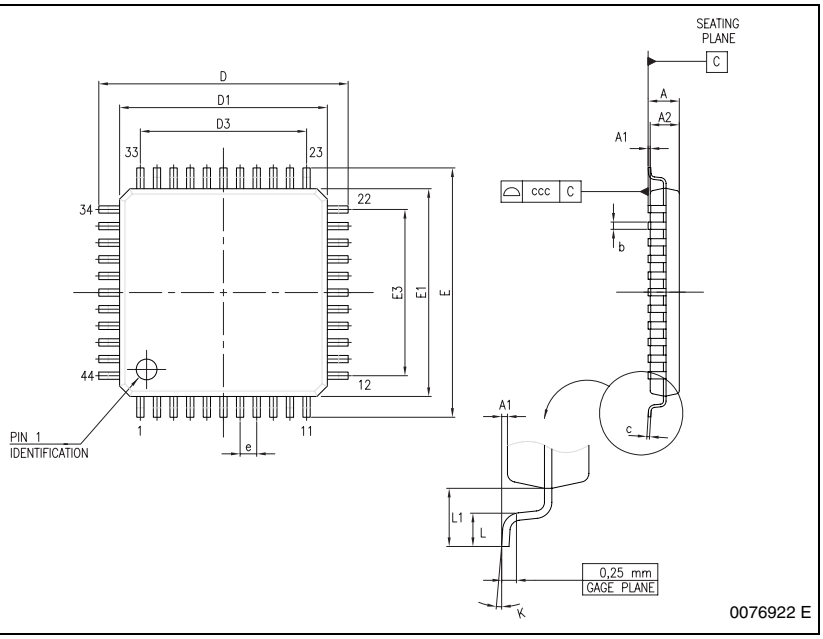
**Figure 10. LQFP44 (10x10x1.4mm) mechanical data and package dimensions**

| DIM. | mm | | | inch | | |
|---|---|---|---|---|---|---|
| | MIN. | TYP. | MAX. | MIN. | TYP. | MAX. |
| A | | | 1.60 | | | 0.063 |
| A1 | 0.05 | | 0.15 | 0.002 | | 0.006 |
| A2 | 1.35 | 1.40 | 1.45 | 0.053 | 0.055 | 0.057 |
| B | 0.30 | 0.37 | 0.45 | 0.012 | 0.015 | 0.018 |
| C | 0.09 | | 0.20 | 0.004 | | 0.008 |
| D | 11.80 | 12.00 | 12.20 | 0.464 | 0.472 | 0.480 |
| D1 | 9.80 | 10.00 | 10.20 | 0.386 | 0.394 | 0.401 |
| D3 | | 8.00 | | | 0.315 | |
| E | 11.80 | 12.00 | 12.20 | 0.464 | 0.472 | 0.480 |
| E1 | 9.80 | 10.00 | 10.20 | 0.386 | 0.394 | 0.401 |
| E3 | | 8.00 | | | 0.315 | |
| e | | 0.80 | | | 0.031 | |
| L | 0.45 | 0.60 | 0.75 | 0.018 | 0.024 | 0.030 |
| L1 | | 1.00 | | | 0.039 | |
| k | 0°(min.), 3.5°(typ.), 7°(max.) | | | | | |
| ccc | | | 0.10 | | | 0.0039 |

**OUTLINE AND MECHANICAL DATA**



**LQFP44 (10 x 10 x 1.4mm)**



# 8 Revision history

**Table 29. Document revision history**

| Date | Revision | Changes |
|---|---|---|
| 06-May-2009 | 1 | Initial release. |
| 08-Jun-2009 | 1.1 | Updated *Table 4: Thermal data on page 13*. |
| 29-Jan-2010 | 1.2 | Minor text changes in *Section 2.13: Serial interface*.<br>Modified min. value of “tHD-DAT” parameter in *Table 12: $I^2C$ interface on page 17* |

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