



## TDA7528

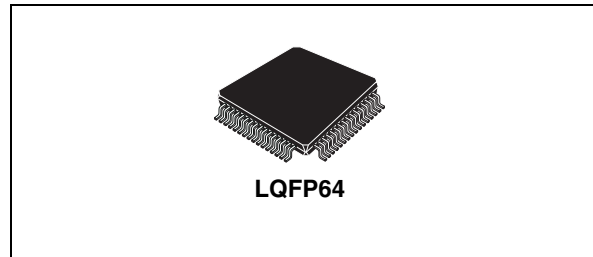
### FM/AM car-radio receiver front-end for IF-sampling systems with fully integrated VCO

#### Features

- High-performance AM/FM front-end chip for IF-sampling car-radio tuners
- Compatible with AM(LW, MW, SW) / FM(EU, US, JAPAN, OIRT) / Weather Band / HD-Radio / DRM applications
- Ready for multi-tuner applications (phase diversity, background tuner)
- Dual input FM-mixer with high image rejection, specialized for different front-end circuits
- Integrated AM preamplifier and tank for lower-cost applications
- Fully integrated tuning PLL with two VCO's for diversity systems
- World tuning capable
- Integrated IF tank
- AGC controlled IF amplifier with four inputs for connection of up to four ceramic filters
- Fully electronically adjustable
- I<sup>2</sup>C/SPI controlled

#### Description

The TDA7528 is a front-end module for use in car radio receivers with digital IF processing, using the STA3004, respectively the STA3005 backend IC.



Its field of use includes all the current radio broadcast services in the range of 50kHz to 163MHz for AM radio, FM radio and US weather band. Digital standards such as DRM and HD radio can also be handled. A single superheterodyne architecture with 10.7 MHz IF-frequency provides high dynamic range.

The IMR mixer has separate input and output stages for AM frequency bands up to 30 MHz and for FM frequencies above 30 MHz.

The integrated AM-preamplifier and the fully integrated low-pass filter enable low cost applications. Two FM inputs with different noise / IP3 parameter, provide full flexibility for the pre-stage circuitry. Each mixer output is able to drive two IF-filters, which can be selected by the different IF-amplifier inputs.

The fast tuning PLL controls two different VCO, which are designed to operate without frequency overlap.

Table 1. Device summary

| Order code | Package                           | Packing |
|------------|-----------------------------------|---------|
| TDA7528    | LQFP64 exposed pad (10x10x1.4 mm) | Tray    |

# Contents

|          |                                                         |           |
|----------|---------------------------------------------------------|-----------|
| <b>1</b> | <b>Product description</b>                              | <b>8</b>  |
| 1.1      | Summary                                                 | 8         |
| 1.2      | Block diagram                                           | 9         |
| <b>2</b> | <b>Pin description</b>                                  | <b>10</b> |
| 2.1      | Pin connection                                          | 10        |
| 2.2      | Pin description                                         | 10        |
| <b>3</b> | <b>Electrical characteristics</b>                       | <b>13</b> |
| 3.1      | Absolute maximum ratings                                | 13        |
| 3.2      | General parameters                                      | 13        |
| 3.3      | Power management and voltage regulator                  | 14        |
| 3.3.1    | Power management                                        | 14        |
| 3.3.2    | Power-on circuit and low supply voltage detector        | 14        |
| 3.3.3    | Voltage regulator                                       | 15        |
| 3.4      | FM - Section                                            | 16        |
| 3.4.1    | IMR and active balun                                    | 16        |
| 3.4.2    | FM AGC                                                  | 18        |
| 3.5      | AM - Section                                            | 21        |
| 3.5.1    | AM LNA                                                  | 21        |
| 3.5.2    | Switchable LPF 4 <sup>th</sup> order                    | 21        |
| 3.5.3    | IMR and active balun                                    | 22        |
| 3.5.4    | AM AGC                                                  | 24        |
| 3.6      | IF - Section                                            | 27        |
| 3.6.1    | IF-Amplifier                                            | 27        |
| 3.6.2    | IF-AGC                                                  | 29        |
| 3.6.3    | IF buffer amplifier                                     | 30        |
| 3.7      | Phase Locked Loop                                       | 30        |
| 3.7.1    | VCO                                                     | 31        |
| 3.7.2    | Reference oscillator / reference frequency input buffer | 32        |
| 3.7.3    | Divider                                                 | 32        |
| 3.7.4    | Phase frequency detector and charge pump                | 33        |
| 3.8      | Temperature sensor                                      | 33        |

|          |                                                         |           |
|----------|---------------------------------------------------------|-----------|
| 3.9      | D/A-converter .....                                     | 34        |
| 3.10     | A/D-converter .....                                     | 35        |
| 3.11     | GPIO - general purpose I/O interface pins .....         | 36        |
| 3.11.1   | Serial data interface .....                             | 36        |
| 3.11.2   | Communication using the I <sup>2</sup> C protocol ..... | 37        |
| 3.11.3   | Communication using the SPI protocol .....              | 38        |
| <b>4</b> | <b>Application information .....</b>                    | <b>40</b> |
| <b>5</b> | <b>Programming information .....</b>                    | <b>41</b> |
| 5.1      | Address organization .....                              | 41        |
| 5.2      | Data byte specification .....                           | 42        |
| 5.2.1    | Short_reg (0) .....                                     | 42        |
| 5.2.2    | ADCctrl (1) .....                                       | 43        |
| 5.2.3    | GPIO mode (2) .....                                     | 44        |
| 5.2.4    | AGC and mixer control (3) .....                         | 45        |
| 5.2.5    | Supply control (4) .....                                | 46        |
| 5.2.6    | Divider R MSB (5) .....                                 | 46        |
| 5.2.7    | IF AGC control (6) .....                                | 47        |
| 5.2.8    | FM AGC (7) .....                                        | 47        |
| 5.2.9    | AGC voltage threshold (8) .....                         | 48        |
| 5.2.10   | Mixer alignment 1 (9) .....                             | 48        |
| 5.2.11   | Mixer alignment 2 (10) .....                            | 49        |
| 5.2.12   | PLL control 1 (11) .....                                | 50        |
| 5.2.13   | PLL control 2 (12) .....                                | 50        |
| 5.2.14   | PLL test (13) .....                                     | 51        |
| 5.2.15   | Misc 1 (14) .....                                       | 51        |
| 5.2.16   | Misc 2 (15) .....                                       | 52        |
| 5.2.17   | AGC time constant settings (16 / 32) .....              | 53        |
| 5.2.18   | AMAGC control (17 / 33) .....                           | 54        |
| 5.2.19   | GPIO output level control (18 / 34) .....               | 54        |
| 5.2.20   | IF control (19 / 35) .....                              | 55        |
| 5.2.21   | VCO divider (V-divider) (20 / 36) .....                 | 55        |
| 5.2.22   | PLL main divider (N-divider) 1 (21 / 37) .....          | 56        |
| 5.2.23   | PLL main divider (N-divider) 2 (22 / 38) .....          | 56        |
| 5.2.24   | PLL main divider (N-divider) 3 (23 / 39) .....          | 56        |
| 5.2.25   | PLL Divider ratio calculation .....                     | 57        |

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|          |                                     |           |
|----------|-------------------------------------|-----------|
| 5.2.26   | Divider R LSB (24/40) .....         | 57        |
| 5.2.27   | Charge pump current (25 / 41) ..... | 57        |
| 5.2.28   | Tuning DAC 1 (26 / 42) .....        | 58        |
| 5.2.29   | Tuning DAC 2 (27 / 43) .....        | 58        |
| 5.2.30   | Different controls (28 / 44) .....  | 59        |
| 5.2.31   | AM filter adjust (29 / 45) .....    | 60        |
| 5.2.32   | Misc 3 (30 / 46) .....              | 61        |
| 5.2.33   | AD converter test (31 / 47) .....   | 61        |
| 5.2.34   | Read 1 (48) .....                   | 62        |
| 5.2.35   | Read 2 (49) .....                   | 62        |
| <br>     |                                     |           |
| <b>6</b> | <b>Package information .....</b>    | <b>63</b> |
| <br>     |                                     |           |
| <b>7</b> | <b>Revision history .....</b>       | <b>64</b> |

## List of tables

|           |                                                                                              |    |
|-----------|----------------------------------------------------------------------------------------------|----|
| Table 1.  | Device summary . . . . .                                                                     | 1  |
| Table 2.  | Pin function description . . . . .                                                           | 10 |
| Table 3.  | Absolute maximum ratings . . . . .                                                           | 13 |
| Table 4.  | General parameters electrical characteristics . . . . .                                      | 13 |
| Table 5.  | Voltage sag detection electrical characteristics . . . . .                                   | 15 |
| Table 6.  | Voltage regulator electrical characteristics . . . . .                                       | 15 |
| Table 7.  | IMR and active balun electrical characteristics . . . . .                                    | 16 |
| Table 8.  | FM-AGC electrical characteristics . . . . .                                                  | 19 |
| Table 9.  | AM LNA electrical characteristics . . . . .                                                  | 21 |
| Table 10. | Switchable LPF 4 <sup>th</sup> order electrical characteristics . . . . .                    | 21 |
| Table 11. | IMR and active balun electrical characteristics . . . . .                                    | 22 |
| Table 12. | AM-AGC electrical characteristics . . . . .                                                  | 25 |
| Table 13. | IF-Amplifier with anti aliasing filter and ADC buffer electrical characteristics . . . . .   | 27 |
| Table 14. | IF-AGC electrical characteristics . . . . .                                                  | 29 |
| Table 15. | IF buffer amplifier electrical characteristics . . . . .                                     | 30 |
| Table 16. | Phase Locked Loop electrical characteristics . . . . .                                       | 30 |
| Table 17. | VCO electrical characteristics . . . . .                                                     | 31 |
| Table 18. | Reference oscillator / reference frequency input buffer electrical characteristics . . . . . | 32 |
| Table 19. | Divider electrical characteristics . . . . .                                                 | 32 |
| Table 20. | Phase frequency detector and charge pump electrical characteristics . . . . .                | 33 |
| Table 21. | Temperature sensor electrical characteristics . . . . .                                      | 33 |
| Table 22. | D/A-converter electrical characteristics . . . . .                                           | 34 |
| Table 23. | A/D-converter . . . . .                                                                      | 35 |
| Table 24. | GPIO - general purpose I/O interface pins electrical characteristics . . . . .               | 36 |
| Table 25. | GPIO test conditions . . . . .                                                               | 36 |
| Table 26. | Pin configuration of the serial data interface . . . . .                                     | 37 |
| Table 27. | I <sup>2</sup> C addresses . . . . .                                                         | 38 |
| Table 28. | Communication using the SPI protocol electrical characteristics . . . . .                    | 38 |
| Table 29. | Short_reg (0) . . . . .                                                                      | 42 |
| Table 30. | ADCctrl (1) . . . . .                                                                        | 43 |
| Table 31. | GPIO mode (2) . . . . .                                                                      | 44 |
| Table 32. | AGC and mixer control (3) . . . . .                                                          | 45 |
| Table 33. | Supply control (4) . . . . .                                                                 | 46 |
| Table 34. | Divider R MSB (5) . . . . .                                                                  | 46 |
| Table 35. | IF AGC control (6) . . . . .                                                                 | 47 |
| Table 36. | FM AGC (7) . . . . .                                                                         | 47 |
| Table 37. | AGC voltage threshold (8) . . . . .                                                          | 48 |
| Table 38. | Mixer alignment 1 (9) . . . . .                                                              | 48 |
| Table 39. | Mixer alignment 2 (10) . . . . .                                                             | 49 |
| Table 40. | PLL control 1 (11) . . . . .                                                                 | 50 |
| Table 41. | PLL control 2 (12) . . . . .                                                                 | 50 |
| Table 42. | PLL test (13) . . . . .                                                                      | 51 |
| Table 43. | Misc 1 (14) . . . . .                                                                        | 51 |
| Table 44. | Misc 2 (15) . . . . .                                                                        | 52 |
| Table 45. | AGC time constant settings (16 / 32) . . . . .                                               | 53 |
| Table 46. | AMAGC control (17 / 33) . . . . .                                                            | 54 |
| Table 47. | GPIO output level control (18 / 34) . . . . .                                                | 54 |
| Table 48. | IF control (19 / 35) . . . . .                                                               | 55 |

|           |                                                    |    |
|-----------|----------------------------------------------------|----|
| Table 49. | VCO divider (V-divider) (20 / 36) . . . . .        | 55 |
| Table 50. | PLL main divider (N-divider) 1 (21 / 37) . . . . . | 56 |
| Table 51. | PLL main divider (N-divider) 2 (22 / 38) . . . . . | 56 |
| Table 52. | PLL main divider (N-divider) 3 (23 / 39) . . . . . | 56 |
| Table 53. | PLL Divider ratio calculation . . . . .            | 57 |
| Table 54. | Divider R LSB (24/40) . . . . .                    | 57 |
| Table 55. | Charge pump current (25 / 41) . . . . .            | 57 |
| Table 56. | Tuning DAC 1 (26 / 42) . . . . .                   | 58 |
| Table 57. | Tuning DAC 2 (27 / 43) . . . . .                   | 58 |
| Table 58. | Different controls (28 / 44) . . . . .             | 59 |
| Table 59. | AM filter adjust (29 / 45) . . . . .               | 60 |
| Table 60. | Misc 3 (30 / 46) . . . . .                         | 61 |
| Table 61. | AD converter test (31 / 47) . . . . .              | 61 |
| Table 62. | Read 1 (48) . . . . .                              | 62 |
| Table 63. | Read 2 (49) . . . . .                              | 62 |
| Table 64. | Document revision history . . . . .                | 64 |

## List of figures

|            |                                                                                |    |
|------------|--------------------------------------------------------------------------------|----|
| Figure 1.  | Block diagram . . . . .                                                        | 9  |
| Figure 2.  | Pinout diagram (top view) . . . . .                                            | 10 |
| Figure 3.  | FM AGC - Controlled current output mode 1 . . . . .                            | 18 |
| Figure 4.  | FM AGC - Controlled current output mode 2 . . . . .                            | 18 |
| Figure 5.  | FM AGC - Controlled Voltage / current output . . . . .                         | 19 |
| Figure 6.  | AM AGC - Controlled current output mode 1 . . . . .                            | 24 |
| Figure 7.  | AM AGC - Voltage and current mode with hand-over . . . . .                     | 24 |
| Figure 8.  | Application information . . . . .                                              | 40 |
| Figure 9.  | Address organization . . . . .                                                 | 41 |
| Figure 10. | LQFP64 (10x10x1.4mm) exposed pad down mechanical data and package dimensions . | 63 |

# 1 Product description

## 1.1 Summary

The TDA7528 is a front-end module for use in car radio receivers on the 50 kHz - 108 MHz and 161 MHz - 163 MHz frequency bands. Its field of use includes all the current radio broadcast services worldwide on long, medium and short wave, CB radio, FM radio on the OIRT, Japanese and ITU frequency bands and the American weather band. Both analogue AM and FM and digital standards such as DRM and HD radio (IBOC) can be handled.

The receiver is designed as a single super-heterodyne with an intermediate frequency of 10.7 MHz. The IF signal is digitized, filtered and demodulated in the appropriate backend IC. The combination of two independently-operating front-ends with the backend makes phase diversity operation possible or the simultaneous reception of two freely-selectable frequencies with any combination of types of demodulation.

The TDA7528 IMR mixer has separate input- and output-stages for AM frequency bands up to 30 MHz (narrowband services) and for FM frequencies above 30 MHz (broadband signals).

As an option, the AM path can be operated with an integrated preamplifier stage and an integrated low-pass filter to reduce interfering input signals on the IF and image frequencies. The mixer has two FM inputs with different properties. The more sensitive (lower noise) input is intended for the use of a passive pre-selection stage and the high level, advanced IP3 input for an active preamplifier stage. The mixer outputs have a single ended low impedance design to drive one or two IF filters with different bandwidths. A switchable gain IF amplifier, independent IF AGC and an integrated anti-aliasing stage drive the IF A/D converter of the backend. Programmable RF AGCs to actuate adjustable preamplifier stages and two D/A converters for tuning external filter stages complete the reception path.

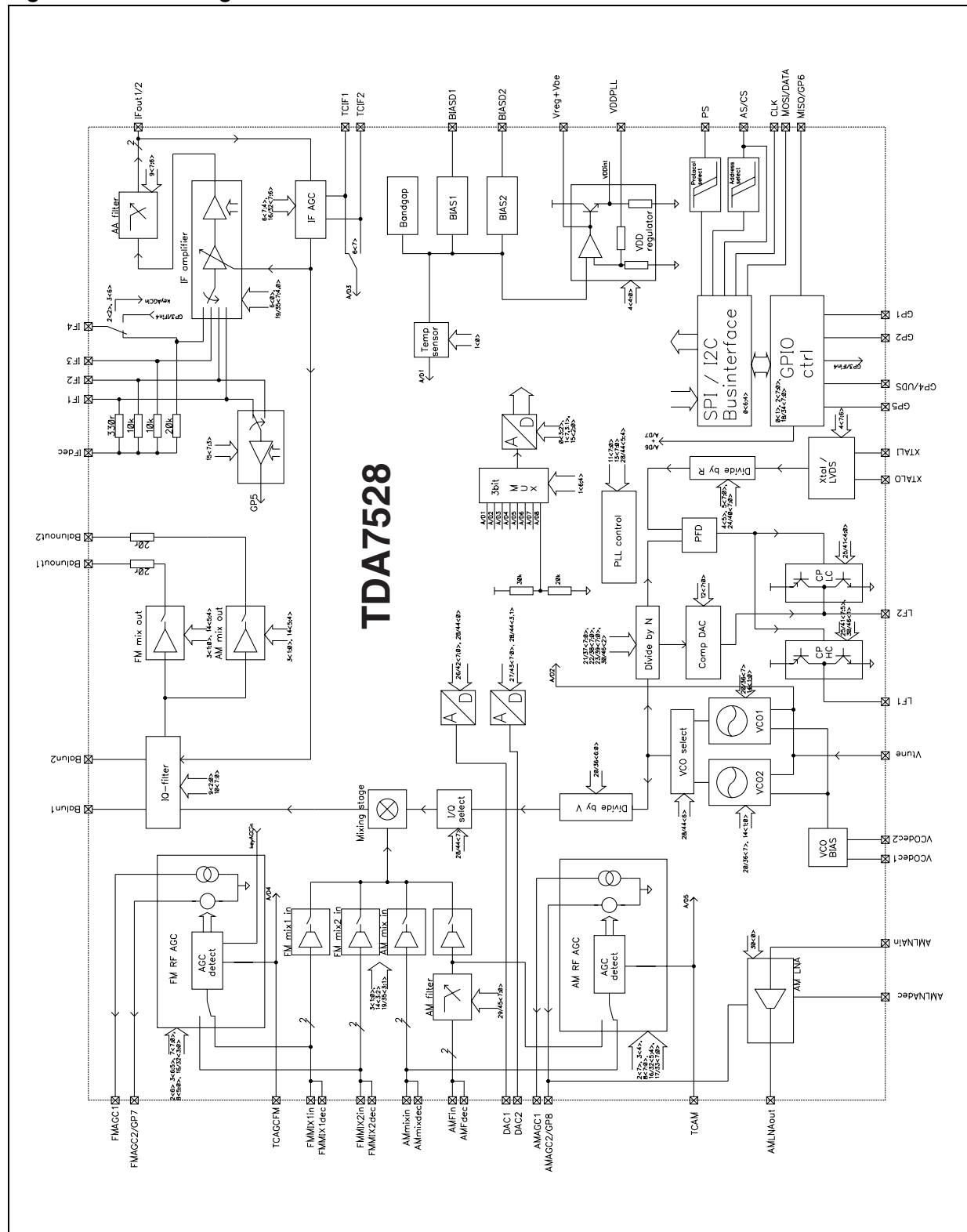
Two fully-integrated VCOs are included in the TDA7528, oscillating in a range around 3.7 GHz and 4.7 GHz respectively. The output signal of the selected VCO drives a programmable divider generating the LO signal for the mixer stage. The PLL, integrated with the exception of the loop filter, facilitates reception on all the above-mentioned frequencies, rapid frequency changes in the standard tuning steps of 50 kHz for FM, 9 or 10 kHz for LW and MW and 5 kHz for SW. The smallest available tuning steps are 12.5 kHz for FM and 1 kHz for all AM bands.

The TDA7528 is controlled by a serial command interface, switchable between SPI and I<sup>2</sup>C protocol. The external reference source is typically 74.1 MHz. However, the TDA7528 also has its own reference oscillator.

All the necessary calibration steps can be carried out electronically during production. An integrated temperature sensor facilitates the adaptation of various parameters during operation, like IF gain or AGC threshold.

## 1.2 Block diagram

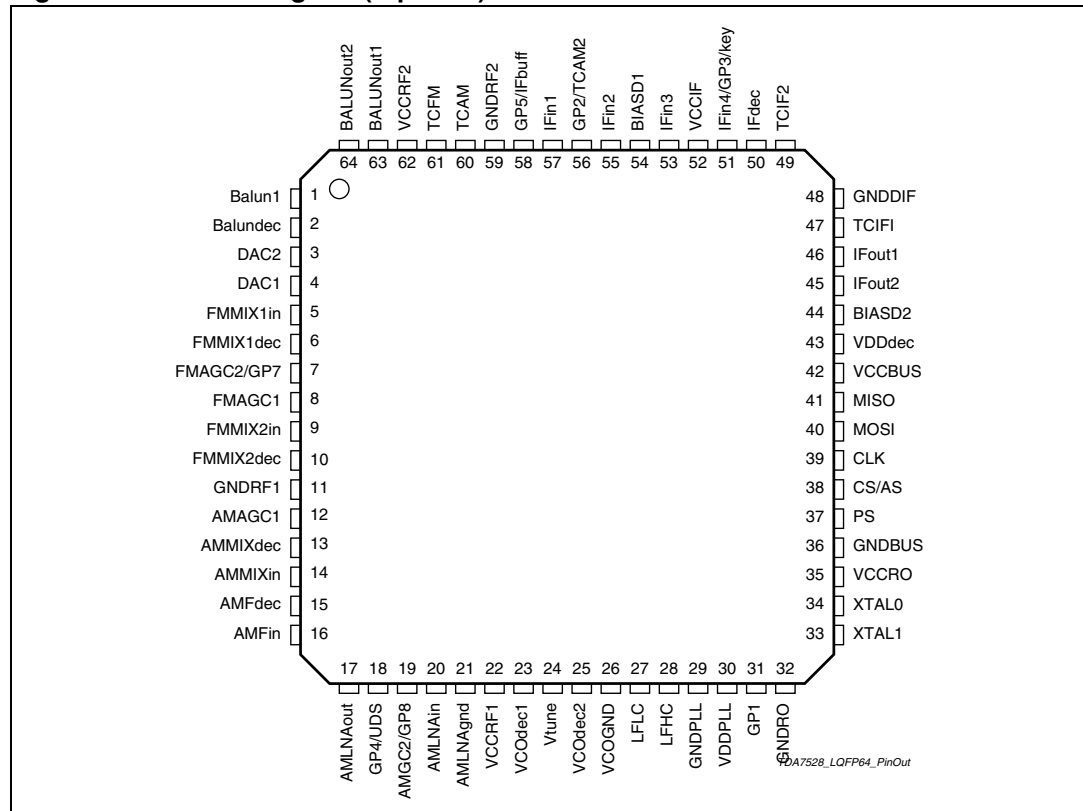
**Figure 1. Block diagram**



## 2 Pin description

### 2.1 Pin connection

Figure 2. Pinout diagram (top view)



### 2.2 Pin description

Table 2. Pin function description

| Pin # | Pin name   | Description                                    |
|-------|------------|------------------------------------------------|
| 1     | BALUN1     | Active balun input 1                           |
| 2     | BALUNdec   | Active balun input 2 (decoupling)              |
| 3     | DAC2       | Tuning DAC 2 output                            |
| 4     | DAC1       | Tuning DAC 1 output                            |
| 5     | FMMIX1in   | FM mixer input – high gain stage = mode 1      |
| 6     | FMMIX1dec  | FM mixer decouple                              |
| 7     | FMAGC2/GP7 | FM AGC voltage output / alternative GP7 output |
| 8     | FMAGC1     | FM AGC current output for PIN diode            |
| 9     | FMMIX2in   | FM Mixer input – low gain stage = mode2        |

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

| Pin # | Pin name   | Description                                    |
|-------|------------|------------------------------------------------|
| 10    | FMMIX2dec  | FM Mixer decouple                              |
| 11    | GNDRF1     | GND RF1 section                                |
| 12    | AMAGC1     | AMAGC PIN diode driver output                  |
| 13    | AMMIXdec   | AM mixer decouple                              |
| 14    | AMMIXin    | AM mixer input                                 |
| 15    | AMFdec     | Decoupling of AM filter                        |
| 16    | AMFin      | Input of AM filter                             |
| 17    | AMLNAout   | AM LNA output                                  |
| 18    | GP4/UDS    | GPIO 4 / UDS input                             |
| 19    | AMAGC2/GP8 | AM AGC voltage output / alternative GP8 output |
| 20    | AMLNAin    | AM LNA input                                   |
| 21    | AMLNAGND   | AM LNA Ground                                  |
| 22    | VCCRF1     | Supply RF1 section                             |
| 23    | VCOdec1    | BIAS decouple for VCO                          |
| 24    | Vtune      | VCO tuning voltage                             |
| 25    | VCOdec2    | BIAS decouple for VCO                          |
| 26    | GNDVCO     | VCO Ground                                     |
| 27    | LFLC       | Loop filter low current output                 |
| 28    | LFHC       | Loop filter high current output                |
| 29    | GNDPLL     | PLL Ground                                     |
| 30    | VDDPLL     | Supply PLL                                     |
| 31    | GP1        | GPIO 1                                         |
| 32    | GNDRO      | Ground PLL digital part                        |
| 33    | XTALI      | Reference oscillator input                     |
| 34    | XTALO      | Reference oscillator output                    |
| 35    | VCCRO      | Supply PLL digital part                        |
| 36    | BUSGND     | BUS interface Ground                           |
| 37    | PS         | Protocol Select                                |
| 38    | CS/AS      | Chip select / Address select                   |
| 39    | CLK        | SPI / I2C clock                                |
| 40    | MOSI       | SPI data input / I2C Data                      |
| 41    | MISO       | SPI data output / GP6                          |
| 42    | VCCBUS     | Supply of BUS interface                        |
| 43    | VDDdec     | Decouple of internal 3.3V (=3,3V + Vbe)        |
| 44    | BIASD2     | Decoupling for biasing                         |

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

| Pin # | Pin name    | Description                                          |
|-------|-------------|------------------------------------------------------|
| 45    | IFout2      | Differential IF output 2                             |
| 46    | IFout1      | Differential IF output 1                             |
| 47    | TCIF1       | time constant IF AGC for AM                          |
| 48    | GNDIF       | ground IF section                                    |
| 49    | TCIF2       | time constant IF AGC for FM                          |
| 50    | IFdec       | Decouple of IF amplifier                             |
| 51    | IFin4 / GP3 | IF input 4 (= AM IBOC input) / GPIO 3                |
| 52    | VCCIF       | Supply IF section                                    |
| 53    | IFin3       | IF input 3 (= AM analog input)                       |
| 54    | BIASD1      | Decoupling for biasing                               |
| 55    | IFin2       | IF input 2 (= FM IBOC input)                         |
| 56    | GP2/TCAM2   | GPIO 2 / input for 2nd order time constant of AM AGC |
| 57    | IFin1       | IF input 1 (= FM analog input)                       |
| 58    | GP5/IFbuff  | GPIO 5 / IF buffer amplifier output                  |
| 59    | GNDRF2      | GND RF2 section = active balun GND                   |
| 60    | TCAM        | AM AGC time constant                                 |
| 61    | TCFM        | FM AGC time constant                                 |
| 62    | VCCRF2      | Supply voltage RF2 section                           |
| 63    | Balunout1   | Active balun output 1 = FM output                    |
| 64    | Balunout2   | Active balun output 2 = AM output                    |

## 3 Electrical characteristics

### 3.1 Absolute maximum ratings

**Table 3. Absolute maximum ratings**

| Symbol    | Parameter                 | Value      | Unit |
|-----------|---------------------------|------------|------|
| $V_{CC}$  | Supply voltage            | 5.5        | V    |
| $V_{DD}$  | Supply voltage            | 3.6        | V    |
| $T_{amb}$ | Ambient temperature range | -40 to 125 | °C   |
| $T_s$     | Storage temperature       | -55 to 150 | °C   |
| $T_j$     | Max. junction temperature | 150        | °C   |

Operating temperature and supply voltage range: -40 °C to 105 °C; 4.7 V to 5.35 V.  
 All specification parameter are fulfilled in this temperature and supply voltage range, unless otherwise specified. Typical values reflect average measurement at  $T_{amb} = 25$  °C,  $V_{CC} = 5.0$  V and  $V_{DD} = 3.3$  V.

### 3.2 General parameters

**Table 4. General parameters electrical characteristics**

| Symbol        | Parameter                             | Test conditions                                        | Min. | Typ | Max  | Unit |
|---------------|---------------------------------------|--------------------------------------------------------|------|-----|------|------|
| $V_{CC}$      | 5V supply voltage                     | Full performance                                       | 4.7  | 5   | 5.35 | V    |
|               |                                       | Fully functional but with reduced performance          | 4.6  | -   | 4.7  | V    |
| $V_{DD}$      | 3.3V supply voltage                   | When used with external 3.3 V power supply regulator   | 3.1  | 3.3 | 3.5  | V    |
|               | $V_{CC}$ slew rate range              | -                                                      | 0.01 | -   | 1000 | V/ms |
| $I_{CC}$      | Supply current @5V typ                | FM typical application                                 | -    | 160 | 200  | mA   |
|               |                                       | AM external pre-stage                                  | -    | 160 | 200  | mA   |
|               |                                       | AM integrated pre-stage                                | -    | 175 | 215  | mA   |
| $I_{CCmax}$   | Max supply current                    | FM, max application, (FM typ + Xtal, IF-buffer, AMAGC) | -    | 170 | 215  | mA   |
| $I_{CC\_pwd}$ | Supply current @5V in power down mode | -                                                      | -    | 7   | 11   | mA   |
| $P_{max}$     | Power dissipation                     | FM typical application                                 | -    | 650 | 950  | mW   |
|               |                                       | AM external pre-stage                                  | -    | 650 | 950  | mW   |
|               |                                       | AM integrated pre-stage                                | -    | 710 | 1015 | mW   |
| $T_{amb}$     | Ambient temperature range             | Full performance, unless otherwise specified           | -40  | -   | 105  | °C   |
| $T_{extend}$  | Extended ambient temperature range    | Signal path functional with reduced performance        | 105  | -   | 125  | °C   |

### 3.3 Power management and voltage regulator

The TDA7528 has a single 5 V supply. The 3.3 V supply for the VCO must be derived from an external NPN transistor controlled by the internal voltage regulator. It is also possible to use an external 3.3 V regulator. In this case, special care has to be taken on this 3.3V .

#### 3.3.1 Power management

The TDA7528 detects whether all the voltages are high enough and stable when the operating power supply is applied. The power-on reset is tripped and all the control registers are set to "low" if this condition is not met.

As long as the voltages remain within the permissible range, the SPI/I<sup>2</sup>C interface is active (in the I<sup>2</sup>C mode this can be detected by the  $\mu$ P through the acknowledge signal on every communication with the bus master).

The SPI-/I<sup>2</sup>C interface is in power-on mode when the operating voltage is applied to the TDA7528.

The following function groups can be switched on/off via SPI/I<sup>2</sup>C:

- PLL {divider R, N and V, PFD, charge pump, VCO1 (3,7 GHz-VCO) or VCO2 (4,7 GHz-VCO), Reference-Oscillator or LVDS input buffer}
- FM/AM-mixer and active balun, FM-AGC
- D/A-converter\_1
- D/A-converter\_2
- AM-LNA
- AM-low pass filter
- AM-AGC
- IF-section {IF-amplifier, anti-aliasing-filter, IF-AGC}
- GPIO
- temperature-sensor,
- Sensor ADC

#### 3.3.2 Power-on circuit and low supply voltage detector

##### Power-on circuit:

The power-on circuit produces a reset whenever one of the following voltages is below its POR level. (BIASD1, BIASD2 < 1.2 V; VDDPLL < 2.4V; VCCIF < 3.8 V)

##### Low supply voltage detector:

The "PWR\_STABLE\_read" status bit has the value "0" after power on. This bit is set to "1" by an SPI/I<sup>2</sup>C write command from the microcontroller in initialization communication to the "PWR\_STABLE\_write" bit. The microcontroller cannot reset the "PWR\_STABLE\_read" bit. A "0" transmitted in the "PWR\_STABLE\_write" bit has no effect.

If the power supply falls below the programmed threshold all registers are set to their power-on default, including that the "PWR\_STABLE\_read" bit is set to "0". By this the microcontroller can verify at any time whether a critical drop in voltage (value "0") has taken place since the last TDA7528 read out of this bit. The threshold voltage can be calibrated

indirect by measuring the DAC1 (9 bit) output voltage for DAC1=0x200 or the DAC2 (8 bit) output voltage for DAC2=0x100).

The PWR\_STABLE functionality can be switched on/off. The default value is the switched off mode.

**Table 5. Voltage sag detection electrical characteristics**

| Symbol       | Parameter                     | Test conditions                  | Min. | Typ | Max | Unit    |
|--------------|-------------------------------|----------------------------------|------|-----|-----|---------|
| $V_{STHmin}$ | Min. supply voltage threshold | -40 to 150 °C, $T_j \leq 150$ °C | 4.1  | 4.3 | 4.5 | V       |
| $V_{STHmax}$ | Max supply voltage threshold  | -                                | 4.4  | 4.6 | 4.9 | V       |
| -            | Step size                     | -                                | -    | 100 | -   | mV      |
| $t_c$        | Time constant                 | -                                | -    | 1   | -   | $\mu$ s |

### 3.3.3 Voltage regulator

The internal voltage regulator drives the external transistor for the 3.3V supply of the VCO and PLL. The 3.3 V voltage regulator for the bus interface and the reference oscillator is fully integrated.

**Table 6. Voltage regulator electrical characteristics**

| Symbol   | Parameter                    | Test conditions                                                   | Min. | Typ | Max | Unit |
|----------|------------------------------|-------------------------------------------------------------------|------|-----|-----|------|
| $V_{DD}$ | 3.3V supply voltage          | Internal voltage regulator with external power transistor         | 3.1  | 3.3 | 3.5 | V    |
| $I_{DD}$ | current of external $V_{DD}$ | Current through external transistor or from external 3.3 V supply | -    | 60  | 80  | mA   |

When an external 3.3 V supply is used for the VCO and PLL supply, special care has to be taken on the supply voltages during the ramp-up phase:

- the 3.3 V supply must never be higher than the 5 V supply;
- the difference between 5 V and 3.3 V must never exceed 3.6 V.

The second prerequisite is automatically met using a 3.3 V Z-diode between the 5 V and the 3.3 V supplies.

### 3.4 FM - Section

#### 3.4.1 IMR and active balun

The IMR mixer has two software-selectable FM inputs (referred to as mode 1 and mode 2). These inputs are implemented with different gains, noise figures, IIP3, maximum input signal.

There are two single ended outputs of the IMR mixer. One is dedicated to FM (Balunout1) and the other to AM (Balunout2). It is not recommended to use both outputs in parallel.

**Table 7. IMR and active balun electrical characteristics**

(All parameter are referred to Balunout1, unless otherwise specified)

| Symbol            | Parameter                                                  | Test condition                                                                                                | Min.       | Typ        | Max                              | Units   |
|-------------------|------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|------------|------------|----------------------------------|---------|
| $G_{mix1}$        | Gain vs. Balunout1                                         | Mode 1 (unloaded gain)                                                                                        | 20         | 22         | 24                               | dB      |
| $G_{mix2}$        | Gain vs. Balunout1                                         | Mode 2 (unloaded gain)                                                                                        | 13         | 15         | 17                               |         |
| $G_{mix1}$        | Gain vs. Balunout2                                         | Mode 1 (unloaded gain)                                                                                        | 16         | 18         | 20                               | dB      |
| $G_{mix2}$        | Gain vs. Balunout2                                         | Mode 2 (unloaded gain)                                                                                        | 9          | 11         | 13                               |         |
| -                 | Absolute gain error                                        | @ 100 MHz @ 25°C                                                                                              | -          | -          | ± 1.0                            | dB      |
| -                 | Gain error vs. frequency                                   | Freq. range @ 25°C<br>47,0 to 74,0 MHz<br>76,0 to 90,0 MHz<br>87,5 to 108,0 MHz<br>30,0 to 170,0 MHz          | -          | -          | ± 0,5<br>± 0,5<br>± 0,5<br>± 2,0 | dB      |
| -                 | Gain error vs. temperature                                 | -40 °C to 105 °C                                                                                              | -          | -          | ± 2,0                            | dB      |
| -                 | Gain attenuation range                                     | Controlled by IF-AGC                                                                                          | 17.5       | 20         | -                                | dB      |
| -                 | Input impedance                                            | Mode 1<br>Mode 2                                                                                              | 5<br>5     | -          | -                                | kΩ      |
| -                 | Input resistance                                           | Mode 1<br>Mode 2                                                                                              | 30<br>9.5  | 50<br>12.5 | 19.5                             | kΩ      |
| -                 | Output impedance                                           | Active balun                                                                                                  | 15         | 20         | 30                               | Ω       |
| -                 | External load                                              | Full current: reg14[5] = 0<br>Red. current: reg14[5] = 1                                                      | 320<br>600 | -          | -                                | Ω<br>Ω  |
| $V_{out\_max}$    | Max. output voltage                                        | 1dB below 1dB compression point                                                                               | 121        | 123        | -                                | dBμV    |
| $V_{in\_max}$     | Max. input voltage                                         | Mode 1<br>Mode 2<br>1dB below 1dB compression point                                                           | 100<br>108 | -          | -                                | dBμV    |
| $V_{noise}^{(1)}$ | Input noise voltage – mode1<br>Input noise voltage – mode2 | Rsource=1.5 kΩ, noiseless<br>in 65 MHz-170 MHz range<br>Rsource = 800 Ω, noiseless<br>in 65 MHz-170 MHz range | -          | 3.1<br>5   | 3.7<br>6                         | nV/√ Hz |
| $d_{noise}$       | vnoise*atten*dnoise                                        | AGC noise behavior<br>@ 6 dB attenuation                                                                      | -          | 6          | -                                | dB      |

**Table 7. IMR and active balun electrical characteristics (continued)**

(All parameter are referred to Balunout1, unless otherwise specified)

| Symbol              | Parameter                                                        | Test condition                                                                                            | Min.       | Typ         | Max      | Units      |
|---------------------|------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|------------|-------------|----------|------------|
| IIP3 <sup>(1)</sup> | 3 <sup>rd</sup> order intercept point<br>Reg9[5:4]=00            | Mode 1<br>up to Vin/tone = 90 dB $\mu$ V                                                                  | 123        | 125         |          | dB $\mu$ V |
|                     |                                                                  | Mode 2<br>up to Vin/tone = 98 dB $\mu$ V                                                                  | 126        | 133         | -        |            |
|                     |                                                                  | up to 95 °C junction<br>temperature                                                                       | 130        |             |          |            |
|                     | 3 <sup>rd</sup> order intercept point in<br>reduced current mode | Mode 1; reg14[3:2]=01                                                                                     | -          | 120         | -        | dB $\mu$ V |
|                     |                                                                  | Mode 2; reg14[3:2]=01<br>60 °C up to 125 °C junction<br>temperature                                       | 130        | 132         | -        |            |
|                     |                                                                  | Mode 1; reg14[3:2]=10                                                                                     | -          | 117         | -        |            |
|                     |                                                                  | Mode 2; reg14[3:2]=10<br>junction temperature > 90 °C                                                     | 129        | 130         | -        |            |
| IIP2 <sup>(1)</sup> | 2 <sup>nd</sup> order intercept point                            | Mode 1<br>Mode 2                                                                                          | 144<br>157 | -           | -        | dB $\mu$ V |
| IFattn              | IF- output attenuation<br>(without external circuitry)           | @ 26.35 MHz<br>@ 100 MHz                                                                                  | 1<br>9     | 2           | -        | dB         |
| -                   | IF rejection                                                     | -                                                                                                         | 38         | -           | -        | dB         |
| V <sub>LO_IN</sub>  | LO signal @ mixer input                                          | R <sub>source</sub> = 1.5 k $\Omega$<br>@ fundamental LO freq.<br>@ LO harmonics                          | -          | -           | 10<br>40 | dB $\mu$ V |
| V <sub>LO_OUT</sub> | LO signal @ balun output                                         | Incl. LC-tank with Q=2,<br>R <sub>load</sub> = 1.0 k $\Omega$<br>@ fundamental LO freq.<br>@ LO harmonics | -          | -           | 66<br>60 | dB $\mu$ V |
| I <sub>QG</sub>     | I/Q gain adjust<br>Min.<br>Max.                                  | 4bit                                                                                                      | -          | -0.7<br>0.7 | -        | dB         |
| -                   | gain step                                                        | -                                                                                                         | -          | 0.1         | -        | dB         |
| P <sub>IQ</sub>     | I/Q phase adjust<br>Min.<br>Max.                                 | 4bit                                                                                                      | -          | -1.2<br>1.2 | -        | °          |
| -                   | Phase step                                                       | -                                                                                                         | -          | 0.2         | -        | °          |
| -                   | Center frequency adjust<br>Min.<br>Max.                          | 3bit                                                                                                      | -          | -2.4<br>2.4 | -        | MHz        |
| -                   | Frequency step                                                   | -                                                                                                         | -          | 0.6         | -        | MHz        |
| IRR                 | Image rejection ratio                                            | without gain/phase adjust                                                                                 | 30         | 45          | -        | dB         |
|                     |                                                                  | with freq/gain adjust @ 25°C                                                                              | 45         | -           | -        |            |
|                     |                                                                  | with freq/gain/phase adjust<br>vs. complete temp. range                                                   | 40         | -           | -        |            |

1. Parameter not guaranteed by production test

### 3.4.2 FM AGC

The time constant of the FM AGC is defined by an external capacitor and the programmable internal currents (details given in the [Table 8](#)). The currents can be selected independently for AGC attack and decay. By this a symmetrical behavior rather than a 2...250 times faster attack behavior can be programmed.

Control behavior:

The FM-RF-AGC is realized with two output pins which control the gain of the corresponding pre-stage.

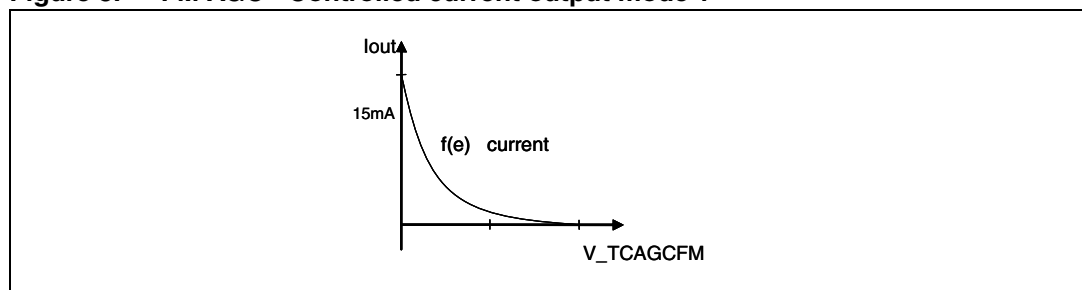
The control behavior can be programmed to the following modes:

1. **Controlled current output mode 1**

data byte FMAGC[3:0] = 1000

positive current  $I = f(e)$ : after reaching the AGC threshold voltage the current output delivers a current  $I = f(e)$  up to -15 mA in a voltage range from 0.2V up to  $V_{CC}-1.5$  V.

**Figure 3. FM AGC - Controlled current output mode 1**

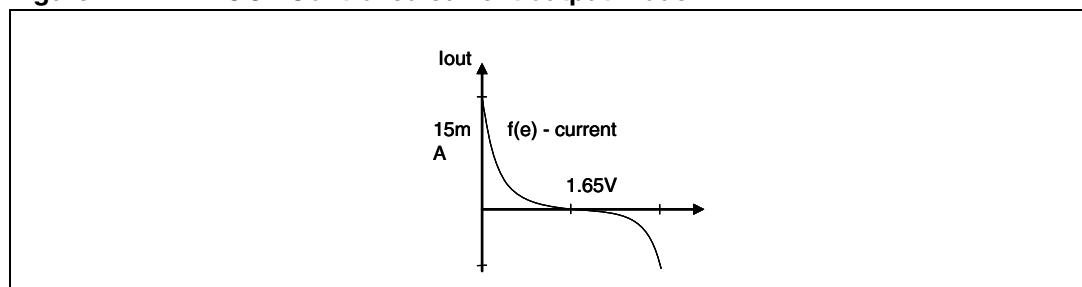


2. **Controlled current output mode 2**

data byte FMAGC[3:0] = 1100

Below the AGC threshold voltage the AGC output sinks a constant current of 5 mA. When the RF input level crosses the AGC threshold voltage the current is reduced down to 0mA with a quasi-log. behavior. At half control voltage the current becomes positive and reaches up to -15 mA following an exponential function.

**Figure 4. FM AGC - Controlled current output mode 2**



3. **Constant current mode**

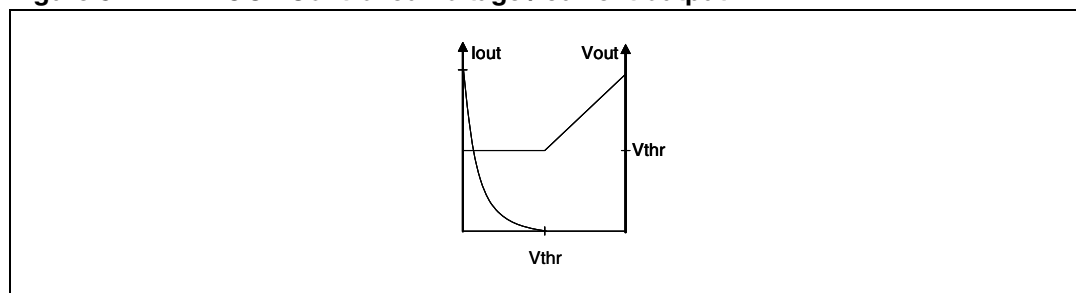
data byte FMAGC[3:0] = 0100

The output current can be set to 2 mA source current. The AGC detector is in power-down mode and only the pin diode driver is active.

4. **Controlled Voltage / current output**

data byte FMAGC[3:0] = 1011

voltage and current mode with hand-over: the  $V_{thr}$  level is programmable in the range of 0.2 V to 2.6 V.

**Figure 5. FM AGC - Controlled Voltage / current output****5. Calibration mode**

data byte FMAGC[3:0] = 0010

calibration mode for voltage output: The voltage  $V_{thr}$  can be switched directly to the voltage output pin.

All other possible bit combinations of data byte FMAGC[3:0] are not recommended.

The voltage output can be configured as GPO.

The FMAGC2 output (voltage output) is short-circuit protected by a current limiter. The FMAGC1 output (current output) needs an external resistor for current limitation. The current output is voltage-tolerant up to  $V_{CC}$ , the voltage output up to  $V_{DD}$ .

The microcontroller can read the voltage at the AGC capacitor via the serial control interface. On request of the microcontroller the measurement is done by applying the time constant capacitor voltage to the central ADC (specified in chapter 3.10) and gives information to calculate the AGC-attenuation.

The FM AGC system is controlled by a peak detector.

The Key AGC function is controlled by a D/A converter in the backend.

**Table 8. FM-AGC electrical characteristics**

| Symbol | Parameter                                                                                       | Test condition                                                                          | Min. | Typ   | Max | Units      |
|--------|-------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|------|-------|-----|------------|
| Lthr   | Threshold RF level<br>Min. Threshold                                                            | Referred to mixer input                                                                 | -    | -     | -   | dB $\mu$ V |
|        |                                                                                                 | Mode 1 - high gain mixer                                                                | -    | 86    | -   |            |
|        |                                                                                                 | Mode 2 – low gain mixer                                                                 | -    | 92    | -   |            |
|        | Max Threshold                                                                                   | Mode 1 - high gain mixer                                                                | -    | 100   | -   |            |
|        |                                                                                                 | Mode 2 – low gain mixer                                                                 | -    | 106   | -   |            |
| -      | Threshold steps                                                                                 | 4 bit control                                                                           | 0.5  | 1     | 1.5 | dB         |
| -      | Threshold error                                                                                 | 30 to 170 MHz @ 25 °C                                                                   | -1.5 | -     | 1,5 | dB         |
| -      | Total threshold error                                                                           | 30.0 to 170.0 MHz                                                                       | -3   | -     | 3   | dB         |
| -      | Temperature behavior of AGC thresholds                                                          | -                                                                                       | -    | 0.011 | -   | dB/°C      |
| -      | Frequency range                                                                                 | -                                                                                       | 30   | -     | 170 | MHz        |
| -      | Pin diode source current<br>( $I \approx -1.5 \text{ mA} * (\exp(V_{DD} - V_{AGCTC}) - 1)$ )    | $V_{AGCTC} < 1 \text{ V}$<br>(due to exponential behavior,<br>external resistor needed) | -    | -     | -10 | mA         |
| -      | Pin diode sink current<br>( $I \approx 1 \text{ mA} * (\exp(V_{AGCTC} - 1.65 \text{ V}) - 1)$ ) | $V_{AGCTC} = V_{DD}$<br>(due to exponential behavior,<br>external resistor needed)      | 3    | -     | -   | mA         |

Table 8. FM-AGC electrical characteristics (continued)

| Symbol         | Parameter                                                  | Test condition                                                                      | Min.              | Typ               | Max                | Units   |
|----------------|------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------|-------------------|--------------------|---------|
| -              | Pin diode source current in constant current mode          | -                                                                                   | -                 | -2                | -1                 | mA      |
| -              | Min. voltage                                               | AGC control pin 1<br>@ positive current mode<br>@ pos/neg current mode              | -                 | -                 | 0.2<br>0.4         | V       |
| -              | Max. voltage                                               | AGC control pin 1                                                                   | $V_{CC}-1.5$      | $V_{CC}-1.3$      | -                  | V       |
| -              | Max. source current                                        | AGC control pin 2;<br>voltage output                                                | 1                 | -                 | -                  | mA      |
| -              | Min. sink current                                          | AGC control pin 2;<br>voltage output                                                | -                 | -100              | -                  | $\mu$ A |
| -              | Max. output voltage in analog voltage mode (follower mode) | AGC control pin 2<br>@ $I_{load} = 1$ mA                                            | $V_{DD}-0.3$      | -                 | $V_{DD}$           | V       |
| -              | Min. output voltage in analog voltage mode                 | AGC control pin 2<br>@ $I_{load} = -50$ $\mu$ A                                     | -                 | -                 | 1                  | V       |
| $V_{thr\_min}$ | $V_{thr\_min}$                                             | -                                                                                   | 0.1               | 0.2               | 0.3                | V       |
| $V_{thr\_max}$ | $V_{thr\_max}$                                             | -                                                                                   | 2.4               | 2.6               | 2.8                | V       |
| -              | Step size of $V_{thr}$                                     | 6bit                                                                                | -                 | 40                | -                  | mV      |
| DNL            | nonlinearity of $V_{thr}$                                  | -                                                                                   | -0.5              |                   | 0.5                | LSB     |
| -              | I attack for 6dB control error                             | Mode A1<br>Mode A2<br>Mode A3                                                       | 30<br>150<br>0.75 | 50<br>250<br>1.25 | 80<br>400<br>2.0   | $\mu$ A |
| -              | I decay max                                                | Mode D1<br>Mode D2<br>Mode D3                                                       | -6<br>-30<br>-150 | -4<br>-20<br>-100 | -2.5<br>-12<br>-60 | $\mu$ A |
| -              | Typical AGC time constant for attack <sup>(1)</sup>        | $C_{AGCTC} = 1$ $\mu$ F, mode A2<br>AGC conductance versus<br>$V_{AGCTC} = 20$ dB/V | -                 | 0.5               | -                  | ms      |
| -              | Typical AGC time constant for decay <sup>(1)</sup>         | $C_{AGCTC} = 1$ $\mu$ F, mode D2<br>AGC conductance versus<br>$V_{AGCTC} = 20$ dB/V | -                 | 15                | -                  | ms      |
| -              | Threshold shift keyed AGC                                  | Control input range = 0.2 to 1 V                                                    | -                 | 19                | -                  | dB/V    |
| -              | Keyed AGC range                                            | -                                                                                   | 10                | -                 | -                  | dB      |

1. The time constant is defined as the  $1\tau$  value after a 6 dB level step

### 3.5 AM - Section

#### 3.5.1 AM LNA

**Table 9. AM LNA electrical characteristics**

| Symbol                | Parameter                             | Test condition                                                                          | Min. | Typ        | Max                              | Units   |
|-----------------------|---------------------------------------|-----------------------------------------------------------------------------------------|------|------------|----------------------------------|---------|
| gm                    | Transconductance                      | @ 25°C                                                                                  | 10   | 15         | 20                               | mS      |
| -                     | Gain error vs. frequency              | Freq. range<br>150 to 350 kHz<br>520 to 1710 kHz<br>2.0 to 30.0 MHz<br>0.05 to 30.0 MHz | -    | -          | ± 0.5<br>± 0.5<br>± 1.0<br>± 2.5 | dB      |
| -                     | Input impedance                       | -                                                                                       | 500  | 1000       |                                  | kΩ      |
| vnoise <sup>(1)</sup> | Input noise voltage                   | @ 1 MHz<br>@ 150 kHz                                                                    | -    | 1.7<br>2.6 | 2                                | nV/√ Hz |
| IIP3 <sup>(1)</sup>   | 3 <sup>rd</sup> order intercept point | @ gain 20 dB                                                                            | 123  | 128        | -                                | dBμV    |
| IIP2                  | 2 <sup>nd</sup> order intercept point | @ gain 20 dB                                                                            | 127  | 132        | -                                | dBμV    |
| AGC                   | AGC range                             | -                                                                                       | 8    | -          | -                                | dB      |

1. Parameter not guaranteed by production test

#### 3.5.2 Switchable LPF 4<sup>th</sup> order

**Table 10. Switchable LPF 4<sup>th</sup> order electrical characteristics**

| Symbol           | Parameter                      | Test condition                                                                                                                                                                                                      | Min.                                                     | Typ | Max  | Units |
|------------------|--------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|-----|------|-------|
| f <sub>LP1</sub> | LP corner frequency 1          | Mode 1 <sup>(1)</sup>                                                                                                                                                                                               | 1.71                                                     | -   | 1.95 | MHz   |
| f <sub>LP2</sub> | LP corner frequency 2          | Mode 2 <sup>(1)</sup>                                                                                                                                                                                               | 6.2                                                      | -   | 7.1  | MHz   |
| f <sub>LP3</sub> | LP corner frequency 3          | Mode 3 <sup>(1)</sup>                                                                                                                                                                                               | 14.0                                                     | -   | 16.0 | MHz   |
| f <sub>LP4</sub> | LP corner frequency 4          | Mode 4 <sup>(1)</sup>                                                                                                                                                                                               | 22.0                                                     | -   | 25.5 | MHz   |
| f <sub>LP5</sub> | LP corner frequency 5          | Mode 5 <sup>(1)</sup>                                                                                                                                                                                               | 26.1                                                     | -   | 31.0 | MHz   |
| G                | Gain incl. mix vs. Balunout1   | -                                                                                                                                                                                                                   | 3                                                        | 4.5 | 6    | dB    |
| G                | Gain incl. mix vs. Balunout2   | -                                                                                                                                                                                                                   | -1                                                       | 0.5 | 2    | dB    |
| -                | Passband ripple <sup>(2)</sup> | -                                                                                                                                                                                                                   | -                                                        | -   | -    | -     |
| -                | Stop band attenuation          | Mode=1 @ 10.7 MHz<br>(LW+MW) @ >22MHz<br>Mode=2 @ >28 MHz<br>(KW low) @ >87.5 MHz<br>Mode=3 @ >43 MHz<br>(KW mid) @ >87.5 MHz<br>Mode=4 @ >74 MHz<br>(KW high) @ >87.5 MHz<br>Mode=5 @ >74 MHz<br>(11m) @ >87.5 MHz | 40<br>60<br>30<br>60<br>20<br>45<br>25<br>30<br>20<br>25 | -   | -    | dB    |

**Table 10. Switchable LPF 4<sup>th</sup> order electrical characteristics (continued)**

| Symbol                | Parameter                             | Test condition                                   | Min. | Typ      | Max      | Units                  |
|-----------------------|---------------------------------------|--------------------------------------------------|------|----------|----------|------------------------|
| Vnoise <sup>(2)</sup> | Input noise voltage incl. IMR noise   | @ 1 to 30 MHz, @ 25°C<br>@ 0.15 to 1 MHz, @ 25°C | -    | 30<br>33 | 34<br>37 | nV/ $\sqrt{\text{Hz}}$ |
| IIP3                  | 3 <sup>rd</sup> order intercept point | Up to 10 MHz input frequency                     | 137  | 140      | -        | dB $\mu$ V             |
| IIP2 <sup>(2)</sup>   | 2 <sup>nd</sup> order intercept point | Up to 10 MHz input frequency                     | 160  | -        | -        | dB $\mu$ V             |

1. Corner frequency needs calibration
2. Parameter not guaranteed by production test

### 3.5.3 IMR and active balun

All parameter are referred to Balunout2, unless otherwise specified

**Table 11. IMR and active balun electrical characteristics**

| Symbol                | Parameter                             | Test condition                                                                          | Min.       | Typ  | Max                                              | Units                    |
|-----------------------|---------------------------------------|-----------------------------------------------------------------------------------------|------------|------|--------------------------------------------------|--------------------------|
| G                     | Gain                                  | vs. Balunout2                                                                           | 7          | 9    | 11                                               | dB                       |
|                       |                                       | vs. Balunout1                                                                           | 11         | 13   | 15                                               | dB                       |
| -                     | Gain error                            | @ 1 MHz --> 10.7MHz                                                                     | -          | -    | $\pm 1.0$                                        | dB                       |
| -                     | Gain Error vs. frequency              | freq. range<br>150 to 350 kHz<br>520 to 1710 kHz<br>2.0 to 30.0 MHz<br>0.05 to 30.0 MHz | -          | -    | $\pm 0,5$<br>$\pm 0,5$<br>$\pm 1.0$<br>$\pm 2,0$ | dB                       |
| -                     | Gain error vs. temperature            | -40°C to 105 °C                                                                         | -          | -    | $\pm 2,0$                                        | dB                       |
| -                     | Gain attenuation range                | IFAGC controlled                                                                        | 17.5       | 20   |                                                  | dB                       |
| -                     | Input impedance                       | For ext. LNA input                                                                      | 9.2        | 11.8 | 17.2                                             | k $\Omega$               |
| -                     | Output impedance                      | -                                                                                       | 15         | 20   | 30                                               | $\Omega$                 |
| -                     | Max. external load                    | -                                                                                       | 400        | -    | -                                                | $\Omega$                 |
| Vmax                  | Max. output voltage                   | 1 dB below 1 dB compression point                                                       | 121        | 123  | -                                                | dB $\mu$ V               |
| Vin_max               | Max. input voltage                    | Single tone<br>two tone                                                                 | 101<br>98  | -    | -                                                | dB $\mu$ V<br>dB $\mu$ V |
| Vin_max               | Max. input voltage                    | @4.6 V-4.7 V<br>single tone<br>two tone                                                 | 99<br>96   | -    | -                                                | dB $\mu$ V<br>dB $\mu$ V |
| vnoise <sup>(1)</sup> | Input noise voltage                   | @ full gain 150 kHz-30 MHz                                                              |            | 5.8  | 7.0                                              | nV/ $\sqrt{\text{Hz}}$   |
| IIP3 <sup>(1)</sup>   | 3 <sup>rd</sup> order intercept point | @ full gain Reg14[5:4] = 00<br>up to 95 °C junction temperature                         | 128<br>131 | 134  | -                                                | dB $\mu$ V               |

Table 11. IMR and active balun electrical characteristics (continued)

| Symbol                            | Parameter                                                     | Test condition                                                                                                                                                                    | Min. | Typ           | Max            | Units      |
|-----------------------------------|---------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|---------------|----------------|------------|
| -                                 | 3 <sup>rd</sup> order intercept point in reduced current mode | Reg14[5:4] = 01<br>60 °C up to 125 °C junction temperature                                                                                                                        | 131  | 133           | -              | dB $\mu$ V |
|                                   |                                                               | Reg14[5:4] = 10<br>junction temperature > 90 °C                                                                                                                                   | 131  | 132           | -              | dB $\mu$ V |
| IIP2 <sup>(1)</sup>               | 2 <sup>nd</sup> order intercept point                         | -                                                                                                                                                                                 | 159  | -             | -              | dB $\mu$ V |
| -                                 | IF-output attenuation                                         | @ 26.35 MHz                                                                                                                                                                       | 1    | -             | -              | dB         |
| -                                 | IF rejection                                                  | -                                                                                                                                                                                 | 40   | 48            | -              | dB         |
| V <sub>LO_IN</sub> <sup>(1)</sup> | LO signal @ mixer input                                       | R <sub>source</sub> = 1.5 k $\Omega$<br>@ fundamental LO freq<br>@ harmonics of LO freq.                                                                                          | -    | -             | 10<br>30       | dB $\mu$ V |
| V <sub>LO_OUT</sub>               | LO signal @ balun output using mixer input                    | Incl. LC-tank with Q=2,<br>R <sub>load</sub> = 1.0 k $\Omega$<br>@ fundamental LO freq.<br>with 1 k $\Omega$ input termination resistor <sup>(1)</sup><br>@ harmonics of LO freq. | -    | -             | 95<br>80<br>66 | dB $\mu$ V |
|                                   | LO signal @ balun output, using low pass filter               | Incl. LC-tank with Q=2,<br>R <sub>load</sub> =1.0 k $\Omega$<br>@ fundamental LO freq.<br>@ harmonics of LO freq.                                                                 | -    | -             | 85<br>66       |            |
| I <sub>QG</sub>                   | I/Q gain adjust<br>Min.<br>Max.                               | 4 bit                                                                                                                                                                             | -    | -0.7<br>0.7   | -              | dB         |
| -                                 | Gain step                                                     | -                                                                                                                                                                                 | -    | 0.1           | -              | dB         |
| PIQ                               | I/Q phase adjust<br>Min.<br>Max.                              | 4bit                                                                                                                                                                              | -    | -0.25<br>0.25 | -              | °          |
| -                                 | phase step                                                    | -                                                                                                                                                                                 | -    | 0.25          | -              | °          |
| -                                 | Center frequency adjust<br>Min.<br>Max.                       | 3bit                                                                                                                                                                              | -    | -2.4<br>2.4   | -              | MHz        |
| -                                 | Frequency step                                                | -                                                                                                                                                                                 | -    | 0.6           | -              | MHz        |
| IRR                               | Image rejection ratio                                         | Without gain/phase adjust                                                                                                                                                         | 30   | 45            | -              | dB         |
| IRR                               | Image rejection ratio                                         | With gain/phase adjust @ 25°C                                                                                                                                                     | 45   | -             | -              | dB         |
| IRR                               | Image rejection ratio                                         | With gain/phase adjust vs. complete temp. range                                                                                                                                   | 40   | -             | -              | dB         |

1. Parameter not guaranteed by production test

### 3.5.4 AM AGC

The time constant of the AM AGC is defined by an external capacitor and the programmable internal currents (details given in the [Table 12](#)).

Control behavior:

The AM RF AGC is realized with two output pins which controls the gain of the corresponding pre-stage.

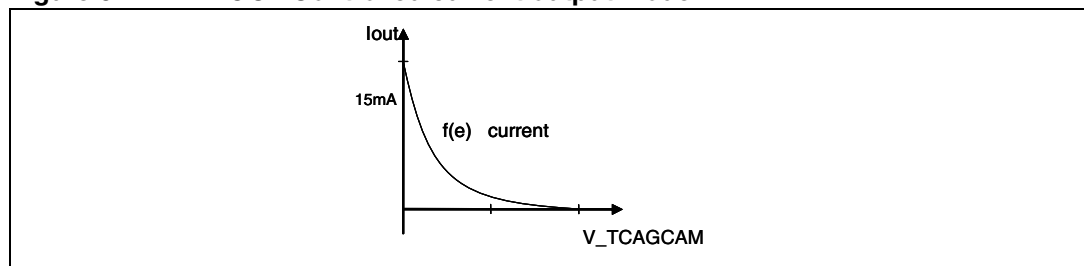
The control behavior can be programmed to the following modes:

1. **Controlled current output mode 1**

data byte AMAGC[3:0] = 1000

positive current  $I = f(e)$ : after reaching the AGC threshold voltage the current output delivers a current  $I = f(e)$  up to 15 mA in a voltage range from 0.1 V up to  $V_{CC}-1.5$  V.

**Figure 6. AM AGC - Controlled current output mode 1**



2. **Constant current mode**

data byte AMAGC[3:0] = 0100

constant current mode: the output current can be set to 2 mA source current. The AGC detector is in power-down mode and only the pin diode driver is active.

3. **Voltage and current mode with hand-over**

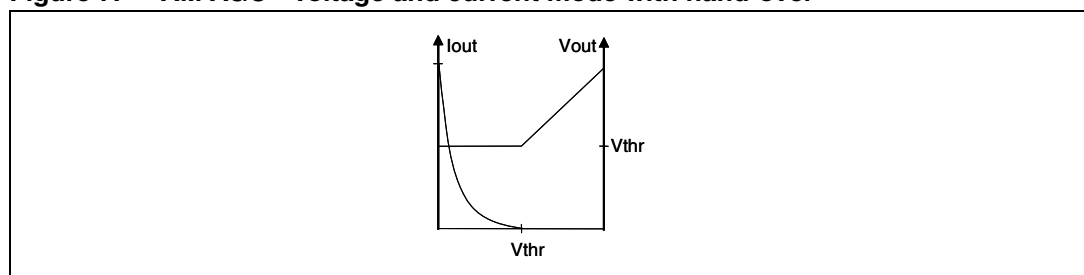
a) internal feedback

data byte AMAGC[3:0] = 1001

voltage and current mode with hand-over: the  $V_{thr}$  level is programmable in the range 1 V to 2.6 V.

This mode can be used in combination with both the internal and the external LNA. In combination with the internal AM LNA, the maximum output voltage is limited to 2.7 V.

**Figure 7. AM AGC - Voltage and current mode with hand-over**



b) external feedback

data byte AMAGC[3:0] = 1011

Voltage and current mode with hand-over: the  $V_{thr}$  level is programmable in the range 0.2 to 2.6 V. The voltage  $V_{thr}$  is the internal reference voltage for the

external feedback to pin GP4/UDS. This mode can only be used with an external LNA.

#### 4. Calibration mode for voltage output

- a) internal feedback  
data byte AMAGC[3:0] = 1110  
calibration mode for voltage output (mode 3.a.): the voltage  $V_{thr}$  can be switched directly to the voltage output pin. The reference voltage is programmable in the range described in 3.a.
- b) external feedback  
data byte AMAGC[3:0] = 0010  
calibration mode for external feedback (mode 3.b.): the output voltage is set to a value, that the feedback on GP4(UDS) is equal to  $V_{thr}$ . The reference voltage is programmable in the range described in 3.b.

All other possible bit combinations of data byte AMAGC[3:0] are prohibited.

The voltage output can be configured as GPO.

The AMAGC2 output (voltage output) is short-circuit protected by a current limiter. The AMAGC1 output (current output) needs an external resistor. The current output is voltage-tolerant up to VCC, the voltage output up to VDD.

The microcontroller (STA3005 backend) can read the voltage at the AGC capacitor via the serial control interface. On the microcontroller request, the measurement is done by connecting the time constant capacitor to the central ADC (specified in chapter 3.10); the information can be used to calculate the AGC attenuation.

The AM AGC system is controlled by an average detector.

The AM AGC can be enabled independently in AM and FM mode

**Table 12. AM-AGC electrical characteristics**

| Symbol | Parameter                            | Test condition          | Min. | Typ   | Max | Units      |
|--------|--------------------------------------|-------------------------|------|-------|-----|------------|
| Lthr   | Threshold RF level<br>Min. Threshold | Referred to mixer input | -    | -     | -   | -          |
|        |                                      | AM mixer input          | -    | 89    | -   | dB $\mu$ V |
|        |                                      | AM filter input         | -    | 94    | -   | dB $\mu$ V |
|        | Max Threshold                        | AM mixer input          | -    | 101.5 | -   | dB $\mu$ V |
|        |                                      | AM filter input         | -    | 106.5 | -   | dB $\mu$ V |
| -      | Threshold steps                      | 4 bit control           | 0.4  | 0.9   | 1.4 | dB         |
| -      | Absolute threshold error             | 0.5 to 30.0 MHz @ 25 °C | -1   | -     | 2   | dB         |
| -      | Total threshold error                | 0.5 to 30.0 MHz         | -2   | -     | 3   | dB         |
| -      | Absolute threshold error             | 0.1 to 0.5 MHz @ 25 °C  | -0.5 | -     | 3   | dB         |
| -      | Total threshold error                | 0.1 to 0.5 MHz          | -2   | -     | 3.5 | dB         |
| -      | Temperature drift of AGC thresholds  | -                       | -    | 0.011 | -   | dB/°C      |
| -      | Frequency range                      | Reduced performance     | 0.05 | -     | 0.1 | MHz        |
| -      | frequency range                      | -                       | 0.1  | -     | 30  | MHz        |

Table 12. AM-AGC electrical characteristics (continued)

| Symbol         | Parameter                                                                                   | Test condition                                                                                   | Min.            | Typ            | Max              | Units         |
|----------------|---------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|-----------------|----------------|------------------|---------------|
| -              | Pin diode source current<br>( $I \approx 1.5 \text{ mA} * (\exp(V_{DD} - V_{AGCTC}) - 1)$ ) | AGC control pin 1<br>$V_{AGCTC} < 1 \text{ V}$<br>external resistor necessary                    | -               | -              | -10              | mA            |
| -              | Min. voltage                                                                                | AGC control pin                                                                                  | -               | -              | 0.2              | V             |
| -              | Pin diode source current in constant current mode                                           | -                                                                                                | -               | -2             | -1               | mA            |
| -              | Max. voltage                                                                                | AGC control pin 1                                                                                | VCC-1.5         | VCC-1.3        |                  | V             |
| -              | Max. source current                                                                         | AGC control pin 2;<br>voltage output                                                             | -               | -              | -1               | mA            |
| -              | Min. sink current                                                                           | AGC control pin 2;<br>voltage output                                                             | 90              | -              | -                | $\mu\text{A}$ |
| -              | Max. output voltage in analog voltage mode (follower mode)                                  | AGC control pin 2<br>@ $I_{load} = 1 \text{ mA}$                                                 | $V_{DD}-0.3$    | -              | $V_{DD}$         | V             |
| -              | Min. output voltage in analog voltage mode                                                  | AGC control pin 2<br>@ $I_{load} = -50 \mu\text{A}$                                              | -               | -              | 1                | V             |
| $V_{thr\_min}$ | $V_{thr\_min}$                                                                              | -                                                                                                | 0.1             | 0.2            | 0.3              | V             |
| $V_{thr\_max}$ | $V_{thr\_max}$                                                                              | -                                                                                                | 2.4             | 2.6            | 2.8              | V             |
| -              | Step size of $V_{thr}$                                                                      | 6 bit                                                                                            |                 | 40             |                  | mV            |
| DNL            | Nonlinearity of $V_{thr}$                                                                   | -                                                                                                | -0.5            |                | 0.5              | LSB           |
| -              | TC current for 6 dB control error                                                           | Mode T1<br>Mode T2<br>Mode T3                                                                    | 2.5<br>12<br>60 | 4<br>20<br>100 | 6.5<br>32<br>160 | $\mu\text{A}$ |
| -              | I attack in fast attack mode<br>@ 10 dB control error                                       | Active if control deviation is more than 7 dB                                                    | 0.9             | 1.7            | 2.3              | mA            |
| -              | Typical AGC time constant <sup>(1)</sup>                                                    | $C_{AGCTC} = 1 \mu\text{F}$ , mode T2<br>AGC conductance versus<br>$V_{AGCTC} = 20 \text{ dB/V}$ | -               | 15             | -                | ms            |

1. The time constant is defined as the  $1\tau$  value, means when the AGC is settled to 63% after a 6dB step

## 3.6 IF - Section

### 3.6.1 IF-Amplifier

**Table 13. IF-Amplifier with anti aliasing filter and ADC buffer electrical characteristics**

| Symbol                        | Parameter                                | Test condition                                                                | Min.       | Typ        | Max      | Units   |
|-------------------------------|------------------------------------------|-------------------------------------------------------------------------------|------------|------------|----------|---------|
| Gain                          | Min. programmable gain                   | Input 1-3 (FM,HD,AM)<br>Input 4 (HD-Radio AM)                                 | -          | 23<br>16   | -        | dB      |
|                               | Max programmable gain                    | Input 1-3 (FM,HD,AM)<br>Input 4 (HD-Radio AM)                                 |            | 37<br>30   |          |         |
| Gstep                         | Gain step                                | 3 bit control                                                                 | 1          | 2          | 3        | dB      |
| Gmin                          | Minimum gain of IF-Amplifier in AGC mode | Full AGC reaction<br>$V_{TCIF} < 1V$                                          | 14<br>7    | 17<br>10   | 19<br>12 | dB      |
|                               | Input 1-3<br>Input 4                     |                                                                               |            |            |          |         |
| Gerr                          | Gain error                               | @ 10.7 MHz, AAfilt<1:0>=10                                                    | -2         | -          | 2        | dB      |
|                               |                                          | with AAfilt<1:0>=00                                                           | -4         | -          | 2        | dB      |
| f <sub>cut</sub>              | Cut off frequency without calibration    | -3 dB without calibration                                                     | 10         | 15         | 21       | MHz     |
| f <sub>cut_cal</sub>          | Cut off frequency after calibration      | -3 dB with calibration                                                        | 13         | 15         | 17       | MHz     |
| -                             | Stop band attenuation with calibration   | @ 26.35 MHz<br>@ 47.75 MHz                                                    | 15<br>30   | -          | -        | dB      |
| -                             | Pass band ripple                         | @ 400kHz bandwidth                                                            | -          | -          | 0.5      | dB      |
| Rin_input1                    | Input impedance input 1                  | FM –input                                                                     | 265        | 330        | 400      | Ω       |
| Rin_input2                    | Input impedance input 2                  | HD-Radio FM input                                                             | 5.5        | 10         | 18       | kΩ      |
| Rin_input3                    | Input impedance input 3                  | AM input                                                                      | 5.5        | 10         | 18       | kΩ      |
| Rin_input4                    | Input impedance input 4                  | HD-Radio AM input                                                             | 11         | 20         | 34       | kΩ      |
| Vout_max                      | Max. output voltage                      | $R_L \geq 180 \Omega$                                                         | 117        | -          | -        | dBμV    |
| IIP3 <sup>(1)</sup>           | 3 <sup>rd</sup> order intercept point    | Input stage 1-3<br>Input stage 4                                              | 120<br>128 | 125<br>132 | -        | dBμV    |
| OIP3 <sup>(1)</sup>           | 3 <sup>rd</sup> order intercept point    | Up to 116 dBμV output voltage, without AGC attenuation, $R_L \geq 180 \Omega$ | 142        | 145        | -        | dBμV    |
| IIP2 <sup>(1)</sup>           | 2 <sup>nd</sup> order intercept point    | Input stage 1-3<br>input stage 4                                              | 147<br>157 | -          | -        | dBμV    |
| Vnoise_input 1 <sup>(1)</sup> | Input noise voltage @ 330 Ω input        | @ source impedance 330 Ω noiseless, @31 dB gain                               | -          | 3.5        | 4.2      | nV/√ Hz |
| Vnoise_input 2 <sup>(1)</sup> | Input noise voltage @ 3.3 kΩ input       | @ source impedance 470 Ω noiseless, @ 31 dB gain                              | -          | 3.8        | 4.6      | nV/√ Hz |

**Table 13. IF-Amplifier with anti aliasing filter and ADC buffer electrical characteristics (continued)**

| Symbol                        | Parameter                                                 | Test condition                                                                                                     | Min. | Typ | Max | Units                  |
|-------------------------------|-----------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|------|-----|-----|------------------------|
| Vnoise_input 3 <sup>(1)</sup> | Input noise voltage @ 10 k $\Omega$ input                 | @ source impedance 2.2 k $\Omega$ noiseless, @31 dB gain, with external 2.7 k $\Omega$ input termination resistor  | -    | 5   | 6   | nV/ $\sqrt{\text{Hz}}$ |
| Vnoise_input 4 <sup>(1)</sup> | Input noise voltage @ 10k $\Omega$ input                  | @ source impedance 2.2 k $\Omega$ noiseless, @ 24 dB gain, with external 2.7 k $\Omega$ input termination resistor | -    | 7.5 | 8.5 | nV/ $\sqrt{\text{Hz}}$ |
| Iout,max                      | Max. output current                                       | With resistive load                                                                                                | 4    | -   | -   | mA                     |
| Zout                          | Output impedance                                          | -                                                                                                                  | -    | 20  | 40  | $\Omega$               |
| -                             | Isolation between different IF input ports <sup>(1)</sup> | @ Input impedance 2.5k $\Omega$                                                                                    | 30   | -   | -   | dB                     |

1. Parameter not guaranteed by production test

### 3.6.2 IF-AGC

The IF AGC system is controlled in AM with an average detector and in FM with a peak detector.

The time constant is defined with two external capacitors and programmable internal currents (details given in the table below).

The microcontroller can read the voltage at the AGC capacitor via the serial control interface. On request of the microcontroller the measurement is done by applying the time constant capacitor voltage to the central ADC (specified in chapter 3.10) and gives information to calculate the AGC-attenuation.

**Table 14. IF-AGC electrical characteristics**

| Symbol | Parameter                                                                      | Test condition                                                                  | Min.      | Typ          | Max       | Units      |
|--------|--------------------------------------------------------------------------------|---------------------------------------------------------------------------------|-----------|--------------|-----------|------------|
| Lthr   | AGC threshold IF level                                                         | Referred to differential output of ADC buffer                                   | -         | -            | -         | -          |
|        | Min. AGC threshold                                                             | FM                                                                              | -         | 105          | -         | dB $\mu$ V |
|        |                                                                                | AM                                                                              | -         | 99           | -         | dB $\mu$ V |
|        | Max AGC threshold                                                              | FM, Max. recommended AGC threshold 115 dB $\mu$ V                               | -         | 119          | -         | dB $\mu$ V |
|        |                                                                                | AM, Max. recommended AGC threshold 109 dB $\mu$ V                               | -         | 113          | -         | dB $\mu$ V |
| -      | Threshold steps                                                                | 3 bit                                                                           | 1.5       | 2            | 2.5       | dB         |
| -      | Absolute threshold error                                                       | 10.7 MHz @ 25 °C (up to 117 dB $\mu$ V output voltage)                          | -1        | -            | 1         | dB         |
| -      | Total threshold error                                                          | 10.7 MHz (up to 117dB $\mu$ V output voltage)                                   | -2.5      | -            | 2.5       | dB         |
| -      | Temp drift of AGC threshold                                                    | FM-mode<br>AM mode                                                              | -         | 0.008<br>0.0 |           | dB/°C      |
| -      | IF gain deviation                                                              | Remaining gain control error                                                    | -         | -            | 1         | dB         |
| -      | Fast attack mode in AM-mode                                                    | Active if control deviation is more than 7dB                                    | 0.3       | 0.5          | 1         | ms         |
| -      | Time constant in AM mode <sup>(1)</sup><br>symmetric behavior (attack = decay) | With external 2.2 $\mu$ F capacitor,<br>IF gain = 31 dB input 1-3; 24 dB input4 |           |              |           |            |
|        |                                                                                | mode S1 (slow)<br>mode S2 (fast)                                                | 55<br>5.5 | 110<br>11    | 220<br>22 | ms<br>ms   |
| -      | Time constant in FM mode <sup>(2)</sup><br>asymmetric behavior                 | With external 220 nF capacitor,<br>IF gain = 31 dB input1-3; 24 dB input4       |           |              |           |            |
|        |                                                                                | decay mode U1 / U2                                                              | 7         | 15           | 32        | ms         |
|        |                                                                                | attack mode U1 (slow)                                                           | 150       | 300          | 600       | $\mu$ s    |
|        |                                                                                | attack mode U2 (fast)                                                           | 30        | 60           | 120       | $\mu$ s    |

1. The AGC time constant for AM is the  $1\tau$  value, means when the AGC is settled to 63% after a 6dB step

2. The AGC time constant for FM is the time needed to settle the AGC to 90% for a 6dB level step

### 3.6.3 IF buffer amplifier

The IF buffer amplifier is a programmable, single ended amplifier. The input for the IF buffer amplifier can be selected by software between IFin1 and IFin2. The output of the amplifier is multiplexed with GPIO5

**Table 15. IF buffer amplifier electrical characteristics**

| Symbol                | Parameter                             | Test condition                                                     | Min. | Typ | Max  | Units                  |
|-----------------------|---------------------------------------|--------------------------------------------------------------------|------|-----|------|------------------------|
| Gmin                  | Min. gain                             | Series resistance 220 $\Omega$ , terminated with 330 $\Omega$      | -    | -11 | -    | dB                     |
| Gmax                  | Max. gain                             | Series resistance 220 $\Omega$ , terminated with 330 $\Omega$      | -    | 3   | -    | dB                     |
| Gstep                 | Gain step                             | 3bit                                                               | -    | 2   | -    | dB                     |
| -                     | Absolute gain error                   | -                                                                  | -3   |     | 3    | dB                     |
| -                     | Relative gain error                   | Step by step                                                       | -1.5 |     | 1.5  | dB                     |
| vnoise <sup>(1)</sup> | Input noise voltage                   | @ 10.7 MHz, 3 dB gain                                              | -    | 8.5 | 15   | nV/ $\sqrt{\text{Hz}}$ |
| IIP3 <sup>(1)</sup>   | 3 <sup>rd</sup> order intercept point | @ gain 3 dB, Vout=1 Vpp with 500 $\Omega \leq R_L \leq 600 \Omega$ | 115  | 120 | -    | dB $\mu$ V             |
| -                     | 3 dB bandwidth                        | -                                                                  | -    | 50  | -    | MHz                    |
| -                     | Output DC voltage                     | -                                                                  | 1.6  | -   | 2.1  | V                      |
| -                     | External output load                  | -                                                                  | 400  | 550 | 1000 | $\Omega$               |
| -                     | Output impedance                      | -                                                                  | 80   | 140 | 250  | $\Omega$               |

1. Parameter not guaranteed by production test

## 3.7 Phase Locked Loop

**Table 16. Phase Locked Loop electrical characteristics**

| Parameter                       | Test condition                                                                                                                                                                            | Min. | Typ        | Max        | Units         |
|---------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------------|------------|---------------|
| Settling time FM <sup>(1)</sup> | $\Delta f < 0.01 \%$<br>@ $f_{\text{PFD}} = 300 \text{ kHz}$<br>fractional mode, with loop filter according application schematic<br>@ $f_{\text{PFD}} = 100 \text{ kHz}$<br>integer mode | -    | 300        | 500        | $\mu\text{s}$ |
|                                 | VCC = 4.6 – 4.7V, $f_{\text{PFD}} = 300\text{kHz}$ , loop filter according application schematic<br>$f_{\text{PFD}} = 100 \text{ kHz}$                                                    | -    | 300<br>500 | 600<br>600 | $\mu\text{s}$ |
| Spurious suppression            | Suppression of spurious with compensation DAC<br>low current charge pump<br>50 $\mu\text{A} \leq I_{\text{cp}} \leq 750 \mu\text{A}$                                                      | 5    | 20         | -          | dB            |

1. Parameter not guaranteed by production test, depends on loop filter circuitry and CP current settings. For further information see application note information

### 3.7.1 VCO

**Table 17. VCO electrical characteristics**

| Symbol                        | Parameter                                         | Test condition, comments                                                                                                                                                                                                                                                  | Min. | Typ                                      | Max  | Units      |
|-------------------------------|---------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------------------------------------------|------|------------|
| $f_{osc}$                     | Frequency range VCO1                              | Tuning range, incl. switch between upper and lower range<br>$0.2\text{ V} \leq V_{tune} \leq 4.2\text{ V}$                                                                                                                                                                | 4480 | -                                        | 4970 | MHz        |
|                               | Frequency range VCO2                              | Tuning range, incl. switch between upper and lower range<br>$0.2\text{ V} \leq V_{tune} \leq 4.2\text{ V}$                                                                                                                                                                | 3430 | -                                        | 4010 | MHz        |
| -                             | Phase Noise of LO                                 | At any LO frequency between 55.1 MHz and 118.7 MHz, VCO free running, NV=8 (VCO2), NV=10 (VCO1)<br>@ 10 Hz<br>@ 100 Hz<br>@ 1 kHz<br>@ 10 kHz<br>@ 100 kHz                                                                                                                | -    | -40<br>-60<br>-86<br>-106<br>-126        | -    | dBc<br>Hz  |
| -                             | Phase Noise of LO<br>min. requirements for AM,DRM | At any LO frequency between 10.7 MHz and 40.0 MHz VCO free running NV=25 (VCO2), NV=30 (VCO1)<br>@ 1 Hz<br>@ 10 Hz<br>@ 100 Hz<br>@ 1 kHz<br>@ 10 kHz<br>@ 100 kHz                                                                                                        | -    | -33<br>-40<br>-80<br>-90<br>-100<br>-120 | -    | dBc<br>Hz  |
| -                             | Deviation error <sup>(1)</sup>                    | FM reception, deem phase<br>$50\mu\text{s}$ , $f_{NF}=20\text{ Hz}$ to $20\text{ kHz}$ @ min. VCO frequency NV=8 (VCO2), NV=10 (VCO1)<br>$f_{PFD}=300\text{ kHz}$ <sup>(2)</sup> , loop filter according application schematic<br>$f_{PFD}=1.9\text{ MHz}$ <sup>(3)</sup> | -    | 8                                        | 8    | Hz         |
| -                             | KVCOmax/KVCOmin                                   | For tuning voltage range<br>$0.2\text{ V} - 4.2\text{ V}$                                                                                                                                                                                                                 | -    | 5                                        | 7    | -          |
| PSRR <sup>(1)</sup>           | Power supply ripple rejection ratio               | -                                                                                                                                                                                                                                                                         | 20   | -                                        | -    | dB         |
| $V_{VCO\_OUT}$ <sup>(1)</sup> | VCO signal emission                               | @ tuning voltage input,<br>1 k $\Omega$ load                                                                                                                                                                                                                              | -    | -                                        | 60   | dB $\mu$ V |

1. Parameter not guaranteed by production test

2. Adaptation of low current CP values needed

3. With appropriate loop filter circuit

### 3.7.2 Reference oscillator / reference frequency input buffer

**Table 18. Reference oscillator / reference frequency input buffer electrical characteristics**

| Parameter                                              | Test condition, comments                | Min. | Typ    | Max  | Units            |
|--------------------------------------------------------|-----------------------------------------|------|--------|------|------------------|
| <b>Reference oscillator mode – fundamental crystal</b> |                                         |      |        |      |                  |
| Oscillation frequency                                  | Fundamental mode                        | -    | 74.1   | -    | MHz              |
| Phase noise                                            | @ 1 Hz                                  | -    | -20    | -    | dBc              |
|                                                        | @ 10 Hz                                 |      | -50    |      | dBc              |
|                                                        | @ 100 Hz                                |      | -80    |      | dBc              |
|                                                        | @ 1 kHz                                 |      | -110   |      | dBc              |
|                                                        | @ 10 kHz                                |      | -130   |      | dBc              |
|                                                        | @ 100 kHz                               |      | < -130 |      | dBc              |
|                                                        | @ 1 MHz                                 |      | < -130 |      | dBc              |
| Frequency stability                                    | Degradation generated by the oscillator | -20  | -      | 20   | ppm              |
| <b>Single ended input</b>                              |                                         |      |        |      |                  |
| Input frequency                                        | -                                       | -    | -      | 75   | MHz              |
| Input voltage range                                    | Single ended mode                       | 200  | -      | 1000 | mV <sub>PP</sub> |
| Input impedance                                        | Single ended mode                       | 10   | -      | -    | kΩ               |
| <b>Reference frequency input buffer mode</b>           |                                         |      |        |      |                  |
| reference input frequency                              | differential input                      | 0.1  | -      | 150  | MHz              |
| max input voltage high                                 | -                                       | -    | -      | 1475 | mV               |
| min. input voltage low                                 | -                                       | 925  | -      | -    | mV               |
| Input differential voltage                             | -                                       | 247  | -      | 454  | mV               |
| Input offset voltage                                   | -                                       | 1125 | -      | 1275 | mV               |
| input impedance                                        | -                                       | 150  | -      | -    | kΩ               |

### 3.7.3 Divider

The mixer divider V is followed by a division-by-4-stage that generates 0°/90°/-90° LO signals for the IMR mixer (90°/-90° mode to switch between upper or lower sideband suppression in the IMR).

The main divider N can be operated in integer mode or in fractional mode. Three fraction factors are programmable: 2, 3 and 6. A fractional compensation circuit is located at the charge pump. The compensation acts for the low current only.

**Table 19. Divider electrical characteristics**

| Symbol                                                          | Parameter               | Test condition, comments | Min. | Typ | Max     | Units |
|-----------------------------------------------------------------|-------------------------|--------------------------|------|-----|---------|-------|
| <b>Mixer divider V – integer values</b>                         |                         |                          |      |     |         |       |
| N <sub>V</sub>                                                  | Divider value divider_V | 7 bit                    | 5    | -   | 131     | -     |
| <b>Main divider N – fractional 2, 3 and 6 / integer divider</b> |                         |                          |      |     |         |       |
| N <sub>N</sub>                                                  | Divider value divider_N | 22bit (32/33 pre scaler) | 1024 | -   | 4194304 | -     |
| <b>Reference divider R – integer values</b>                     |                         |                          |      |     |         |       |
| N <sub>R</sub>                                                  | Divider value divider_R | 16 bit                   | 1    | -   | 65535   | -     |

### 3.7.4 Phase frequency detector and charge pump

**Table 20. Phase frequency detector and charge pump electrical characteristics**

| Symbol             | Parameter                                                                                      | Test condition         | Min.         | Typ   | Max      | Units   |
|--------------------|------------------------------------------------------------------------------------------------|------------------------|--------------|-------|----------|---------|
| <b>PFD</b>         |                                                                                                |                        |              |       |          |         |
| $f_{PFD}$          | PFD input frequency                                                                            | -                      | 2            | -     | 3000     | kHz     |
| <b>Charge pump</b> |                                                                                                |                        |              |       |          |         |
| $I_{sink}$         | Sink current<br><br>fractional compensation only<br>for low current modes<br>(bit 5 – bit 8)   | High current mode bit1 | -            | -0.65 | -        | mA      |
|                    |                                                                                                | high current mode bit2 |              | -1,3  |          | mA      |
|                    |                                                                                                | High current mode bit3 |              | -2,5  |          | mA      |
|                    |                                                                                                | High current mode bit4 |              | -4,6  |          | mA      |
|                    |                                                                                                | Low current mode bit1  |              | -65   |          | $\mu$ A |
|                    |                                                                                                | Low current mode bit2  |              | -130  |          | $\mu$ A |
|                    |                                                                                                | Low current mode bit3  |              | -260  |          | $\mu$ A |
|                    |                                                                                                | Low current mode bit4  |              | -520  |          | $\mu$ A |
|                    |                                                                                                | Low current mode bit5  |              | -980  |          | $\mu$ A |
| $I_{source}$       | Source current<br><br>fractional compensation only<br>for low current modes<br>(bit 5 – bit 8) | High current mode bit1 | -            | 0.65  | -        | mA      |
|                    |                                                                                                | high current mode bit2 |              | 1.3   |          | mA      |
|                    |                                                                                                | High current mode bit3 |              | 2.5   |          | mA      |
|                    |                                                                                                | High current mode bit4 |              | 4.6   |          | mA      |
|                    |                                                                                                | low current mode bit1  |              | 65    |          | $\mu$ A |
|                    |                                                                                                | Low current mode bit2  |              | 130   |          | $\mu$ A |
|                    |                                                                                                | Low current mode bit3  |              | 260   |          | $\mu$ A |
|                    |                                                                                                | Low current mode bit4  |              | 520   |          | $\mu$ A |
|                    |                                                                                                | Low current mode bit5  |              | 980   |          | $\mu$ A |
| -                  | Current error                                                                                  | -                      | -            | -     | $\pm 30$ | %       |
| $V_{OH}$           | Output voltage high                                                                            | -                      | $V_{CC}-0.3$ | -     | $V_{CC}$ | V       |
| $V_{OL}$           | Output voltage low                                                                             | -                      | -0.05        | -     | 0.15     | V       |

## 3.8 Temperature sensor

**Table 21. Temperature sensor electrical characteristics**

| Parameter                 | Test condition                                      | Min. | Typ | Max      | Units        |
|---------------------------|-----------------------------------------------------|------|-----|----------|--------------|
| Temperature range         | -                                                   | -40  | -   | 150      | $^{\circ}$ C |
| Resolution <sup>(1)</sup> | $^{\circ}$ C / LSB (no direct measurement possible) | 4.5  | 5.1 | 5.7      | $^{\circ}$ C |
| Absolute error            | -                                                   | -    | -   | $\pm 15$ | $^{\circ}$ C |
| Relative error            | No direct measurement possible                      | -    | 0.5 | -        | LSB          |

1. Not guaranteed by production test

### 3.9 D/A-converter

The TDA7528 contains two D/A-Converters for tuning the filters of the FM pre-stage. The converter 1 has a resolution of 8 bit; converter 2 has a resolution of 9 bit.

**Table 22. D/A-converter electrical characteristics**

| Symbol    | Parameter                             | Test condition                | Min.          | Typ          | Max | Units      |
|-----------|---------------------------------------|-------------------------------|---------------|--------------|-----|------------|
| $V_{out}$ | Output voltage minimum voltage        | Unloaded output               | -             | 0.6          | 0.8 | V          |
|           | Maximum voltage                       | -                             | $V_{CC}-0.15$ | $V_{CC}-0.1$ | -   |            |
| -         | Output impedance                      | -                             | -             | 2            | -   | k $\Omega$ |
| -         | Max. output current                   | -                             | 400           | -            | -   | $\mu$ A    |
| -         | Average voltage step converter 1      | Resolution 8 bit              | -             | 18           | -   | mV         |
| -         | Average voltage step converter 2      | Resolution 9 bit              | -             | 9            | -   | mV         |
| -         | Additional error vs. temperature      | -                             | -2            | -            | 2   | LSB        |
| -         | INL                                   | -                             | -2            | -            | 2   | LSB        |
| -         | DNL                                   | -                             | -0.5          | -            | 0.5 | LSB        |
| -         | Output noise                          | @ $C_L=1nF$ and 2.2k $\Omega$ | -             | 100          | 200 | $\mu$ V    |
| -         | Conversion time                       | @ $C_L=1nF$                   | -             | 20           | 40  | $\mu$ s    |
| VSRR      | Supply voltage ripple rejection ratio | @ 1kHz                        | 20            | -            | -   | dB         |

### 3.10 A/D-converter

The TDA7528 contains a 6bit SAR A/D-Converter for sensing several analog values of the tuner. The following analog sources can be switched to the ADC input by software command:

- Temperature sensor
- TCFM
- TCAM
- TCIF1/2 (depends on which one is active)
- VCO tuning voltage ( $=3/5 \cdot V_{\text{tune}}$ )
- GP1
- GP2
- Internal VCC divider ( $2/5 \cdot V_{\text{CC}}$ )

The ADC is clocked by an integrated RC-oscillator, or the PLL reference frequency.

**Table 23. A/D-converter**

| Symbol           | Parameter                                  | Test condition, comments | Min. | Typ  | Max             | Units         |
|------------------|--------------------------------------------|--------------------------|------|------|-----------------|---------------|
| -                | INL                                        | Referred to internal VDD | -2   | -    | 2               | LSB           |
| -                | DNL                                        | -                        | -0.5 | -    | 0.5             | LSB           |
| -                | Input voltage range                        | -                        | 0    | -    | $V_{\text{DD}}$ | V             |
| $f_{\text{Osc}}$ | Oscillation frequency<br>2bit programmable | RCfreq<1:0> = 00         |      | 0.68 |                 | MHz           |
|                  |                                            | RCfreq<1:0> = 01         |      | 1.31 |                 | MHz           |
|                  |                                            | RCfreq<1:0> = 10         |      | 1.9  |                 | MHz           |
|                  |                                            | RCfreq<1:0> = 11         | 1.72 | 2.5  |                 | MHz           |
| -                | frequency error                            | -                        | -    | -    | $\pm 40$        | %             |
| $t_{\text{ADC}}$ | Conversion time <sup>(1)</sup>             | 12 clock cycles          | -    | -    | 7               | $\mu\text{s}$ |

1. With RC-oscillator frequency = 2.5MHz

### 3.11 GPIO - general purpose I/O interface pins

The TDA7528 has eight GPIO - general purpose - control pins (GP1...GP8) to switch external stages (output), e.g. amplifiers, or to read the status of external stages (input), e.g. control voltages. Some control pins are multiplexed with other functions that are not necessary in every tuner design.

**Table 24. GPIO - general purpose I/O interface pins electrical characteristics**

| Pin name | GPIO functionality |                   |           |                 |                            |            | Multiplexed<br>functionality details<br>are given in the<br>corresponding<br>chapters |
|----------|--------------------|-------------------|-----------|-----------------|----------------------------|------------|---------------------------------------------------------------------------------------|
|          | GPIO-output        |                   |           |                 | GPIO-input                 |            |                                                                                       |
|          | High level         |                   | Low level |                 | Functionality              | voltage    |                                                                                       |
|          | voltage            | Source<br>current | voltage   | Sink<br>current |                            |            |                                                                                       |
| GP1      | 3,3V               | 1 mA              | 0V        | 1 mA            | Analog input A/D-converter | 0 ... 3,3V |                                                                                       |
| GP2      | 3,3V               | 1 mA              | 0V        | 1 mA            | Analog input A/D-converter | 0 ... 3,3V | AMAGC 2nd TC input                                                                    |
| GP3      | 3.3V               | 0.1 mA            | 0V        | 10 mA           | -                          | -          | FM key AGC input                                                                      |
| GP4      | 3.3V               | 0.1 mA            | 0V        | 10 mA           | -                          | -          | AM cascode U <sub>DS</sub> input                                                      |
| GP5      | 3,3V               | 1 mA              | 0V        | 1 mA            | Digital Input              | 0 / 3,3V   | IF buffer output                                                                      |
| GP6      | 3,3V               | 1 mA              | 0V        | 1 mA            | Digital Input              | 0 / 3,3V   | SPI MISO output                                                                       |
| GP7      | 3,3V               | 1 mA              | 0V        | 1 mA            | -                          | -          | FM-AGC voltage output                                                                 |
| GP8      | 3,3V               | 1 mA              | 0V        | 1 mA            | -                          | -          | AM-AGC voltage output                                                                 |

**Table 25. GPIO test conditions**

| Parameter                 | Test condition                                             | Min.         | Typ  | Max      | Units      |
|---------------------------|------------------------------------------------------------|--------------|------|----------|------------|
| High level output voltage | @ 100k $\Omega$ load to GND                                | $V_{DD}-0.3$ | -    | $V_{DD}$ | V          |
| Low level output voltage  | @ 100k $\Omega$ load to $V_{DD}$                           | -0.05        | -    | 0.3      | V          |
| High level source current | GP1 / GP2 / GP5 ... GP8:<br>@ 1k $\Omega$ load to GND      | 0.5          | 1    | -        | mA         |
| High level source current | GP3 / GP4<br>@ 1k $\Omega$ load to GND                     | 0.08         | 0.25 | -        | mA         |
| Low level sink current    | GP1 / GP2 / GP5 ... GP8:<br>@ 1k $\Omega$ load to $V_{DD}$ | 0.8          | 1.5  | -        | mA         |
| Low level sink current    | GP3 / GP4:<br>@ 100 $\Omega$ load to $V_{DD}$              | 8.0          | 10   | -        | mA         |
| Input impedance           | digital input mode                                         | 100          | -    |          | k $\Omega$ |
| Input voltage range       | GP1 / GP2                                                  | 0            | -    | 3.5      | V          |
| High level input voltage  | GP5 / GP6 used as digital input                            | 2.2          | -    | 3.5      | V          |
| Low level input voltage   | GP5 / GP6 used as digital input                            | -0.05        | -    | 1.0      | V          |

#### 3.11.1 Serial data interface

The TDA7528 features a serial data port for communication with the microcontroller. It is used to program the TDA7528 and to convey the read-out values of its detectors. This port supports data communication using the SPI and the I<sup>2</sup>C protocols.

Pin configuration of the serial data interface:

**Table 26. Pin configuration of the serial data interface**

| Signal # | Pin  | SPI signal                           | Pin  | I <sup>2</sup> C signal              |
|----------|------|--------------------------------------|------|--------------------------------------|
| Signal 1 | PS   | Protocol Select SPI/I <sup>2</sup> C | PS   | Protocol Select SPI/I <sup>2</sup> C |
| Signal 2 | CS   | Chip Select                          | AS   | Address Select                       |
| Signal 3 | CLK  | Clock                                | CLK  | Clock                                |
| Signal 4 | MOSI | Master Out – Slave In                | DATA | bidirectional Data                   |
| Signal 5 | MISO | Master In – Slave Out                | GP6  | General Purpose Out                  |

The "PS"-pin (Protocol Select) determines which communication protocol is used for communication between the microcontroller and the TDA7528. The information is not latched, so any level change at this pin immediately affects the protocol used by the TDA7528.<sup>(a)</sup>

### 3.11.2 Communication using the I<sup>2</sup>C protocol

For I<sup>2</sup>C communication, pin "PS" needs to be open. Pin "AS" (Address Select) determines which I<sup>2</sup>C address or group of addresses (see below) is used for communication between the microcontroller and TDA7528. Three different external connections are defined to represent three groups of addresses. The information is not latched, so any level change at this pin immediately affects the address used by the TDA7528.<sup>(b)</sup>

- 
- a. Protocol changes are not permitted during a communication sequence unless the I<sup>2</sup>C STOP condition is established or in SPI mode the CS line is deactivated, because the consequences are not predictable. Usually there is no need for any protocol change during operation, so the PS pin is connected to either GND or left open
  - b. Address changes are not permitted during an I<sup>2</sup>C communication sequence unless the I<sup>2</sup>C STOP condition is established, because the consequences are not predictable. Usually there is no need for any address change during operation, so the AS pin is connected to either GND, an 20k pull down resistor or left open.

## I<sup>2</sup>C addresses

**Table 27. I<sup>2</sup>C addresses**

| Tuner:              | Tuner 3   | Tuner 2               | Tuner 1   |
|---------------------|-----------|-----------------------|-----------|
| "AS"-pin connection | open      | 20k +/- 50% pull down | GND       |
| address:            | 1100 1xxd | 1100 x1xd             | 1100 xx1d |
| MSB ... LSB         | -         | -                     | -         |
| 1100 000d           | -         | -                     | -         |
| 1100 001d           | -         | -                     | R / W     |
| 1100 010d           | -         | R / W                 | -         |
| 1100 011d           | -         | W                     | W         |
| 1100 100d           | R / W     | -                     | -         |
| 1100 101d           | W         | -                     | W         |
| 1100 110d           | W         | W                     | -         |
| 1100 111d           | W         | W                     | W         |

x = must be "0" for reading, can be "1" or "0" for writing to the TDA7528

d = determinates the direction of data transfer, reading or writing

R / W = indicates the address to write to and/or to read from a TDA7528

W = indicates those addresses that can be used to transmit equal data to several TDA7528s, e.g. to program an synchronous AF jump of two tuners. A read out has no purpose for these addresses.

### 3.11.3 Communication using the SPI protocol

For SPI communication, pin "PS" needs to be connected to GND.

No IC address is transmitted in SPI mode, as in this mode the chip is selected through its CS (Chip Select) line.

SPI-Protocol: CPOL=1, CPHA=1

**Table 28. Communication using the SPI protocol electrical characteristics**

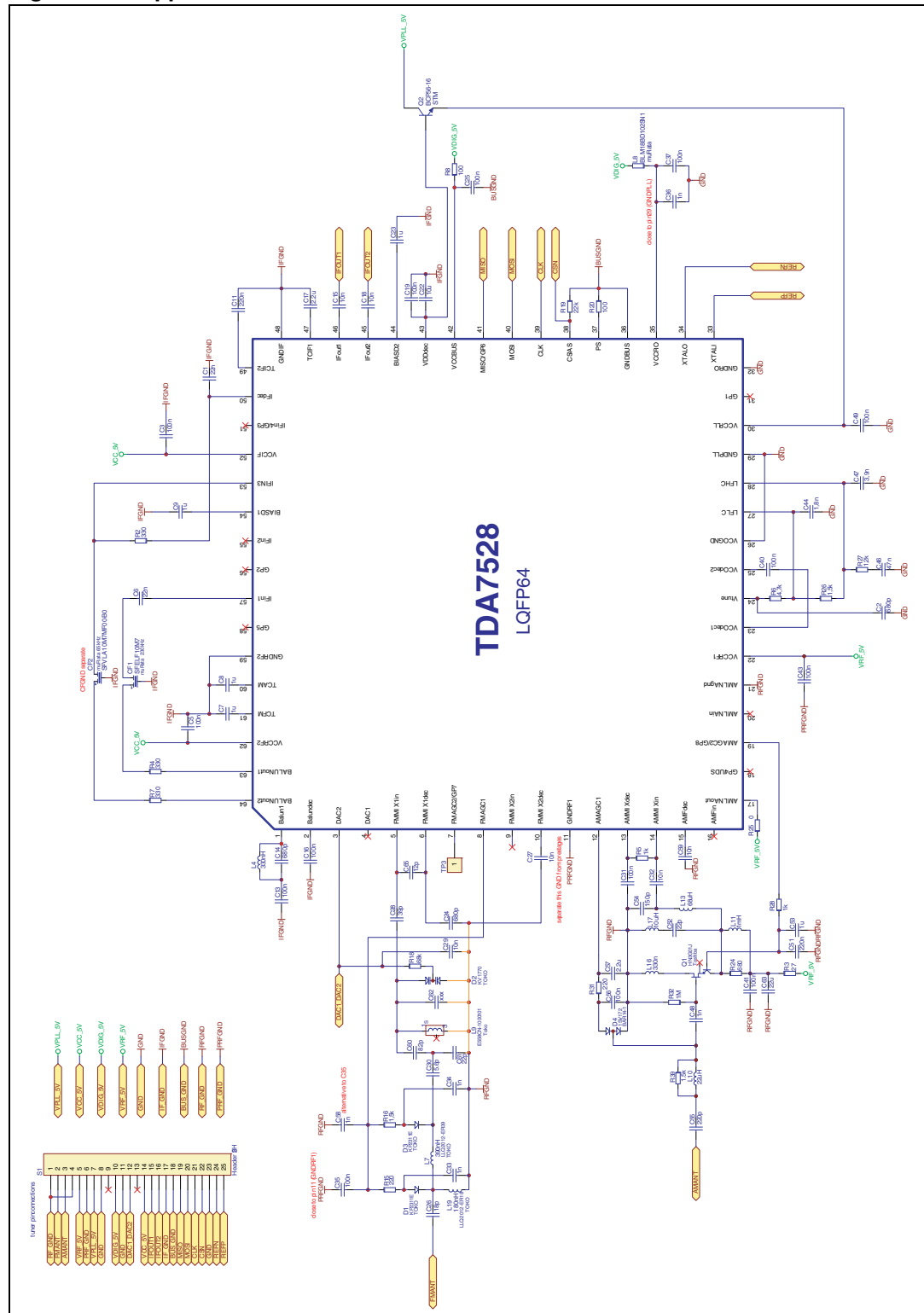
| Parameter                 | Test condition                                                | Min.                 | Typ | Max             | Units      |
|---------------------------|---------------------------------------------------------------|----------------------|-----|-----------------|------------|
| Clock frequency           | Guaranteed range @ SPI<br>Guaranteed range @ I <sup>2</sup> C | 4<br>1               | -   | -               | MHz<br>MHz |
| Inter byte time           | -                                                             | -                    | -   | 0               |            |
| Power-on delay time       | Ready for communication after<br>power-on reset               | -                    | -   | 10              | ms         |
| High level output voltage | Output signals                                                | V <sub>DD</sub> -0.3 | -   | V <sub>DD</sub> | V          |
| Low level output voltage  | Output signals                                                | -0.05                | -   | 0.3             | V          |
| High level source current | Output signals                                                | -                    | 0.1 | -               | mA         |
| low level sink current    | Output signals                                                | -                    | 1   | -               | mA         |
| High level input voltage  | Input signals, except AS                                      | 2.3                  | -   | 3.5             | V          |
| Low level input voltage   | Input signals, except AS                                      | -0.05                | -   | 1.0             | V          |
| Internal pull up resistor | AS pin                                                        | 16.5                 | 20  | 24              | kΩ         |
| Internal pull up resistor | PS pin                                                        | 16.5                 | 20  | 24              | kΩ         |

**Table 28. Communication using the SPI protocol electrical characteristics**

| Parameter          | Test condition              | Min. | Typ | Max | Units      |
|--------------------|-----------------------------|------|-----|-----|------------|
| Input impedance    | Input signals, except AS,PS | 100  | -   | -   | k $\Omega$ |
| Power-on impedance | All signals, except AS, PS  | 100  | -   | -   | k $\Omega$ |

## 4 Application information

### Figure 8. Application information



## 5 Programming information

### 5.1 Address organization

Figure 9. Address organization

| Name        | No | r/w | MSB                                                                                                                     | 6           | 5           | 4           | 3            | 2            | 1            | LSB            |
|-------------|----|-----|-------------------------------------------------------------------------------------------------------------------------|-------------|-------------|-------------|--------------|--------------|--------------|----------------|
| Short reg   | 0  | r/w | x                                                                                                                       | PWRSTABLEw  | ShAGC       | ShPLL       | ADCstart     | ADCEn        | GPIOen       | PWR            |
| ADCctrl     | 1  | r/w | ADCclk                                                                                                                  | ADCs2       | ADCs1       | ADCs0       |              | RCenable     | ADCautomode  | Temp_pwr       |
| GPIOmode    | 2  | r/w | GPO8                                                                                                                    | GPO7        | GPO6        | GPO5        | GPO4         | GPO3         | GPO2         | GPIO1          |
| AGCmixCtrl  | 3  | r/w |                                                                                                                         | KeyAGCen    | FMAGCpwr    | AMAGCpwr    |              |              | Mixout1      | Mixout2        |
| Supply      | 4  | r/w | refmode1                                                                                                                | refmode0    | DivRen      | VCCmon_adj1 | VCCmon_adj0  | En_VCCmon    | VDD_korr     | VDD_int_ext    |
| DivR1       | 5  | r/w | divr15                                                                                                                  | divr14      | divr13      | divr12      | divr11       | divr10       | divr9        | divr8          |
| IFAGC       | 6  | r/w | IFAGC_FM_AM                                                                                                             | IFAGCthr2   | IFAGCthr1   | IFAGCthr0   |              |              |              | IFsection_pwr  |
| FMAGC       | 7  | r/w | FMthr3                                                                                                                  | FMthr2      | FMthr1      | FMthr0      | FMAGCmodeC1  | FMAGCmodeC0  | FMAGCmodeV1  | FMAGCmodeV0    |
| FM_AM_Vthr  | 8  | r/w | AMAGCflat                                                                                                               | AM2nd_order | Vthr5       | Vthr4       | Vthr3        | Vthr2        | Vthr1        | Vthr0          |
| MIXalign1   | 9  | r/w | AAfilt1                                                                                                                 | AAfilt0     |             |             | Mix_ctl      | IMRF2        | IMRF1        | IMRF0          |
| MIXalign2   | 10 | r/w | IMRph3                                                                                                                  | IMRph2      | IMRph1      | IMRph0      | IMRG3        | IMRG2        | IMRG1        | IMRG0          |
| PLLctrl     | 11 | r/w | DZ2                                                                                                                     | DZ1         | DS2         | DS1         | VCOext       | PLLtest2     | PLLtest      | PLLpwr         |
| PLLctrl2    | 12 | r/w | CompDAC3                                                                                                                | CompDAC2    | CompDAC1    | CompDAC0    | CompDACtest2 | CompDACtest1 | CompDACtest0 | CompDACdisable |
| PLLtest     | 13 | r/w | POL                                                                                                                     | PFD_D1      | PFD_D0      | PLLt4       | PLLt3        | PLLt2        | PLLt1        | PLLt0          |
| Misc1       | 14 | r/w | AGCtest1                                                                                                                | AGCtest0    | BalunoutIMP | Ired_Balun  | IredH        | IredL        | VCOMag1      | VCOMag0        |
| Misc2       | 15 | r/w | IFbufG2                                                                                                                 | IFbufG1     | IFbufG0     | IFbufin     | IFbufPWR     | RC_test      | RCfreq_1     | RCfreq_0       |
| AGCctc_A    | 16 | r/w | IFAGCctcAM                                                                                                              | IFAGCctcFM  | AMtc1       | AMtc0       | FMTc3        | FMTc2        | FMTc1        | FMTc0          |
| AMAGC_A     | 17 | r/w | AMthr3                                                                                                                  | AMthr2      | AMthr1      | AMthr0      | AMAGCmodeC1  | AMAGCmodeC0  | AMAGCmodeV1  | AMAGCmodeV0    |
| GPIOm_A     | 18 | r/w | GPO8hi                                                                                                                  | GPO7hi      | GPO6hi      | GPO5hi      | GPO4hi       | GPO3hi       | GPO2hi       | GPIO1hi        |
| IFCTRL_A    | 19 | r/w | IFin0_Std_IBOC                                                                                                          | IFAmpgainA2 | IFAmpgainA1 | IFAmpgainA0 | MixinFM      | MixinAM_LPF  | MixinFMAM    | IFin1_AM_FM    |
| DivV_A      | 20 | r/w | VCO1r                                                                                                                   | divVA6      | divVA6      | divVA6      | divVA6       | divVA6       | divVA6       | divVA0         |
| DivN_A1     | 21 | r/w | divnA20                                                                                                                 | divnA19     | divnA18     | divnA17     | divnA16      | divnA15      | divnA14      | divnA13        |
| DivN_A2     | 22 | r/w | divnA12                                                                                                                 | divnA11     | divnA10     | divnA9      | divnA8       | divnA7       | divnA6       | divnA5         |
| DivN_A3     | 23 | r/w | divnA4                                                                                                                  | divnA3      | divnA2      | divnA1      | divnA0       | fracA2       | fracA1       | fracA0         |
| DivR2_A     | 24 | r/w | divr7                                                                                                                   | divr6       | divr5       | divr4       | divr3        | divr2        | divr1        | divr0          |
| CPcur_A     | 25 | r/w | CPAh3                                                                                                                   | CPAh2       | CPAh1       | CPAh0       | CPA3         | CPA2         | CPA1         | CPA0           |
| DAC1_A      | 26 | r/w | DAC1A8                                                                                                                  | DAC1A7      | DAC1A6      | DAC1A5      | DAC1A4       | DAC1A3       | DAC1A2       | DAC1A1         |
| DAC2_A      | 27 | r/w | DAC2A8                                                                                                                  | DAC2A7      | DAC2A6      | DAC2A5      | DAC2A4       | DAC2A3       | DAC2A2       | DAC2A1         |
| PLL_DAC_A   | 28 | r/w | IQsetA                                                                                                                  | VCOsw       | CPctr11     | CPctr10     | DAC2A0       |              | DAC2off      | DAC1off        |
| AMFilt_A    | 29 | r/w | AMfita7                                                                                                                 | AMfita6     | AMfita5     | AMfita4     | AMfita3      | AMfita2      | AMfita1      | AMfita0        |
| Misc3_A     | 30 | r/w |                                                                                                                         |             |             |             | DivVtest     | divnA21      | CPAh0        | AMfita0        |
| ADCTest_A   | 31 | r/w | IF test                                                                                                                 | ADC test    | ADCDAC5     | ADCDAC4     | ADCDAC3      | ADCDAC2      | ADCDAC1      | ADCDAC0        |
| AGCctc_B    | 32 | r/w | this byte is valid on the output if bit SHAGC is set to '1', otherwise byte Nr. 16 is valid on the output               |             |             |             |              |              |              |                |
| AMAGC_B     | 33 | r/w | all bytes from 33 to 47 are valid on the output if SHPLL is set to '1', otherwise byte 17 to 31 are valid on the output |             |             |             |              |              |              |                |
| GPIOm_B     | 34 | r/w |                                                                                                                         |             |             |             |              |              |              |                |
| IFCTRL_B    | 35 | r/w |                                                                                                                         |             |             |             |              |              |              |                |
| DivV_B      | 36 | r/w |                                                                                                                         |             |             |             |              |              |              |                |
| DivN_B1     | 37 | r/w |                                                                                                                         |             |             |             |              |              |              |                |
| DivN_B2     | 38 | r/w |                                                                                                                         |             |             |             |              |              |              |                |
| DivN_B3     | 39 | r/w |                                                                                                                         |             |             |             |              |              |              |                |
| DivR2_B     | 40 | r/w |                                                                                                                         |             |             |             |              |              |              |                |
| CPcur_B     | 41 | r/w |                                                                                                                         |             |             |             |              |              |              |                |
| DAC1_B      | 42 | r/w |                                                                                                                         |             |             |             |              |              |              |                |
| DAC2_B      | 43 | r/w |                                                                                                                         |             |             |             |              |              |              |                |
| PLL_DAC_B   | 44 | r/w |                                                                                                                         |             |             |             |              |              |              |                |
| AMFilt_B    | 45 | r/w |                                                                                                                         |             |             |             |              |              |              |                |
| Misc3_B     | 46 | r/w |                                                                                                                         |             |             |             |              |              |              |                |
| ADCTest_B   | 47 | r/w |                                                                                                                         |             |             |             |              |              |              |                |
| READ_Status | 48 | r   |                                                                                                                         |             | GPIO6r      | GPIO5r      | PWR_stable   | MaskSet0     | MaskSet1     | MaskSet2       |
| READ_ADC    | 49 | r   |                                                                                                                         | ADCok       | ADC5        | ADC4        | ADC3         | ADC2         | ADC1         | ADC0           |

initialization registers, to be changed after power on  
depends on reception band (FM / MW / SW / ...)  
to be changed with each frequency change  
additional controls, changed independent from reception  
IF buffer control  
test registers, not to be changed at all

Note: The power on value of all registers is zero.

## 5.2 Data byte specification

### 5.2.1 Short\_reg (0)

Table 29. Short\_reg (0)

| MSB            |                |                |                |                |                |                | LSB            | Function                                                                                     |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------------------------------------------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                                                              |
| -              | -              | -              | -              | -              | -              | -              | 0<br>1         | <b>Global PWR</b><br>Power down the IC<br>Power on the IC                                    |
| -              | -              | -              | -              | -              | -              | 0<br>1         | -              | <b>GPIO enable</b><br>all GPIO in tristate<br>all GPIO enable                                |
| -              | -              | -              | -              | -              | 0<br>1         | -              | -              | <b>ADCen</b><br>6bit ADC on<br>6bit ADC off                                                  |
| -              | -              | -              | -              | 0<br>1         | -              | -              | -              | <b>ADCstart</b><br>N/A<br>Starts a single AD conversion                                      |
| -              | -              | -              | 0<br>1         | -              | -              | -              | -              | <b>ShPLL</b><br>PLL register from 17 to 31 are valid<br>PLL register from 33 to 47 are valid |
| -              | -              | 0<br>1         | -              | -              | -              | -              | -              | <b>ShAGC</b><br>AGC TC register 16 is valid<br>AGC TC register 32 is valid                   |
| -              | 0<br>1         | -              | -              | -              | -              | -              | -              | <b>Power stable</b><br>N/A<br>sets the power stable read bit                                 |
| 0              | -              | -              | -              | -              | -              | -              | -              | <b>Has to be 0</b>                                                                           |

## 5.2.2 ADCctrl (1)

Table 30. ADCctrl (1)

| MSB            |                                      |                                      |                                      |                |                |                | LSB            | Function                                                                                                                                                |
|----------------|--------------------------------------|--------------------------------------|--------------------------------------|----------------|----------------|----------------|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub>                       | D <sub>5</sub>                       | D <sub>4</sub>                       | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                                                                                                                         |
| -              | -                                    | -                                    | -                                    | -              | -              | -              | 0<br>1         | <b>Temperature sensor power</b><br>Enabled<br>Disabled                                                                                                  |
| -              | -                                    | -                                    | -                                    | -              | -              | 0<br>1         | -              | <b>ADC auto mode</b><br>automatic restart disable<br>automatic restart enable                                                                           |
| -              | -                                    | -                                    | -                                    | -              | 0<br>1         | -              | -              | <b>RC oscillator enable</b><br>enable<br>disable                                                                                                        |
| -              | -                                    | -                                    | -                                    | X              | -              | -              | -              | <b>ADCstart (like bit 0.3)</b>                                                                                                                          |
| -              | 0<br>1<br>0<br>1<br>0<br>1<br>0<br>1 | 0<br>0<br>1<br>1<br>0<br>0<br>1<br>1 | 0<br>0<br>0<br>0<br>1<br>1<br>1<br>1 | -              | -              | -              | -              | <b>ADC input selection</b><br>Temp sensor<br>FM AGC<br>AM AGC<br>IF AGC<br>VCO tuning voltage ( $3/5 \cdot V_{tune}$ )<br>GP1<br>GP2<br>$2/5 \cdot VCC$ |
| 0<br>1         | -                                    | -                                    | -                                    | -              | -              | -              | -              | <b>ADC clock selection</b><br>ADC clock source = RC osc<br>ADC clock source = refdiv output                                                             |

### 5.2.3 GPIO mode (2)

Table 31. GPIO mode (2)

| MSB            |                |                |                |                |                |                |                | GPIO function                                                                                                                             |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                                                                                                           |
| -              | -              | -              | -              | -              | -              | -              | 0<br>1         | <b>GPIO1 input / output</b><br>Analog input to AD converter<br>digital output                                                             |
| -              | -              | -              | -              | -              | -              | 0<br>1         | -              | <b>GPIO2 input / output</b><br>Analog input to AD converter<br>Digital output                                                             |
| -              | -              | -              | -              | -              | 0<br>1         | -              | -              | <b>GPIO3 input / output</b><br>Analog Input<br>Digital output                                                                             |
| -              | -              | -              | -              | 0<br>1         | -              | -              | -              | <b>GPIO4 input / output</b><br>Analog Input<br>Digital output                                                                             |
| -              | -              | -              | 0<br>1         | -              | -              | -              | -              | <b>GPIO5 input / output</b><br>Digital input if IF buffer amplifier = OFF,<br>analog output if IF buffer amplifier = ON<br>Digital output |
| -              | -              | 0<br>1         | -              | -              | -              | -              | -              | <b>GPIO6 input / output</b><br>Digital input (or MISO output in SPI mode)<br>Digital output (or MISO output in SPI mode)                  |
| -              | 0<br>1         | -              | -              | -              | -              | -              | -              | <b>GPIO7 input / output</b><br>Digital output<br>FM AGC voltage output                                                                    |
| 0<br>1         | -              | -              | -              | -              | -              | -              | -              | <b>GPIO8 input / output</b><br>Digital output<br>AM AGC voltage output                                                                    |

### 5.2.4 AGC and mixer control (3)

Table 32. AGC and mixer control (3)

| MSB            |                |                |                |                |                |                | LSB            | Function                                                  |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                           |
| -              | -              | -              | -              | -              | -              | 0              | 0              | <b>Mixout 1 / 2</b><br>All Off = power down mixer section |
| -              | -              | -              | -              | -              | -              | 0              | 1              | Mixout 2 active                                           |
| -              | -              | -              | -              | -              | -              | 1              | 0              | Mixout 1 active                                           |
| -              | -              | -              | -              | -              | -              | 1              | 1              | Forbidden state                                           |
| -              | -              | -              | -              | 0              | 0              | -              | -              | <b>Has to be 0</b>                                        |
| -              | -              | -              | 0              | -              | -              | -              | -              | <b>AM AGC On / Off</b><br>Off<br>On                       |
| -              | -              | 0              | -              | -              | -              | -              | -              | <b>FM AGC On / Off</b><br>Off<br>On                       |
| -              | 0              | -              | -              | -              | -              | -              | -              | <b>Keyed AGC enable</b><br>Keyed AGC off<br>keyed AGC on  |
| 0              | -              | -              | -              | -              | -              | -              | -              | <b>Has to be 0</b>                                        |

### 5.2.5 Supply control (4)

Table 33. Supply control (4)

| MSB              |                  |                |                  |                  |                |                | LSB            | Divider R value                                                                                                                            |
|------------------|------------------|----------------|------------------|------------------|----------------|----------------|----------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| D <sub>7</sub>   | D <sub>6</sub>   | D <sub>5</sub> | D <sub>4</sub>   | D <sub>3</sub>   | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                                                                                                            |
| -                | -                | -              | -                | -                | -              | -              | 0<br>1         | <b>VDD regulator connection intern / extern</b><br>external VDD source for VDDPLL is used<br>VDDPLL is derived from onboard NPN transistor |
| -                | -                | -              | -                | -                | -              | 0<br>1         | -              | <b>VDD regulator voltage correction</b><br>internal VDD 150mV lower<br>internal VDD corrected if external source used                      |
| -                | -                | -              | -                | -                | 0<br>1         | -              | -              | <b>Enable low voltage detection on VCC</b><br>VCC low voltage detection off<br>VCC low voltage detection on                                |
| -                | -                | -              | 0<br>0<br>1<br>1 | 0<br>1<br>0<br>1 | -              | -              | -              | <b>Threshold of low voltage detection</b><br>4.3V<br>4.4V<br>4.5V<br>4.6V                                                                  |
| -                | -                | 0<br>1         | -                | -                | -              | -              | -              | <b>Divider R enable</b><br>Divider R off; => DivR value = 1<br>Divider R on                                                                |
| 0<br>0<br>1<br>1 | 0<br>1<br>0<br>1 | -              | -                | -                | -              | -              | -              | <b>Reference oscillator mode</b><br>off<br>single ended mode<br>differential LVDS input<br>controlled XO-mode                              |

### 5.2.6 Divider R MSB (5)

Table 34. Divider R MSB (5)

| MSB            |                |                |                |                |                |                | LSB            | Divider R value                                     |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                     |
| X              | -              | -              | -              | -              | -              | -              | X              | <b>Divider R value</b><br>DivR8<br>:<br>:<br>DivR15 |

### 5.2.7 IF AGC control (6)

Table 35. IF AGC control (6)

| MSB            |                       |                       |                       |                |                |                |                | Function                                                                                                                                                                                                             |
|----------------|-----------------------|-----------------------|-----------------------|----------------|----------------|----------------|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub>        | D <sub>5</sub>        | D <sub>4</sub>        | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                                                                                                                                                                                      |
| -              | -                     | -                     | -                     | -              | -              | -              | 0<br>1         | <b>IF section On / Off</b><br>Off<br>On                                                                                                                                                                              |
| -              | -                     | -                     | -                     | 0              | 0              | 0              | -              | Has to be 0                                                                                                                                                                                                          |
| -              | 0<br>0<br>:<br>:<br>1 | 0<br>0<br>:<br>:<br>1 | 0<br>1<br>:<br>:<br>1 | -              | -              | -              | -              | <b>IF AGC threshold</b><br>IF output level = 99dB $\mu$ V(AM) / 105dB $\mu$ V (FM)<br>IF output level = 101dB $\mu$ V(AM) / 107dB $\mu$ V (FM)<br>:<br>:<br>IF output level = 113dB $\mu$ V(AM) / 119dB $\mu$ V (FM) |
| 0<br>1         | -                     | -                     | -                     | -              | -              | -              | -              | <b>IF AGC mode FM / AM selection</b><br>FM mode<br>AM mode                                                                                                                                                           |

### 5.2.8 FM AGC (7)

Table 36. FM AGC (7)

| MSB                                            |                                                |                                                |                                                |                            |                            |                            |                            | Function                                                                                                                                                                                                                                                                                                                                                                                                                             |
|------------------------------------------------|------------------------------------------------|------------------------------------------------|------------------------------------------------|----------------------------|----------------------------|----------------------------|----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| D <sub>7</sub>                                 | D <sub>6</sub>                                 | D <sub>5</sub>                                 | D <sub>4</sub>                                 | D <sub>3</sub>             | D <sub>2</sub>             | D <sub>1</sub>             | D <sub>0</sub>             |                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| -                                              | -                                              | -                                              | -                                              | 0<br>1<br>1<br>0<br>1<br>0 | 0<br>0<br>1<br>1<br>0<br>0 | 0<br>0<br>0<br>0<br>1<br>1 | 0<br>0<br>0<br>0<br>1<br>0 | <b>AGC output mode</b><br>Off<br>positive current output (mode 1)<br>pos / neg current output (mode 2)<br>constant 2mA current output (mode 3)<br>voltage and current output with hand over (mode 4)<br>calibration mode for voltage output (mode 5)                                                                                                                                                                                 |
| 0<br>0<br>:<br>:<br>0<br>1<br>1<br>:<br>:<br>1 | 0<br>0<br>:<br>:<br>1<br>0<br>0<br>:<br>:<br>1 | 0<br>0<br>:<br>:<br>1<br>0<br>0<br>:<br>:<br>1 | 0<br>1<br>:<br>:<br>1<br>0<br>1<br>:<br>:<br>1 | -                          | -                          | -                          | -                          | <b>FM AGC threshold</b><br>mixer input level = 93dB $\mu$ V (FM1) / 99dB $\mu$ V (FM2)<br>Mixer input level = 94dB $\mu$ V (FM1) / 100dB $\mu$ V (FM2)<br>:<br>:<br>Mixer input level = 100dB $\mu$ V (FM1)/ 106dB $\mu$ V (FM2)<br>Mixer input level = 93dB $\mu$ V (FM1)/ 99dB $\mu$ V (FM2)<br>Mixer input level = 92dB $\mu$ V (FM1)/ 98dB $\mu$ V (FM2)<br>:<br>:<br>Mixer input level = 86dB $\mu$ V (FM1)/ 92dB $\mu$ V (FM2) |

### 5.2.9 AGC voltage threshold (8)

Table 37. AGC voltage threshold (8)

| MSB            |                |                            |                            |                            |                            |                            |                            | Function                                                                                                                                   |
|----------------|----------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub>             | D <sub>4</sub>             | D <sub>3</sub>             | D <sub>2</sub>             | D <sub>1</sub>             | D <sub>0</sub>             |                                                                                                                                            |
| -              | -              | 0<br>0<br>:<br>:<br>1<br>1 | 0<br>0<br>:<br>:<br>1<br>1 | 0<br>0<br>:<br>:<br>1<br>1 | 0<br>0<br>:<br>:<br>1<br>1 | 0<br>0<br>:<br>:<br>1<br>1 | 0<br>1<br>:<br>:<br>0<br>1 | <b>Transfer voltage from voltage out to current out</b><br>200mV<br>237.5mV<br>:<br>:<br>2.5625V<br>2.6V                                   |
| -              | 0<br>1         | -                          | -                          | -                          | -                          | -                          | -                          | <b>AMAGC 2nd order lowpass</b><br>AMAGC voltage is derived from TCAM<br>AMAGC voltage is derived from GP2 (for 2nd order lowpass function) |
| 0<br>1         | -              | -                          | -                          | -                          | -                          | -                          | -                          | <b>AM fast attack</b><br>Off<br>On                                                                                                         |

### 5.2.10 Mixer alignment 1 (9)

Table 38. Mixer alignment 1 (9)

| MSB            |                |                |                |                |                                 |                                 |                                 | Function                                                                               |
|----------------|----------------|----------------|----------------|----------------|---------------------------------|---------------------------------|---------------------------------|----------------------------------------------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub>                  | D <sub>1</sub>                  | D <sub>0</sub>                  |                                                                                        |
| -              | -              | -              | -              | -              | 0<br>0<br>:<br>:<br>1<br>:<br>1 | 0<br>0<br>:<br>:<br>0<br>:<br>1 | 0<br>1<br>:<br>:<br>0<br>:<br>1 | <b>IQ-filter frequency adjust</b><br>+2.4MHz<br>+1.8MHz<br>:<br>:<br>0<br>:<br>-1.8MHz |
| -              | -              | -              | -              | 0              | -                               | -                               | -                               | <b>Only for test, has to be '0'</b>                                                    |
| -              | -              | 0              | 0              | -              | -                               | -                               | -                               | <b>Has to be 0</b>                                                                     |
| 1<br>0<br>0    | 0<br>0<br>1    | -              | -              | -              | -                               | -                               | -                               | <b>AA filter frequency adjust</b><br>20.00 MHz<br>14.75 MHz<br>10.87 MHz               |

### 5.2.11 Mixer alignment 2 (10)

Table 39. Mixer alignment 2 (10)

| MSB            |                |                |                | LSB            |                |                |                | Function               |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|------------------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| -              | -              | -              | -              | 0              | 1              | 1              | 1              | IQ-filter gain adjust  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|                |                |                |                | 0              | 1              | 1              | 0              | -0.7dB                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|                |                |                |                | 0              | 1              | 0              | 1              | -0.6dB                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|                |                |                |                | :              | :              | :              | :              | -0.5dB                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|                |                |                |                | 0              | 0              | 0              | 0              | :                      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|                |                |                |                | 1              | 0              | 0              | 0              | 0dB                    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|                |                |                |                | :              | :              | :              | :              | 0dB                    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|                |                |                |                | 1              | 1              | 1              | 0              | :                      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|                |                |                |                | 1              | 1              | 1              | 1              | +0.6dB                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|                |                |                |                | 1              | 1              | 1              | 1              | +0.7dB                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 0              | 0              | 0              | 0              | -              | -              | -              | -              | IQ-filter phase adjust |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 0              | 0              | 0              | 1              |                |                |                |                | 0                      | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0              | 0              | 1              | 0              |                |                |                |                | 0                      | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0              | 0              | 1              | 1              |                |                |                |                | 0                      | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0              | 1              | 0              | 0              |                |                |                |                | 0                      | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| :              | :              | :              | :              |                |                |                |                | 0                      | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0              | 1              | 1              | 1              |                |                |                |                | 0                      | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1              | 0              | 0              | 0              |                |                |                |                | 0                      | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1              | 0              | 0              | 1              |                |                |                |                | 0                      | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1              | 0              | 1              | 0              |                |                |                |                | 0                      | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1              | 0              | 1              | 1              |                |                |                |                | 0                      | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1              | 1              | 0              | 0              |                |                |                |                | 0                      | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| :              | :              | :              | :              |                |                |                |                | 0                      | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1              | 1              | 1              | 0              |                |                |                |                | 0                      | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1              | 1              | 1              | 1              |                |                |                |                | 0                      | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

### 5.2.12 PLL control 1 (11)

Table 40. PLL control 1 (11)

| MSB              |                  |                  |                  |                |                |                | LSB            | Function                                                                                           |
|------------------|------------------|------------------|------------------|----------------|----------------|----------------|----------------|----------------------------------------------------------------------------------------------------|
| D <sub>7</sub>   | D <sub>6</sub>   | D <sub>5</sub>   | D <sub>4</sub>   | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                                                                    |
| -                | -                | -                | -                | -              | -              | -              | 0<br>1         | <b>PLL enable</b><br>PLL Off<br>PLL On                                                             |
| -                | -                | -                | -                | 0              | 0              | 0              | -              | <b>Only for test, has to be 0</b>                                                                  |
| -                | -                | 0<br>:<br>1<br>0 | 0<br>:<br>1<br>1 | -              | -              | -              | -              | <b>Delay of high current CP</b><br>longest<br>:<br>shortest<br>default for optimum PLL performance |
| 0<br>:<br>1<br>0 | 0<br>:<br>1<br>1 | -                | -                | -              | -              | -              | -              | <b>Slope of high current CP</b><br>slowest<br>:<br>fastest<br>default for optimum PLL performance  |

### 5.2.13 PLL control 2 (12)

Table 41. PLL control 2 (12)

| MSB                                                                |                                                               |                                                               |                                                               |                |                |                | LSB            | Function                                                                                                                                                                                                                                                                                                                                                                                                                |
|--------------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|----------------|----------------|----------------|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| D <sub>7</sub>                                                     | D <sub>6</sub>                                                | D <sub>5</sub>                                                | D <sub>4</sub>                                                | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                                                                                                                                                                                                                                                                                                                                                                                         |
| -                                                                  | -                                                             | -                                                             | -                                                             | -              | -              | -              | 0<br>1         | <b>Compensation DAC disable</b><br>compensation DAC on (use in fractional mode)<br>compensation DAC off (use in integer mode)                                                                                                                                                                                                                                                                                           |
| -                                                                  | -                                                             | -                                                             | -                                                             | 0              | 0              | 0              | -              | <b>Only for test, has to be '0'</b>                                                                                                                                                                                                                                                                                                                                                                                     |
| 0<br>1<br>0<br>1<br>0<br>:<br>1<br>0<br>1<br>0<br>1<br>:<br>1<br>1 | 0<br>0<br>1<br>1<br>0<br>:<br>1<br>0<br>1<br>1<br>:<br>1<br>0 | 0<br>0<br>0<br>0<br>1<br>:<br>1<br>0<br>0<br>0<br>:<br>1<br>0 | 0<br>0<br>0<br>0<br>0<br>:<br>0<br>1<br>1<br>1<br>:<br>1<br>1 | -              | -              | -              | -              | <b>Current trimming of compensation DAC</b><br>compensation current -44%<br>compensation current -37.5 %<br>compensation current -31.25%<br>compensation current -25%<br>compensation current -18.7%<br>:<br>default current +/-0%<br>compensation current +6.25%<br>compensation current +12.5%<br>compensation current +18.75%<br>compensation current +25%<br>:<br>compensation current +50%<br><b>optimum value</b> |

### 5.2.14 PLL test (13)

Table 42. PLL test (13)

| MSB            |                |                |                |                |                |                |                | Function                                          |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|---------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                   |
| -              | -              | -              | -              | -              | 1              | 0              | 1              | <b>PLL test</b><br>PLL in standard operation mode |
| -              | -              | -              | 0              | 0              | -              | -              | -              | <b>Only for test, has to be 0</b>                 |
| -              | 0              | 1              | -              | -              | -              | -              | -              | <b>PFD</b><br>Default delay settings              |
| 0              | -              | -              | -              | -              | -              | -              | -              | <b>Only for test, has to be 0</b>                 |

### 5.2.15 Misc 1 (14)

Table 43. Misc 1 (14)

| MSB            |                |                  |                  |                  |                  |                  |                  | Function                                                                                                                                                                                                      |
|----------------|----------------|------------------|------------------|------------------|------------------|------------------|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub>   | D <sub>4</sub>   | D <sub>3</sub>   | D <sub>2</sub>   | D <sub>1</sub>   | D <sub>0</sub>   |                                                                                                                                                                                                               |
| -              | -              | -                | -                | -                | -                | 0<br>0<br>1<br>1 | 0<br>1<br>0<br>1 | <b>VCO magnitude</b><br>1V - default<br>2V<br>3V<br>4V                                                                                                                                                        |
| -              | -              | -                | -                | 0<br>0<br>1<br>1 | 0<br>1<br>0<br>1 | -                | -                | <b>Current reduction of mixer</b><br>full current<br>-2mA<br>-4mA<br>do not use                                                                                                                               |
| -              | -              | 0<br>0<br>1<br>1 | 0<br>1<br>0<br>1 | -                | -                | -                | -                | <b>Current reduction of active balun</b><br>full current (necessary for 2 IF-filters)<br>-2mA (2 IF-filters, reduced output voltage)<br>-4mA (for 1IF filter)<br>-6,5mA (1 IF filter, reduced output voltage) |
| 0              | 0              | -                | -                | -                | -                | -                | -                | <b>Only for test, has to be 0</b>                                                                                                                                                                             |

## 5.2.16 Misc 2 (15)

Table 44. Misc 2 (15)

| MSB            |                |                |                |                |                |                | LSB            |                                                         | Function |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|---------------------------------------------------------|----------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                         |          |
|                |                |                |                |                |                | 0              | 0              | <b>Oscillation frequency of RC oscillator</b>           |          |
| -              | -              | -              | -              | -              | -              | 0              | 1              | 0.68 MHz                                                |          |
|                |                |                |                |                |                | 1              | 0              | 1.31 MHz                                                |          |
|                |                |                |                |                |                | 1              | 0              | 1.9 MHz                                                 |          |
|                |                |                |                |                |                | 1              | 1              | 2.5 MHz                                                 |          |
| -              | -              | -              | -              | -              | 0              |                |                | <b>Only for test, has to be 0</b>                       |          |
|                |                |                |                |                |                |                |                | <b>IF buffer amplifier enable</b>                       |          |
| -              | -              | -              | -              | 0              | -              | -              | -              | IF buffer amplifier off                                 |          |
|                |                |                |                | 1              |                |                |                | IF buffer amplifier on (GPIO5 need to be digital input) |          |
|                |                |                |                |                |                |                |                | <b>IF buffer amplifier input selector</b>               |          |
| -              | -              | -              | 0              | -              | -              | -              | -              | input = IFin1                                           |          |
|                |                |                | 1              |                |                |                |                | input = IFin2                                           |          |
|                |                |                |                |                |                |                |                | <b>IF buffer amplifier gain</b>                         |          |
| 0              | 0              | 0              |                |                |                |                |                | -11dB                                                   |          |
| 0              | 0              | 1              |                |                |                |                |                | -9dB                                                    |          |
| 0              | 1              | 0              |                |                |                |                |                | -7dB                                                    |          |
| 0              | 1              | 1              | -              | -              | -              | -              | -              | -5dB                                                    |          |
| 1              | 0              | 0              |                |                |                |                |                | -3dB                                                    |          |
| :              | :              | :              |                |                |                |                |                | :                                                       |          |
| 1              | 1              | 1              |                |                |                |                |                | 3dB                                                     |          |

### 5.2.17 AGC time constant settings (16 / 32)

Table 45. AGC time constant settings (16 / 32)

| MSB            |                |                |                |                |                |                | LSB            | Function                                                                  |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|---------------------------------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                                           |
| -              | -              | -              | -              | -              | -              | 0              | 0              | <b>FM AGC decay time constant</b><br>D3 (125ms)<br>D2 (25ms)<br>D1 (5ms)  |
|                |                |                |                |                |                | 0              | 1              |                                                                           |
|                |                |                |                |                |                | 1              | 0              |                                                                           |
| -              | -              | -              | -              | 0              | 0              | -              | -              | <b>FM AGC attack time constant</b><br>A3 (12.5)<br>A2 (2.5)<br>A1 (0.5)   |
|                |                |                |                | 0              | 1              |                |                |                                                                           |
|                |                |                |                | 1              | 0              |                |                |                                                                           |
| -              | -              | 0              | 0              | -              | -              | -              | -              | <b>AM AGC time constant</b><br>T3 (125ms)<br>T2 (25ms)<br>T1 (5ms)        |
|                |                | 0              | 1              |                |                |                |                |                                                                           |
|                |                | 1              | 0              |                |                |                |                |                                                                           |
| -              | 0              | -              | -              | -              | -              | -              | -              | <b>IF AGC time constant FM</b><br>U 1 (250μs attack)<br>U 2 (50μs attack) |
|                | 1              |                |                |                |                |                |                |                                                                           |
| 0              | -              | -              | -              | -              | -              | -              | -              | <b>IF AGC time constant AM</b><br>S1 (100ms)<br>S2 (10ms)                 |
| 1              |                |                |                |                |                |                |                |                                                                           |

## 5.2.18 AMAGC control (17 / 33)

Table 46. AMAGC control (17 / 33)

| MSB            |                |                |                |                |                |                |                | LSB                                                  | Function |   |   |                                                       |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|------------------------------------------------------|----------|---|---|-------------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                      |          |   |   |                                                       |
| -              | -              | -              | -              | 0              | 0              | 0              | 0              | <b>AM AGC output mode</b>                            |          |   |   |                                                       |
|                |                |                |                | 1              | 0              | 0              | 0              | Off                                                  |          |   |   |                                                       |
|                |                |                |                | 0              | 1              | 0              | 0              | Positive current output for PIN diode (mode1)        |          |   |   |                                                       |
|                |                |                |                | 1              | 0              | 0              | 1              | Constant 2mA output (mode2)                          |          |   |   |                                                       |
|                |                |                |                | 1              | 0              | 1              | 1              | Voltage and current output / internal sense (mode3a) |          |   |   |                                                       |
|                |                |                |                | 1              | 1              | 1              | 0              | Voltage and current output /external sense (mode3b)  |          |   |   |                                                       |
|                |                |                |                | 0              | 0              | 1              | 0              | Calibration for mode 3a (mode4a)                     |          |   |   |                                                       |
| 0              | 0              | 0              | 0              | -              | -              | -              | -              | <b>AM AGC thresholds</b>                             |          |   |   |                                                       |
|                |                |                |                |                |                |                |                | 1                                                    | 0        | 0 | 0 | Input level = 95.3 dBμV (mixer); 100.3 dBμV (filter)  |
|                |                |                |                |                |                |                |                | 1                                                    | 0        | 0 | 1 | Input level = 96.2 dBμV (mixer); 101.2 dBμV (filter)  |
|                |                |                |                |                |                |                |                | :                                                    | :        | : | : | :                                                     |
|                |                |                |                |                |                |                |                | :                                                    | :        | : | : | :                                                     |
|                |                |                |                |                |                |                |                | 1                                                    | 1        | 1 | 1 | Input level = 101.5 dBμV (mixer); 106.5 dBμV (filter) |
|                |                |                |                |                |                |                |                | 1                                                    | 0        | 0 | 0 | Input level = 95.3 dBμV (mixer); 100.3 dBμV (filter)  |
| 1              | 1              | 1              | 1              | -              | -              | -              | -              | Input level = 94.4 dBμV (mixer); 99.4 dBμV (filter)  |          |   |   |                                                       |
|                |                |                |                |                |                |                |                | :                                                    | :        | : | : | :                                                     |
|                |                |                |                |                |                |                |                | :                                                    | :        | : | : | :                                                     |
|                |                |                |                |                |                |                |                | 1                                                    | 1        | 1 | 1 | Input level = 89 dBμV (mixer); 94 dBμV (filter)       |
|                |                |                |                |                |                |                |                | :                                                    | :        | : | : | :                                                     |
|                |                |                |                |                |                |                |                | :                                                    | :        | : | : | :                                                     |
|                |                |                |                |                |                |                |                | 1                                                    | 1        | 1 | 1 | Input level = 89 dBμV (mixer); 94 dBμV (filter)       |

## 5.2.19 GPIO output level control (18 / 34)

Table 47. GPIO output level control (18 / 34)

| MSB            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                |                |                |                |                |                | LSB | Function |
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| D <sub>7</sub> | D <sub>6</sub>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        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| 0<br>1         | :<br>X<br>:<br><br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>:<br>: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|                |                |                |                |                |                |     |          |

## 5.2.20 IF control (19 / 35)

Table 48. IF control (19 / 35)

| MSB            |                |                |                |                |                |                | LSB            | Function                                                                                                                                                                  |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                                                                                                                                           |
| 0              |                |                |                |                |                |                | 0              | <b>IF input selection</b><br>IF input AM IBOC (=IFin4)<br>IF input FM IBOC (=IFin2)<br>IF input AM analog (=IFin3)<br>IFinput FM analog (=IFin1)                          |
| 0              | -              | -              | -              | -              | -              | -              | 1              |                                                                                                                                                                           |
| 1              |                |                |                |                |                |                | 0              |                                                                                                                                                                           |
| 1              |                |                |                |                |                |                | 1              |                                                                                                                                                                           |
| -              | -              | -              | -              | -              | -              | 0              | -              | <b>Mixer input FM / AM selection</b><br>AM input active<br>FM input active                                                                                                |
|                |                |                |                |                |                | 1              | -              |                                                                                                                                                                           |
| -              | -              | -              | -              | -              | 0              | -              | -              | <b>Mixer input selection for AM</b><br>AM mixer input<br>AM low pass filter input                                                                                         |
|                |                |                |                |                | 1              | -              | -              |                                                                                                                                                                           |
| -              | -              | -              | -              | 0              | -              | -              | -              | <b>Mixer input selection for FM</b><br>FM1 mixer input<br>FM2 mixer input                                                                                                 |
|                |                |                |                | 1              | -              | -              | -              |                                                                                                                                                                           |
| -              | 0              | 0              | 0              |                |                |                |                | <b>IF amplifier Gain</b><br>23dB (input1-3) / 16dB (input4)<br>25dB (input1-3) / 18dB (input4)<br>:<br>35dB (input1-3) / 28dB (input4)<br>37dB (input1-3) / 30dB (input4) |
|                | 0              | 0              | 1              | -              | -              | -              | -              |                                                                                                                                                                           |
|                | :              | :              | :              |                |                |                |                |                                                                                                                                                                           |
|                | 1              | 1              | 0              |                |                |                |                |                                                                                                                                                                           |
|                | 1              | 1              | 1              |                |                |                |                |                                                                                                                                                                           |

## 5.2.21 VCO divider (V-divider) (20 / 36)

Table 49. VCO divider (V-divider) (20 / 36)

| MSB            |                |                |                |                |                |                | LSB            | Function                                                         |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|------------------------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                                  |
|                |                |                |                |                |                |                | X              | <b>Divider V value</b><br>V0<br>V1<br>V2<br>V3<br>V4<br>V5<br>V6 |
|                |                |                |                |                |                | X              |                |                                                                  |
|                |                |                |                | X              | X              |                |                |                                                                  |
|                |                |                | X              |                |                |                |                |                                                                  |
|                | X              | X              |                |                |                |                |                |                                                                  |
|                |                |                |                |                |                |                |                |                                                                  |
|                |                |                |                |                |                |                |                |                                                                  |
| 0              | -              | -              | -              | -              | -              | -              | -              | <b>VCO range selection</b><br>Range 2<br>Range 1                 |
| 1              |                |                |                |                |                |                |                |                                                                  |

Note: Effective V-divider value =  $4^*(V+4)$ , V-patterns xxx0000 are not allowed.

### 5.2.22 PLL main divider (N-divider) 1 (21 / 37)

Table 50. PLL main divider (N-divider) 1 (21 / 37)

| MSB            |                |                |                |                |                |                |                | Function                                                              |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------------------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                                       |
| X              | X              | X              | X              | X              | X              | X              | X              | Divider N value<br>M8<br>M9<br>M10<br>M11<br>M12<br>M13<br>M14<br>M15 |

### 5.2.23 PLL main divider (N-divider) 2 (22 / 38)

Table 51. PLL main divider (N-divider) 2 (22 / 38)

| MSB            |                |                |                |                |                |                |                | Function                                                        |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                                 |
| X              | X              | X              | X              | X              | X              | X              | X              | Divider N value<br>M0<br>M1<br>M2<br>M3<br>M4<br>M5<br>M6<br>M7 |

### 5.2.24 PLL main divider (N-divider) 3 (23 / 39)

Table 52. PLL main divider (N-divider) 3 (23 / 39)

| MSB            |                |                |                |                |                |                |                | Function                                                        |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                                 |
| X              | X              | X              | X              | X              | X              | X              | X              | Divider N value<br>K0<br>K1<br>K2<br>A0<br>A1<br>A2<br>A3<br>A4 |

### 5.2.25 PLL Divider ratio calculation

Table 53. PLL Divider ratio calculation

| M counter          |     |     |    |     |    |    | A counter |    |    |    |    | K (fractional) |    |    | Notes                                                                       |
|--------------------|-----|-----|----|-----|----|----|-----------|----|----|----|----|----------------|----|----|-----------------------------------------------------------------------------|
| M16 <sup>(1)</sup> | M15 | ... | M7 | ... | M1 | M0 | A4        | A3 | A2 | A1 | A0 | K2             | K1 | K0 | $N = 32 \cdot P + A + K/6$ M=32<br>$N = M \cdot P + A + K/6$ M>32<br>(P=32) |

1. Bit M16 is D2 of reg30

### 5.2.26 Divider R LSB (24/40)

Table 54. Divider R LSB (24/40)

| MSB            |                |                |                |                |                |                |                | LSB                                         | Divider R value |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|---------------------------------------------|-----------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                             |                 |
| X              | -              | -              | -              | -              | -              | -              | X              | Divider R value<br>DivR0<br>:<br>:<br>DivR7 |                 |

### 5.2.27 Charge pump current (25 / 41)

Table 55. Charge pump current (25 / 41)

| MSB            |                |                |                |                |                |                |                | LSB                                                                      | FUNCTION |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|--------------------------------------------------------------------------|----------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                                          |          |
| -              | -              |                | X              | X              | X              | X              | X              | Low current charge pump<br>65 µA<br>130 µA<br>260 µA<br>520 µA<br>980 µA |          |
| X              | X              | X              | -              | -              | -              | -              | -              | High current charge pump<br>1mA<br>2mA<br>4mA                            |          |

## 5.2.28 Tuning DAC 1 (26 / 42)

Table 56. Tuning DAC 1 (26 / 42)

| MSB            |                |                |                |                |                |                | LSB            | Function                                                                                                  |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------------------------------------------------------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                                                                           |
| X              | X              | X              | X              | X              | X              | X              | X              | <b>DAC 1 voltage 7..0</b><br>DAC1_0<br>DAC1_1<br>DAC1_2<br>DAC1_3<br>DAC1_4<br>DAC1_5<br>DAC1_6<br>DAC1_7 |

Note:  $DAC\ 1\ output\ voltage = 600mV + DAC1val * 18mV$

## 5.2.29 Tuning DAC 2 (27 / 43)

Table 57. Tuning DAC 2 (27 / 43)

| MSB            |                |                |                |                |                |                | LSB            | Function                                                                                                  |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------------------------------------------------------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                                                                           |
| X              | X              | X              | X              | X              | X              | X              | X              | <b>DAC 2 voltage 8..1</b><br>DAC2_1<br>DAC2_2<br>DAC2_3<br>DAC2_4<br>DAC2_5<br>DAC2_6<br>DAC2_7<br>DAC2_8 |

Note:  $DAC\ 2\ output\ voltage = 600mV + DAC2val * 9mV$

### 5.2.30 Different controls (28 / 44)

Table 58. Different controls (28 / 44)

| MSB            |                |                |                |                |                |                | LSB            | Function                                                                                                |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|---------------------------------------------------------------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                                                                         |
| -              | -              | -              | -              | -              | -              | -              | 0<br>1         | <b>DAC 1 On / Off</b><br>Off<br>On                                                                      |
| -              | -              | -              | -              | -              | -              | 0<br>1         | -              | <b>DAC 2 On / Off</b><br>Off<br>On                                                                      |
| -              | -              | -              | -              | -              | X              | -              | -              | <b>Not used</b>                                                                                         |
| -              | -              | -              | -              | X              | -              | -              | -              | <b>DAC 2_0</b>                                                                                          |
| -              | -              | -              | 0              | -              | -              | -              | -              | <b>Only for test, has to be 0</b>                                                                       |
| -              | -              | 0<br>1         | -              | -              | -              | -              | -              | <b>Charge pump control</b><br>high current controlled from phase error - default<br>high current on     |
| -              | 0<br>1         | -              | -              | -              | -              | -              | -              | <b>VCO 1 / VCO 2 select</b><br>VCO 2 used (3.7GHz)<br>VCO 1 used (4.7GHz)                               |
| 0<br>1         | -              | -              | -              | -              | -              | -              | -              | <b>IQ phase select</b><br>I anticipates Q (low side injection)<br>Q anticipates I (high side injection) |

## 5.2.31 AM filter adjust (29 / 45)

Table 59. AM filter adjust (29 / 45)

| MSB            |                |                |                |                |                |                |                | Function                                           |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                    |
| 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | AM filter corner frequency (-3dB point)<br>1.2 MHz |
| 0              | 0              | 0              | 1              | 0              | 0              | 0              | 0              |                                                    |
| 0              | 0              | 1              | 0              | 0              | 0              | 0              | 0              |                                                    |
| 0              | 0              | 1              | 1              | 0              | 0              | 0              | 0              |                                                    |
| 0              | 1              | 0              | 0              | 0              | 0              | 0              | 0              |                                                    |
| 0              | 1              | 0              | 1              | 0              | 0              | 0              | 0              |                                                    |
| 0              | 1              | 1              | 0              | 0              | 0              | 0              | 0              |                                                    |
| 0              | 1              | 1              | 1              | 0              | 0              | 0              | 0              |                                                    |
| 1              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | 2.38 MHz                                           |
| 1              | 0              | 0              | 0              | 1              | 0              | 0              | 0              |                                                    |
| 1              | 0              | 0              | 1              | 0              | 0              | 0              | 0              |                                                    |
| 1              | 0              | 0              | 1              | 1              | 0              | 0              | 0              |                                                    |
| 1              | 0              | 1              | 0              | 0              | 0              | 0              | 0              |                                                    |
| 1              | 0              | 1              | 0              | 1              | 0              | 0              | 0              |                                                    |
| 1              | 0              | 1              | 1              | 0              | 0              | 0              | 0              |                                                    |
| 1              | 0              | 1              | 1              | 1              | 0              | 0              | 0              |                                                    |
| 1              | 1              | 0              | 0              | 0              | 0              | 0              | 0              | 4.64 MHz                                           |
| 1              | 1              | 0              | 0              | 0              | 1              | 0              | 0              |                                                    |
| 1              | 1              | 0              | 0              | 1              | 0              | 0              | 0              |                                                    |
| 1              | 1              | 0              | 0              | 1              | 1              | 0              | 0              |                                                    |
| 1              | 1              | 0              | 1              | 0              | 0              | 0              | 0              |                                                    |
| 1              | 1              | 0              | 1              | 0              | 1              | 0              | 0              |                                                    |
| 1              | 1              | 0              | 1              | 1              | 0              | 0              | 0              |                                                    |
| 1              | 1              | 0              | 1              | 1              | 1              | 0              | 0              |                                                    |
| 1              | 1              | 1              | 0              | 0              | 0              | 0              | 0              | 8.87 MHz                                           |
| 1              | 1              | 1              | 0              | 0              | 0              | 1              | 0              |                                                    |
| 1              | 1              | 1              | 0              | 0              | 1              | 0              | 0              |                                                    |
| 1              | 1              | 1              | 0              | 0              | 1              | 1              | 0              |                                                    |
| 1              | 1              | 1              | 0              | 1              | 0              | 0              | 0              |                                                    |
| 1              | 1              | 1              | 0              | 1              | 0              | 1              | 0              |                                                    |
| 1              | 1              | 1              | 0              | 1              | 1              | 0              | 0              |                                                    |
| 1              | 1              | 1              | 0              | 1              | 1              | 1              | 0              |                                                    |

Table 59. AM filter adjust (29 / 45) (continued)

| MSB                                     |                |                |                |                |                |                |                | LSB       | Function |
|-----------------------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------|----------|
| D <sub>7</sub>                          | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |           |          |
| AM filter corner frequency (-3dB point) |                |                |                |                |                |                |                |           |          |
| 1                                       | 1              | 1              | 1              | 0              | 0              | 0              | 0              | 16.31 MHz |          |
| 1                                       | 1              | 1              | 1              | 0              | 0              | 0              | 1              | 17.03 MHz |          |
| 1                                       | 1              | 1              | 1              | 0              | 0              | 1              | 0              | 18.07 MHz |          |
| 1                                       | 1              | 1              | 1              | 0              | 0              | 1              | 1              | 18.95 MHz |          |
| 1                                       | 1              | 1              | 1              | 0              | 1              | 0              | 0              | 20.31 MHz |          |
| 1                                       | 1              | 1              | 1              | 0              | 1              | 0              | 1              | 21.43 MHz |          |
| 1                                       | 1              | 1              | 1              | 0              | 1              | 1              | 0              | 23.10 MHz |          |
| 1                                       | 1              | 1              | 1              | 0              | 1              | 1              | 1              | 24.56 MHz |          |
| 1                                       | 1              | 1              | 1              | 1              | 0              | 0              | 0              | 27.91 MHz |          |
| 1                                       | 1              | 1              | 1              | 1              | 0              | 0              | 1              | 30.12 MHz |          |
| 1                                       | 1              | 1              | 1              | 1              | 0              | 1              | 0              | 33.56 MHz |          |
| 1                                       | 1              | 1              | 1              | 1              | 0              | 1              | 1              | 36.80 MHz |          |
| 1                                       | 1              | 1              | 1              | 1              | 1              | 0              | 0              | 42.56 MHz |          |
| 1                                       | 1              | 1              | 1              | 1              | 1              | 0              | 1              | 47.89 MHz |          |
| 1                                       | 1              | 1              | 1              | 1              | 1              | 1              | 0              | 57.14 MHz |          |
| 1                                       | 1              | 1              | 1              | 1              | 1              | 1              | 1              | 67.17 MHz |          |

## 5.2.32 Misc 3 (30 / 46)

Table 60. Misc 3 (30 / 46)

| MSB            |                |                |                |                |                |                | LSB            | Function                                       |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                |
| -              | -              | -              | -              | -              | -              | -              | 0<br>1         | <b>AMLNA on / off</b><br>AMLNA off<br>AMLNA on |
| -              | -              | -              | -              | -              | -              | X              | -              | <b>High current chargepump</b><br>0.5 mA       |
| -              | -              | -              | -              | -              | X              | -              | -              | <b>PLL N divider MSB</b><br>M16                |
| -              | -              | -              | -              | 0              | -              | -              | -              | <b>Only for test, has to be 0</b>              |
| 0              | 0              | 0              | 0              | -              | -              | -              | -              | <b>Has to be 0</b>                             |

## 5.2.33 AD converter test (31 / 47)

Table 61. AD converter test (31 / 47)

| MSB            |                |                |                |                |                |                | LSB            | Function                   |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                            |
| 0              | 0              | 0              | 0              | 0              | 0              | 0              | 0              | Only for test, has to be 0 |

## 5.2.34 Read 1 (48)

Table 62. Read 1 (48)

| MSB            |                |                |                |                |                       |                       | LSB                   | Function                                                                                                 |
|----------------|----------------|----------------|----------------|----------------|-----------------------|-----------------------|-----------------------|----------------------------------------------------------------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub>        | D <sub>1</sub>        | D <sub>0</sub>        |                                                                                                          |
| -              | -              | -              | -              | -              | 0<br>:<br>1<br>:<br>1 | 0<br>:<br>0<br>:<br>1 | 0<br>:<br>1<br>:<br>1 | <b>Mask set revision</b><br>1 <sup>st</sup><br>:<br>6 <sup>th</sup> = latest one<br>:<br>8 <sup>th</sup> |
| -              | -              | -              | -              | 0<br>1         | -                     | -                     | -                     | <b>PWR stable read bit</b><br>Supply voltage not OK, if bit was set once<br>Supply voltage OK            |
| -              | -              | -              | 0<br>1         | -              | -                     | -                     | -                     | <b>GPIO 5 level</b><br>low<br>high                                                                       |
| -              | -              | 0<br>1         | -              | -              | -                     | -                     | -                     | <b>GPIO 6 level</b><br>low<br>high                                                                       |
| -              | X              | -              | -              | -              | -                     | -                     | -                     | <b>not used</b>                                                                                          |
| X              | -              | -              | -              | -              | -                     | -                     | -                     | <b>not used</b>                                                                                          |

## 5.2.35 Read 2 (49)

Table 63. Read 2 (49)

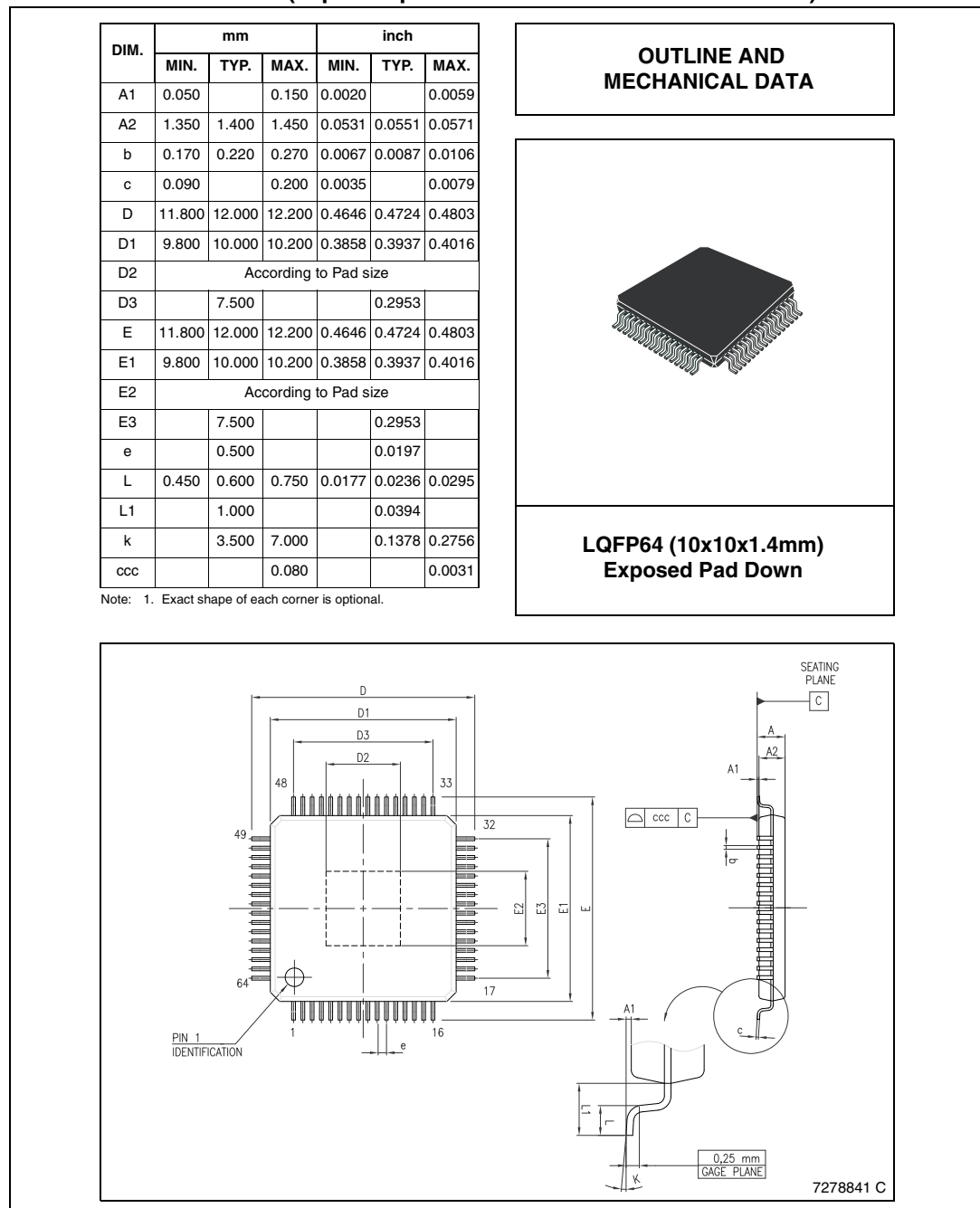
| MSB            |                |                |                |                |                |                | LSB            | Function                                                                              |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|---------------------------------------------------------------------------------------|
| D <sub>7</sub> | D <sub>6</sub> | D <sub>5</sub> | D <sub>4</sub> | D <sub>3</sub> | D <sub>2</sub> | D <sub>1</sub> | D <sub>0</sub> |                                                                                       |
| -              | -              | X              | X              | X              | X              | X              | X              | <b>AD converter result</b><br>ADC0<br>ADC1<br>ADC2<br>ADC3<br>ADC4<br>ADC5            |
| -              | 0<br>1         | -              | -              | -              | -              | -              | -              | <b>AD converter result status</b><br>Not OK (readout before converter finished)<br>OK |
| X              | -              | -              | -              | -              | -              | -              | -              | <b>not used</b>                                                                       |

## 6 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](http://www.st.com).

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**Figure 10. LQFP64 (10x10x1.4mm) exposed pad down mechanical data and package dimensions (exposed pad size for D2 and E2: 4.5mm max.)**



## 7 Revision history

**Table 64. Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                |
|-------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 25-Jan-2007 | 1        | Initial release.                                                                                                                                                                       |
| 08-Mar-2007 | 2        | Corrected typ. value of "I decay max (mode D1)" in the <a href="#">Table 8</a> on page 20.<br>Updated <a href="#">Table 41 on page 50</a> .                                            |
| 19-Mar-2007 | 3        | Corrected the Rev. number on page 1.                                                                                                                                                   |
| 01-Oct-2007 | 4        | Modified <a href="#">Table 56 on page 58</a> .                                                                                                                                         |
| 26-Jun-2008 | 5        | Modified <a href="#">Table 18 on page 32</a> , <a href="#">Table 31 on page 44</a> , <a href="#">Table 44 on page 52</a> .<br>Updated note below <a href="#">Table 49 on page 55</a> . |
| 17-Dec-2009 | 6        | Modified <a href="#">Table 28: Communication using the SPI protocol electrical characteristics on page 38</a> .                                                                        |
| 24-Sep-2013 | 7        | Updated disclaimer.                                                                                                                                                                    |

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