

Automotive GPS/Galileo/GLONASS/BeiDou/QZSS receiver

Datasheet - production data



Features



- AEC-Q100 qualified
 - STMicroelectronics® positioning receiver with 48 tracking channels and 2 fast acquisition channels supporting GPS, Galileo, GLONASS, BeiDou and QZSS systems
 - ST DRAW (Dead Reckoning Automotive Way) supported (STA8089GAD Only)
 - Pin to pin compatible with STA8088GA
 - Single die standalone receiver embedding RF Front-End and low noise amplifier
 - -162 dBm indoor sensitivity (tracking mode)
 - Fast TTFF < 1 s in Hot start and 30 s in Cold Start
 - High performance ARM946 MCU (up to 196 MHz)
 - External SQI Flash interface
 - 256 Kbyte embedded SRAM
 - Real Time Clock (RTC) circuit
 - 32-bit Watch-dog timer
 - 2 UARTs
 - 1 I²C master/slave interface
- USB2.0 full speed (12 MHz) with integrated physical layer transceiver
 - 2 Controller Area Network (CAN)
 - 2 channels ADC (10 bits)
 - Operating condition:
 - Main voltage regulator (V_{INL}): 1.8 V \pm 5%
 - Backup voltage (V_{INB}): 1.6 V to 4.3 V
 - Digital voltage (V_{DD}): 1.1 V to 1.32 V
 - RF core voltage (V_{CC}): 1.2 V \pm 10%
 - IO Ring Voltage (V_{ddIO}): 1.8 V \pm 5% or 3.3 V \pm 10%
 - Package:
 - VFQFPN56 (7 x 7 x 1.0 mm) 0.4 mm pitch
 - Operating temperature range: -40/+85°C

Description

STA8089GA belongs to Teseo III family products.

STA8089GA is a single die standalone positioning receiver IC working on multiple constellations (GPS/Galileo/GLONASS/BeiDou/QZSS).

STA8089GA is compliant with ST Automotive Grade qualification which includes in addition to AEC-Q100 requirements a set of production flow methodologies targeting zero defect per million.

STA8089GA, fulfilling high quality and service level requirements of the Automotive market, is the ideal solution for in-dash navigation and OEM telematics applications.

The device is offered with a complete GNSS firmware which performs all GNSS operations including tracking, acquisition, navigation and data output.

STA8089GAD can run also TESEO-DRAW the STMicroelectronics dead reckoning firmware.

Table 1. Device summary

| Root Part Number | Package | Packaging |
|-------------------------|-----------------|------------------|
| STA8089GA | VFQFPN56 7x7 mm | Tape and Reel |

Contents

| | | |
|----------|--|-----------|
| 1 | Overview | 7 |
| 2 | Pin description | 8 |
| 2.1 | Block diagram | 8 |
| 2.2 | VFQFPN56 pin configuration | 9 |
| 2.3 | Power supply pins | 9 |
| 2.4 | Main function pins | 10 |
| 2.5 | Test/emulated dedicated pins | 10 |
| 2.6 | Communication interface pins | 11 |
| 2.7 | RF front-end pins | 13 |
| 3 | General description | 14 |
| 3.1 | RF front end | 14 |
| 3.2 | GPS/Galileo/GLONASS/BeiDou Base Band (G3BB+) processor | 14 |
| 3.3 | MCU Subsystem | 14 |
| 3.3.1 | AHB slaves | 15 |
| 3.4 | APB peripherals | 16 |
| 3.4.1 | CAN | 16 |
| 3.4.2 | UART | 16 |
| 3.4.3 | I2C | 17 |
| 3.4.4 | MTU | 17 |
| 3.4.5 | WDT | 17 |
| 3.4.6 | GPIO | 18 |
| 3.4.7 | ADC | 18 |
| 3.4.8 | RTC | 18 |
| 4 | Electrical characteristics | 19 |
| 4.1 | Parameter conditions | 19 |
| 4.2 | Minimum and maximum values | 19 |
| 4.3 | Typical values | 19 |
| 4.4 | Typical curves | 19 |
| 4.5 | Absolute maximum ratings | 19 |
| 4.6 | Recommended DC operating conditions | 21 |

| | | |
|----------|--|-----------|
| 4.7 | DC characteristics | 22 |
| 4.8 | AC characteristics | 23 |
| 4.8.1 | RF electrical specifications | 23 |
| 4.8.2 | Oscillator electrical specifications | 25 |
| 4.8.3 | OSCI oscillator specifications | 26 |
| 4.8.4 | ADC specifications | 26 |
| 5 | Package and packing information | 28 |
| 5.1 | ECOPACK packages | 28 |
| 5.2 | VFQFPN56 7 x 7 mm package information | 28 |
| 6 | Ordering information | 30 |
| 7 | Revision history | 31 |

List of tables

| | | |
|-----------|--|----|
| Table 1. | Device summary | 2 |
| Table 2. | Power supply pins | 9 |
| Table 3. | Main function pins | 10 |
| Table 4. | Test/emulated dedicated pins | 10 |
| Table 5. | Communication interface pins | 11 |
| Table 6. | RF front-end pins | 13 |
| Table 7. | TCM Configuration | 15 |
| Table 8. | Voltage characteristics | 19 |
| Table 9. | Thermal characteristics | 20 |
| Table 10. | Frequency limits | 20 |
| Table 11. | Power consumption | 20 |
| Table 12. | Recommended DC operating conditions | 21 |
| Table 13. | LDO1 DC characteristics | 22 |
| Table 14. | LDO2 DC characteristics | 22 |
| Table 15. | Low voltage detection thresholds | 22 |
| Table 16. | I/O buffers DC characteristics | 22 |
| Table 17. | 1.0 V I/O buffers DC characteristics | 23 |
| Table 18. | RFCHAIN – GALGPS filter and VGA | 23 |
| Table 19. | RFCHAIN – GLONASS/BeiDou filter and VGA | 24 |
| Table 20. | Synthesizer | 24 |
| Table 21. | Crystal recommended specifications | 25 |
| Table 22. | Oscillator amplifier specifications | 25 |
| Table 23. | Characteristics of external slow clock input | 26 |
| Table 24. | SARADC specifications | 27 |
| Table 25. | VFQFPN56 7 x 7 mm package dimensions | 28 |
| Table 26. | Document revision history | 31 |

List of figures

| | | |
|-----------|---|----|
| Figure 1. | STA8089GA system block diagram | 8 |
| Figure 2. | VFQFPN56 connection diagram | 9 |
| Figure 3. | 32.768 kHz crystal connection | 26 |
| Figure 4. | SARADC connections. | 27 |
| Figure 5. | VFQFPN56 7 x 7 mm package dimension | 29 |
| Figure 6. | Ordering information scheme | 30 |

1 Overview

STA8089GA is one of the part number of Teseo III STA8089x series.

STA8089GA is a highly integrated single-chip standalone GNSS receiver designed for positioning system applications.

STA8089GA embeds the new ST GNSS positioning engine capable of receiving signals from multiple satellite navigation systems, including the US GPS, European Galileo, Russia's GLONASS, Chinese BeiDou and Japan's QZSS.

The STA8089GA ability of tracking simultaneously the signals from multiple satellites regardless of their constellation, make this chip capable of delivering exceptional accuracy in urban canyons and in the environments where buildings and other obstructions make satellite visibility challenging.

The STA8089GA is backward compatible with STA8088GA, enabling fast customer application migration.

The STA8089GA combines a high performance ARM946 microprocessor with I/O capabilities and enhanced peripherals. It supports USB2.0 standard at full speed (12 Mbps) with on-chip PHY.

The chip embeds backup logic with real time clock.

The device is offered with a complete firmware performing all positioning operations including acquisition, tracking, navigation and data output.

STA8089GAD can be offered also bundled with STMicroelectronics dead reckoning firmware called TESEO-DRAW; TESEO-DRAW firmware is a multi-sensors data fusion hub for Teseo family IC's.

The device powered with 1.8 V enables the on-chip voltage regulators to internally supply the RF front-end, core logic and the backup logic. The device can be directly powered with 1.2 V bypassing the embedded voltage regulators which will be put in power down mode.

I/O lines are compatible with 1.8 V and 3.3 V.

STA8089GA is compliant with ST Automotive Grade qualification which includes in addition to AEC-Q100 requirements a set of production flow methodologies targeting zero defect per million.

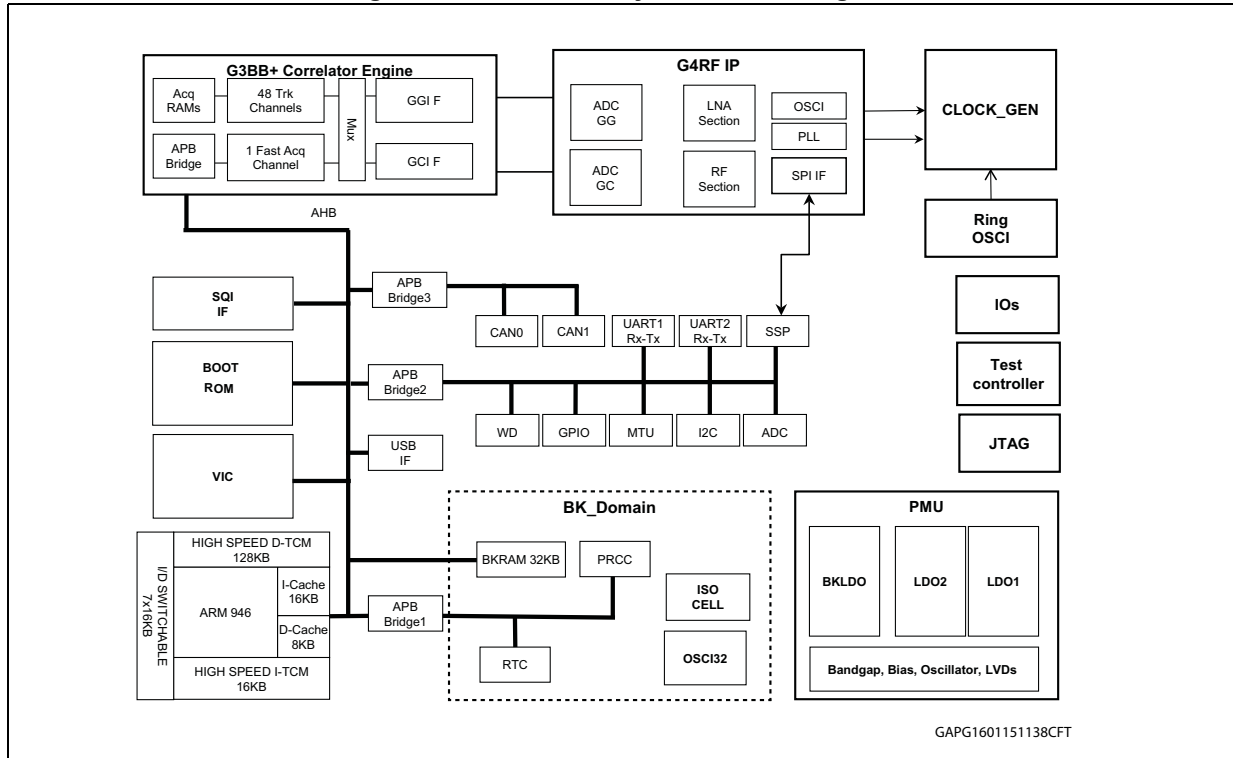
STA8089GA, fulfilling high quality and service level requirements of the Automotive market, is the ideal solution for in-dash navigation and OEM telematics applications.

The STA8089GA, using STMicroelectronics CMOSRF Technology, is housed in a VFQFPN56 (7 x 7 x 1.0 mm) package.

2 Pin description

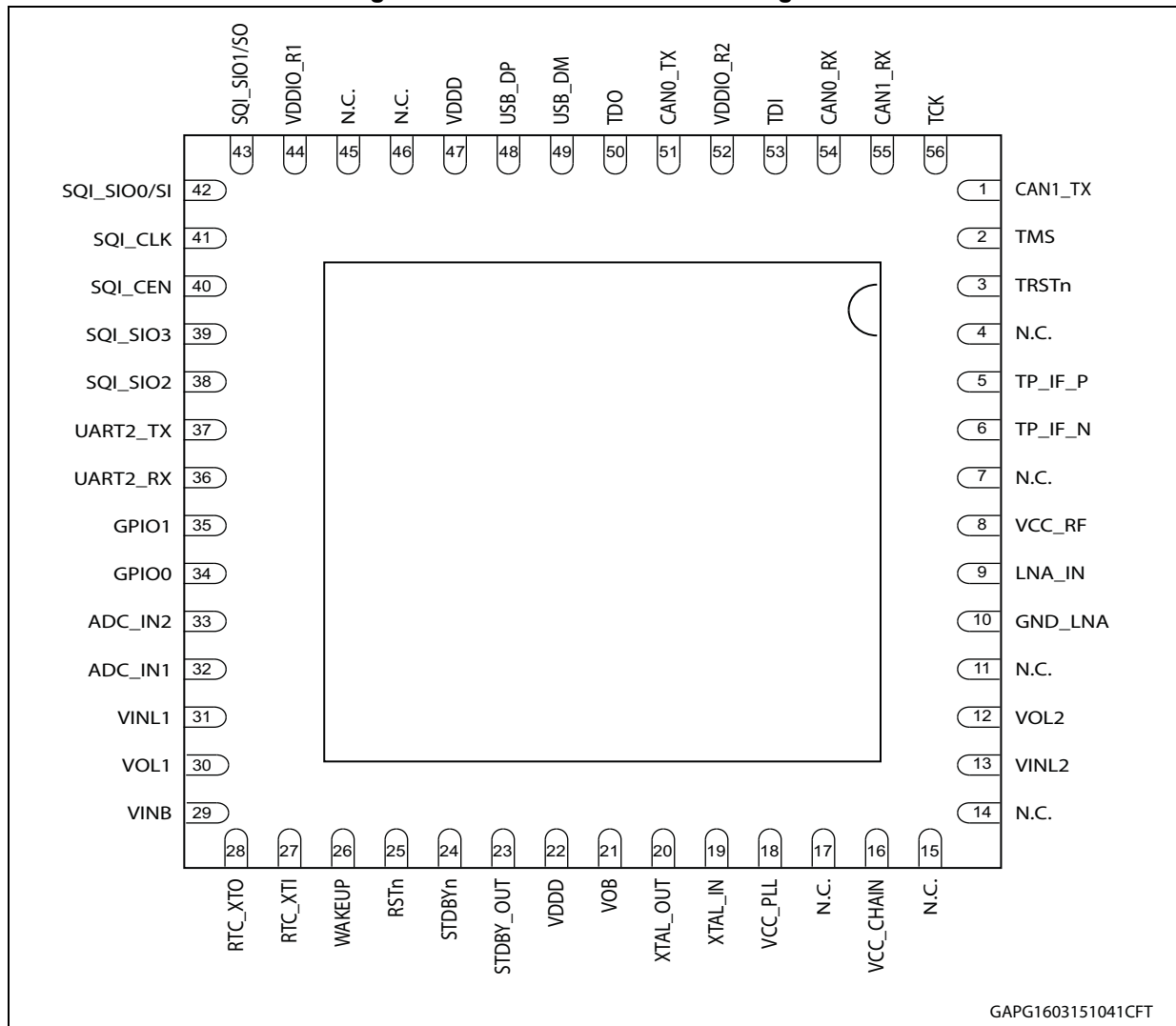
2.1 Block diagram

Figure 1. STA8089GA system block diagram



2.2 VFQFPN56 pin configuration

Figure 2. VFQFPN56 connection diagram



2.3 Power supply pins

Table 2. Power supply pins

| Symbol | I/O voltage | I/O | Description | STA8089GA |
|-----------|----------------|-----|---|-----------|
| VCC_CHAIN | 1.2 V | PWR | Analog supply voltage for RF chain (1.2 V) | 16 |
| VCC_PLL | 1.2 V | PWR | Analog supply voltage for PLL RF (1.2 V) | 18 |
| VCC_RF | 1.2 V | PWR | Analog supply voltage for RF (1.2 V) | 8 |
| VDDD | 1.2 V | PWR | Digital supply voltage | 22, 47 |
| VDDIO_R1 | 1.8 V or 3.3 V | PWR | Digital supply voltage for I/O ring 1 (1.8 V or 3.3V) | 44 |
| VDDIO_R2 | 3.3 V | PWR | Digital supply voltage for I/O ring 2 (3.3 V) | 52 |

Table 2. Power supply pins (continued)

| Symbol | I/O voltage | I/O | Description | STA8089GA |
|---------|---------------|-----|--|-----------|
| VINB | 1.6 V - 4.3 V | PWR | Backup LDO input supply voltage (1.6 V to 4.3 V) | 29 |
| VINL1 | 1.8 V | PWR | LDO1 and ADC input supply voltage | 31 |
| VINL2 | 1.6 V - 4.3 V | PWR | LDO2 input supply voltage (1.6 V to 4.3 V) | 13 |
| VOB | 1.0 V | PWR | LDO backup output voltage (1.0 V) | 21 |
| VOL1 | 1.2 V | PWR | LDO1 output voltage (1.2 V) | 30 |
| VOL2 | 1.2 V | PWR | LDO2 output voltage (1.2 V) | 12 |
| GND | GND | GND | Ground | EP |
| GND_LNA | GND | GND | Ground | 10 |

2.4 Main function pins

Table 3. Main function pins

| Symbol | I/O voltage | I/O | Description | STA8089GA |
|-----------------------|-----------------------|-----|--|-----------|
| ADC_IN1 | 1.4 V – 0 V typ range | I | ADC Analog input [1] | 32 |
| ADC_IN2 | 1.4 V – 0 V typ range | I | ADC Analog input [2] | 33 |
| RSTn | 1.0 V | I | Reset Input with Schmitt-Trigger characteristics and noise filter. | 25 |
| RTC_XTI | 1.0 V (max) | I | Input of the 32 KHz oscillator amplifier circuit and input of the internal real time clock circuit. | 27 |
| RTC_XTO | 1.0 V (max) | O | Output of the oscillator amplifier circuit. | 28 |
| STDBY_OUT | 1.0 V | O | When low, indicates the chip is in Standby mode | 23 |
| STDBYn ⁽¹⁾ | 1.0 V | I | When low, the chip is forced in Standby Mode - All pins in high impedance except the ones powered by Backup supply | 24 |
| WAKEUP | 1.0 V | I | WAKEUP from STANDBY mode | 26 |

1. As STDBYn is forced high to exit standby mode, VINL1 must be present within 200 μ s.

2.5 Test/emulated dedicated pins

Table 4. Test/emulated dedicated pins

| Symbol | I/O voltage | I/O | Description | STA8089GA |
|--------|-------------|-----|-------------------------|-----------|
| TCK | VDDIO_R2 | I | JTAG Test Clock | 56 |
| TDI | VDDIO_R2 | I | JTAG Test Data In | 53 |
| TDO | VDDIO_R2 | O | JTAG Test Data Out | 50 |
| TMS | VDDIO_R2 | I | JTAG Test Mode Select | 2 |
| TRSTn | VDDIO_R2 | I | JTAG Test Circuit Reset | 3 |

Table 4. Test/emulated dedicated pins (continued)

| Symbol | I/O voltage | I/O | Description | STA8089GA |
|---------|-------------|-----|-------------------------------|-----------|
| TP_IF_N | 1.2 V | O | Diff.Test Point for IF – Neg. | 6 |
| TP_IF_P | 1.2 V | O | Diff.Test Point for IF – Pos. | 5 |

2.6 Communication interface pins

Table 5. Communication interface pins

| Symbol | I/O voltage | I/O | Alternative function | Function | Description | STA8089GA |
|-------------|-------------|-----|----------------------|-------------|-------------------------------------|-----------|
| SQI_CLK | VDDIO_R1 | O | AF2 (default) | SQI_CLK | SQI Flash clock | 41 |
| | | — | AF0, AF1, AF3 | Reserved | Reserved | |
| SQI_CEN | VDDIO_R1 | O | AF2 (default) | SQI_CEN | SQI Flash chip enable | 40 |
| | | — | AF0, AF1, AF3 | Reserved | Reserved | |
| SQI_SIO0/SI | VDDIO_R1 | I/O | AF2 (default) | SQI_SIO0/SI | SQI Flash data IO 0 / ser. I/ BOOT2 | 42 |
| | | — | AF0, AF1, AF3 | Reserved | Reserved | |
| SQI_SIO1/SO | VDDIO_R1 | I/O | AF2 (default) | SQI_SIO1/SO | SQI Flash data IO 1 / ser. O | 43 |
| | | — | AF0, AF1, AF3 | Reserved | Reserved | |
| SQI_SIO2 | VDDIO_R1 | I/O | AF2 (default) | SQI_SIO2 | SQI Flash data IO 2 | 38 |
| | | — | AF0, AF1, AF3 | Reserved | Reserved | |
| SQI_SIO3 | VDDIO_R1 | I/O | AF2 (default) | SQI_SIO3 | SQI Flash data IO 3 / BOOT1 | 39 |
| | | — | AF0, AF1, AF3 | Reserved | Reserved | |
| CAN1_TX | VDDIO_R2 | O | AF0 | I2C_CLK | I2C clock | 1 |
| | | I/O | AF1 | GPIO8 | General purpose I/O #8 | |
| | | O | AF2 (default) | CAN1_TX | CAN1 transmit data output | |
| | | — | AF3 | Reserved | Reserved | |
| CAN1_RX | VDDIO_R2 | I/O | AF0 | I2C_SD | I2C serial data | 55 |
| | | I/O | AF1 | GPIO9 | General purpose I/O #9 | |
| | | I/O | AF2 (default) | CAN1_RX | CAN1 receive data input | |
| | | — | AF3 | Reserved | Reserved | |
| CAN0_TX | VDDIO_R2 | O | AF0 (default) | CAN0_TX | CAN0 transmit data output | 51 |
| | | O | AF1 | UART0_TX | UART0 Tx data | |
| | | I/O | AF2 | GPIO7 | General purpose I/O #7 | |
| | | O | AF3 | I2C_CLK | I2C clock | |

Table 5. Communication interface pins (continued)

| Symbol | I/O voltage | I/O | Alternative function | Function | Description | STA8089GA |
|----------|-------------|-----|----------------------|--------------------|---|-----------|
| CAN0_RX | VDDIO_R2 | I | AF0 (default) | CAN0_RX | CAN0 receive data input | 54 |
| | | I | AF1 | UART0_RX | UART0 receive data input | |
| | | I/O | AF2 | T _{SENSE} | External temperature capture port | |
| | | I/O | AF3 | I2C_SD | I2C serial data | |
| UART2_RX | VDDIO_R1 | I | AF0 (default) | UART2_RX | UART2 Rx data | 36 |
| | | I/O | AF1 | GPIO28 | General purpose I/O #28 | |
| | | I/O | AF2 | I2C_SD | I2C serial data | |
| | | — | AF3 | Reserved | Reserved | |
| UART2_TX | VDDIO_R1 | O | AF0 (default) | UART2_TX | UART2 Tx data / BOOT0 | 37 |
| | | I/O | AF1 | GPIO29 | General purpose I/O #29 | |
| | | O | AF2 | I2C_CLK | I2C clock | |
| | | — | AF3 | Reserved | Reserved | |
| GPIO0 | VDDIO_R1 | I/O | AF0 (default) | GPIO0 | General purpose I/O #0 | 34 |
| | | I | AF1 | PPS_IN | Pulse per second input | |
| | | O | AF2 | Timer_OCMPB | Extended Function Timer - Output Compare B | |
| | | O | AF3 | Mag_0 GC | GLONASS and BeiDou 3-bit coding Output (MAG0) | |
| GPIO1 | VDDIO_R1 | I/O | AF0 (default) | GPIO1 | General purpose I/O #1 / BOOT3 | 35 |
| | | — | AF1 | Reserved | Reserved | |
| | | O | AF2 | PPS_OUT | Pulse per second output | |
| | | I/O | AF3 | Tsense | External temperature capture port | |
| USB_DM | VDDIO_R2 | USB | AF0 | USB_DM | USB D- signal | 49 |
| | | I | AF1 (default) | UART1_RX | UART1 Rx data | |
| | | I | AF2 | CAN1_RX | CAN1 receive data input | |
| | | I/O | AF3 | I2C_SD | I2C serial data | |
| USB_DP | VDDIO_R2 | USB | AF0 | USB_DP | USB D+ signal | 48 |
| | | O | AF1 (default) | UART1_TX | UART1 Tx data | |
| | | O | AF2 | CAN1_TX | CAN1 transmit data output | |
| | | O | AF3 | I2C_CLK | I2C clock | |

2.7 RF front-end pins

Table 6. RF front-end pins

| Symbol | I/O voltage | I/O | Description | STA8089GA |
|----------|-------------|-----|--|-----------|
| LNA_IN | 1.2V | I | Low Noise Amplifier Input | 9 |
| XTAL_IN | 1.2V | I | Input Side of Crystal Oscillator or TCXO Input | 19 |
| XTAL_OUT | 1.2V | O | Output Side of Crystal Oscillator | 20 |

3 General description

3.1 RF front end

The RF front-end is able to down-convert both the GPS-Galileo signal from 1575.42 MHz to 4.092 MHz (4 Fo, being F0 = 1.023 MHz), the GLONASS signal from 1601.718 MHz to 8.57 MHz and the BeiDou signal from 1561.098 MHz to 10.23 MHz.

It embeds high performance LNA minimizing external component count and a LDO to supply the internal core facilitating requirements for external power supply. A three bits ADC converts the IF signals to sign (SIGN) and magnitude (MAG0 and MAG1). They can be sampled or not by SPI. The magnitude bits are internally integrated in order to control the variable gain amplifiers. The VGA gain can be also set by the SPI interface.

The RF tuner accepts a wide range of reference clocks (10 to 52 MHz) and can generate 64 Fo sampling clock for the baseband and 192 Fo clock for MCU subsystem.

3.2 GPS/Galileo/GLONASS/BeiDou Base Band (G3BB+) processor

STA8089GA integrates G3BB+ proprietary IP, which is the ST last generation high-sensitivity Baseband processor fully compliant with GPS, Galileo, GLONASS and BeiDou systems.

The baseband receives, from the embedded RF Front-End, two separate IF signals coded in sign-magnitude digital format on 3 bits and the related clocks. The Galileo/GPS (GALGPS) and GLONASS/BeiDou (GNSCOM) signals at the base band inputs are centered on 4.092 MHz, 8.57 MHz and 10.23 MHz.

The baseband processes the two IF signals performing data codification, sample rate conversion and final frequency conversion to zero IF before acquisition and tracking correlations.

The baseband processor has the capability of acquire and track the Galileo, GPS, GLONASS and BeiDou signals in a simultaneous or single way, or a combination of three, being GLONASS and BeiDou mutually exclusive. The number of tracking channels to be used is programmable; the not used tracking channels can be powered down.

A complete multi-OS software library is provided by ST to handle GPS processing, managing satellite acquisition, tracking, pseudo-range calculation and positioning, generating the output in the standard NMEA message format or in a ST binary format. The library includes support of ST self-trained assisted GPS (ST-AGPS), a complete and scalable solution for assisting GPS start-up with autonomous and server-based ephemeris prediction and extension.

3.3 MCU Subsystem

The implemented sub-system includes an AHB Lite bus matrix.

An ARM946 core is embedded in the sub-system and masters the AHB bus. The totally available TCM SRAM is 256 KB. The amount of memory on ITCM and DTCM can be

configured by the ARM946 (see [Table 7: TCM Configuration](#)). ITCM can be configured as $N_i \times 16$ KB; DTCM can be configured as $128 + N_d \times 16$ KB, where $N_i + N_d = 8$, $N_i \geq 1$.

Table 7. TCM Configuration

| TCMcfg [2] | TCMcfg [1] | TCMcfg [0] | ITCM | DTCM |
|------------|------------|------------|--------|--------|
| 0 | 0 | 0 | 16 KB | 240 KB |
| 0 | 0 | 1 | 32 KB | 224 KB |
| 0 | 1 | 0 | 48 KB | 208 KB |
| 0 | 1 | 1 | 64 KB | 192 KB |
| 1 | 0 | 0 | 80 KB | 176 KB |
| 1 | 0 | 1 | 96 KB | 160 KB |
| 1 | 1 | 0 | 112 KB | 144 KB |
| 1 | 1 | 1 | 128 KB | 128 KB |

3.3.1 AHB slaves

- G3 APB port that allows to interface with the G3BB acquisition memory and control registers.
- 512 Kbytes ROM
- Vectored Interrupt Controller (VIC).
- SQI flash memory controller
- 3 x ARM946 APB peripheral bus (APB1, APB2, APB3).

Vectored Interrupt Controller (VIC)

This Vectored Interrupt Controller (VIC) allows the operative system interrupt handler to quickly dispatch interrupt service routines in response to peripheral interrupts. It provides a software interface to the interrupt system. There are up to 64 interrupt lines. The VIC uses a bit position for each different interrupt source.

The software can control each request line to generate software interrupts. Each interrupt line can be independently enabled and configured to trigger a non-vectored Normal Interrupt Request (IRQ) or Fast Interrupt Request (FIQ) to the ARM946 CPU. Sixteen interrupt lines can also be selected to trigger a vectored IRQ.

The VIC has two operation modes: the user mode and the privilege mode, in order to have the possibility to set (or not) one level of protection during execution.

FS USB device controller

Full speed USB device with transceiver. It is an AHB slave. When active requires a 48 MHz clock XTAL_IN.

SQI Flash interface

STA8089GA includes a high-performance interface to Serial Quad Interface (SQI) NOR Flash chips, to support a low-cost simple implementation.

3.4 APB peripherals

3.4.1 CAN

The 2 CAN cores perform communication according to the CAN protocol version 2.0 part A and B. The bit rate can be programmed to values up to 1 MBit/s. For the connection to the physical layer, additional transceiver hardware is required.

CAN consists of the CAN core, message RAM, message handler, control registers and module. For communication on a CAN network, individual message objects are configured. The message objects and identifier masks for acceptance filtering of received messages are stored in the message RAM. All functions concerning the handling of messages are implemented in the message handler. These functions include acceptance filtering, the transfer of messages between the CAN core and the message RAM, and the handling of transmission requests as well as the generation of the module interrupt.

The register set of the CAN can be accessed directly by the CPU through the module interface. These registers are used to control/configure the CAN core and the message handler and to access the message RAM.

CAN features

- Supports CAN protocol version 2.0 part A and B
- 32 messages objects
- Each message object has its own identifier mask
- Maskable interrupt
- Disabled automatic re-transmission mode for time triggered CAN applications
- Programmable loop-back mode for self-test operation
- Two 16-bit module interfaces to the AMBA APB bus from ARM

3.4.2 UART

The UARTx ($x = 1|2$) performs serial-to-parallel conversion on data asynchronously received from a peripheral device on UARTx_RX pin, and parallel-to-serial conversion on data written by CPU for transmission on UARTx_TX pin. The transmit and receive paths are buffered with internal FIFO memories allowing up to 64 data byte for transmission, and 64 data byte with 4-bit status (break, frame, parity, and overrun) for receive.

UART features

The UARTx ($x = 1|2$) are Universal Asynchronous Receiver/Transmitter that support much of the functionality of the industry-standard 16C650 UART. The main features are:

- Programmable baud rates up to $\text{UARTCLK} / 16$ (1.5 Mbps with UARTCLK at 24 MHz), or up to $\text{UARTCLK} / 8$ (3.0 Mbps with UARTCLK at 24 MHz), with fractional baud-rate generator
- 5, 6, 7 or 8 bits of data
- Even, odd, stick or no-parity bit generation and detection
- 1 or 2 stop bit generation
- Support of software flow control using programmable Xon/Xoff characters
- False start bit detection
- Line break generation and detection
- Separate 8-bit wide, 64-deep transmit FIFO and 12-bit wide, 64-deep receive FIFO
- Programmable FIFO disabling for 1-byte depth data path

These UARTs vary from industry-standard 16C650 on some minor points which are:

- Receive FIFO trigger levels
- The internal register map address space, and the bit function of each register differ
- The deltas of the modem status signals are not available
- 1.5 stop bits is not supported
- Independent receive clock feature is not supported

3.4.3 I2C

STA8089GA includes an I2C interface configurable as master or slave.

3.4.4 MTU

The 2 Multi Timer Units provide access to eight interrupt generating programmable 32-bit Free-Running decrementing Counters (FRCs). The FRCs have their own clock input, allowing the counters to run from a much slower clock than the system clock.

The FRC is the part of the timer that performs the counting. There are four instantiations of the FRC block in each MTU, allowing eight counts to be performed in parallel. The 32-bit counter in the FRC is split up into two 16-bit counters.

3.4.5 WDT

Watchdog Timer (WDT) provides a way of recovering from software crashes. The watchdog clock is used to generate a regular interrupt (WDOGINT), depending on a programmed value.

The watchdog monitors the interrupt and asserts a reset signal (WDOGRES) if the interrupt remains unserved for the entire programmed period. You can enable or disable the watchdog unit as required.

Note: Watchdog is stalled when the ARM processor is in Debug mode.

3.4.6 GPIO

The GPIO block provides seven (7) programmable inputs or outputs. Each input or output can be controlled in two modes:

- software mode through an APB bus interface
- alternate mode, where GPIO becomes a peripheral input or output line

Any GPIO input can be independently enabled or disabled (masked) for interrupt generation. User can select for each GPIO which edge (rising, falling, both) will trigger an interrupt.

3.4.7 ADC

10 bit SAR ADC operating at 1.8 V analog supply. It can convert up to 2 single ended channels with analog input multiplexer at 500KSPS

3.4.8 RTC

This is an always-on power domain dedicated to RTC logic (backup system) with 32 Kbyte SRAM and supplied with a dedicated voltage regulator.

The RTC provides a high resolution clock which can be used for GPS. It keeps the time when the system is inactive and can be used to wake the system up when a programmed alarm time is reached. It has a clock trimming feature to compensate for the accuracy of the 32.768 kHz crystal and a secured time update.

RTC features

- 47-bit counter clocked by 32.768 kHz clock
- 32-bit for the integer part (seconds) and 15-bit for the fractional part
- The integer part and the fractional part are readable independently
- The counter, once enabled, can be stopped
- Integer part load register (32-bit)
- Fractional part load register (15-bit)
- Load bit to transfer the content of the entire load register (integer+fractional part) to the 47-bit counter. Once set by the MCU this bits is cleared by the hardware to signal to the MCU that the RTC has been updated.

4 Electrical characteristics

4.1 Parameter conditions

Unless otherwise specified, all voltages are referred to GND.

4.2 Minimum and maximum values

Unless otherwise specified the minimum and maximum values are guaranteed in the worst conditions of ambient temperature, supply voltage and frequencies by tests in production on 100% of the devices.

STA8089GA parts are tested at $T = -40\text{ °C}$ and $T = 85\text{ °C}$.

4.3 Typical values

Unless otherwise specified, typical data are based on $T_A = 25\text{ °C}$, $V_{\text{ddio}} = 1.8\text{ V}$, $V_{\text{dd}} = 1.20\text{ V}$. They are given only as design guidelines and are not tested.

4.4 Typical curves

Unless otherwise specified, all typical curves are given only as design guidelines and are not tested.

4.5 Absolute maximum ratings

This product contains devices to protect the inputs against damage due to high static voltages, however it is advisable to take normal precautions to avoid application of any voltage higher than the specified maximum rated voltages.

[Table 8](#) lists the absolute maximum rating.

Table 8. Voltage characteristics

| Symbol | Parameter | Min. | Max. | Unit |
|------------------------|--|------|------|------|
| $V_{\text{CC_CHAIN}}$ | Analog supply voltage for RF chain (1.2 V) | -0.3 | 1.32 | V |
| $V_{\text{CC_PLL}}$ | Analog supply voltage for PLL RF (1.2 V) | -0.3 | 1.32 | V |
| $V_{\text{CC_RF}}$ | Analog supply voltage for RF (1.2 V) | -0.3 | 1.32 | V |
| V_{DDD} | Power supply pins for the core logic. | -0.3 | 1.32 | V |
| $V_{\text{DDIO_R1}}$ | Digital supply voltage for I/O ring 1 (1.8 V or 3.3 V) | -0.3 | 3.63 | V |
| $V_{\text{DDIO_R2}}$ | Digital supply voltage for I/O ring 2 (3.3 V) | -0.3 | 3.63 | V |
| V_{INB} | Backup LDO input supply voltage (1.6 V to 4.3 V) | -0.3 | 4.8 | V |
| V_{INL1} | LDO1 input supply voltage (1.8 V) | -0.3 | 1.98 | V |
| V_{INL2} | LDO2 input supply voltage (1.6 V to 4.3 V) | -0.3 | 4.8 | V |

Table 8. Voltage characteristics (continued)

| Symbol | Parameter | Min. | Max. | Unit |
|----------------------|---|------|------|------|
| V _{ESD-HBM} | Electrostatic discharge, human body model ⁽¹⁾ . | -2 | 2 | kV |
| V _{ESD-CDM} | Electrostatic discharge, charge device model ⁽²⁾ . | -250 | 250 | V |

1. Pins sustaining only ±500 V are: 12, 13, 21, 27, 28, 29, 30 and 31,
2. Pin 9 (LNA_IN) sustains only ±100 V.

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

Table 9. Thermal characteristics

| Symbol | Parameter | Min. | Max. | Unit |
|--------------------|---|------|------|------|
| T _{oper} | Operative temperature range | -40 | 85 | °C |
| T _j | Operative junction temperature | -40 | 125 | °C |
| T _{st} | Storage temperature | -55 | 150 | °C |
| R _{j-amb} | Thermal resistance junction to ambient ⁽¹⁾ | — | 24.4 | °C/W |

1. According to JEDEC specification on a 2 layers board.

Table 10. Frequency limits

| Symbol | Parameter | Test condition | Min. | Typ. | Max. | Unit |
|------------------|------------------------------|--|------|------|------|------|
| F _{CLK} | Operating ARM9 CPU frequency | V _{DDD} = 1.2 V; T _C = 85 °C ⁽¹⁾ | — | — | 196 | MHz |
| F _{AHB} | AHB frequency | | — | — | 49 | MHz |

1. Not tested in production.

Table 11. Power consumption

| Symbol | Parameter | Test condition | Min. | Typ. | Max. | Unit |
|-----------------|---------------------------------------|---|------|------|------|------|
| P _{RF} | RFIP power (total V _{INL2}) | G2 = GPS/Galileo; T _{amb} = 25 °C; V _{INL2} = 1.8 V | — | 25 | — | mW |
| | | G2 + GLONASS; T _{amb} = 25 °C; V _{INL2} = 1.8 V | — | 35 | — | mW |
| | | G2 + BeiDou; T _{amb} = 25 °C; V _{INL2} = 1.8 V | — | 35 | — | mW |

Table 11. Power consumption (continued)

| Symbol | Parameter | Test condition | Min. | Typ. | Max. | Unit |
|--------------------|---|--|------|------|------|------|
| $P_{MVR}^{(1)}$ | Switchable area power; (total V_{INL1}) | $f_{ARM} = 196$ MHz; $f_{AHB} = 49$ MHz; $T_{amb} = 25$ °C; $V_{INL1} = 1.8$ V; UART active; other peripherals inactive | — | 90 | — | mW |
| $P_{LPVR}^{(1)}$ | Always ON area power (total V_{INB}) | $f_{ARM} = 196$ MHz; $f_{AHB} = 49$ MHz; $T_{amb} = 25$ °C; $V_{INB} = 3.3$ V | — | 1 | — | mW |
| $P_{IO}^{(1)}$ | IO rings power (total $V_{DDIO_R1} + V_{DDIO_R2}$) | $f_{ARM} = 196$ MHz; $f_{AHB} = 49$ MHz; $T_{amb} = 25$ °C; $V_{INL1} = 1.8$ V; UART active; other peripherals inactive | — | 4 | — | mW |
| $I_{DStandby}$ | Standby mode supply current | RTC running = 32.768 KHz; $T_{amb} = 25$ °C; $V_{INB} = 1.8$ V | — | 29 | — | µA |
| $I_{DDeepStandby}$ | Deep standby mode supply current ⁽²⁾ | | — | 7 | — | µA |

1. Not tested in production.
2. STDBY_OUT pin not supported in deep standby.

4.6 Recommended DC operating conditions

Table 12 lists the functional recommended operating DC parameters for STA8089GA.

Table 12. Recommended DC operating conditions

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|-----------------|--|------|------|------|------|
| V_{CC_CHAIN} | Analog supply voltage for RF chain (1.2 V) | 1.08 | 1.20 | 1.32 | V |
| V_{CC_PLL} | Analog supply voltage for PLL RF (1.2 V) | 1.08 | 1.20 | 1.32 | V |
| V_{CC_RF} | Analog supply voltage for RF (1.2 V) | 1.08 | 1.20 | 1.32 | V |
| V_{DDD} | Power supply pins for the core logic. | 1.1 | 1.2 | 1.32 | V |
| V_{DDIO_R1} | Digital supply voltage for I/O ring 1 (1.8 V) | 1.71 | 1.80 | 1.89 | V |
| | Digital supply voltage for I/O ring 1 (3.3 V) | 3.00 | 3.30 | 3.60 | V |
| V_{DDIO_R2} | Digital supply voltage for I/O ring 2 (3.3 V) | 3.00 | 3.30 | 3.60 | V |
| V_{INB} | Backup LDO input supply voltage (1.6 V to 4.3 V) | 1.60 | | 4.30 | V |
| V_{INL1} | LDO1 input supply voltage | 1.71 | | 1.89 | V |
| V_{INL2} | LDO2 input supply voltage to generate 1.2 V | 1.60 | | 4.30 | V |
| T_C | Operating case temperature | -40 | | 85 | °C |

4.7 DC characteristics

[Table 13](#) specifies the LDO1 voltage regulator characteristics.

Table 13. LDO1 DC characteristics

| Symbol | Parameter | Test condition | Min. | Typ. | Max. | Unit |
|-----------|------------------------|--|------|------|------|------|
| V_{OL1} | Output voltage (1.2 V) | $1.71\text{ V} \leq V_{INL1} \leq 1.89\text{ V};$ $I_{OL1} \leq 70\text{ mA}$ | 1.1 | 1.20 | 1.32 | V |
| I_{OL1} | Output current | | 0 | — | 70 | mA |

[Table 14](#) specifies the LDO2 voltage regulator characteristics.

Table 14. LDO2 DC characteristics

| Symbol | Parameter | Test condition | Min. | Typ. | Max. | Unit |
|-----------|----------------|--|------|------|------|------|
| V_{OL2} | Output voltage | $1.6\text{ V} \leq V_{INL2} \leq 4.3\text{ V};$ $I_{OL2} \leq 30\text{ mA}$ | 1.08 | 1.20 | 1.32 | V |
| I_{OL2} | Output current | | 0 | — | 30 | mA |

[Table 15](#) specifies the low voltage detection thresholds

Table 15. Low voltage detection thresholds

| Parameter | | Min. | Typ. | Max. | Unit |
|---|--|------|-------|------|------|
| Input LVD always on and main VRs ⁽¹⁾ | Upper voltage threshold | — | 1.680 | — | V |
| | Lower voltage threshold | — | 1.650 | — | V |
| Output LVD always on VR ⁽¹⁾ | Upper voltage threshold | — | 0.995 | — | V |
| | Lower voltage threshold | — | 0.935 | — | V |
| Output LVD main VR ⁽¹⁾ | Upper voltage threshold @ $V_{OLM} = 1.2\text{ V}$ | — | 1.142 | — | V |
| | Lower voltage threshold @ $V_{OLM} = 1.2\text{ V}$ | — | 1.076 | — | V |

1. Non tested in production.

[Table 16](#) lists the DC characteristics for all the IO digital buffers except for the following input buffers: STBYn (24), STDBY_OUT (23), WAKEUP (26), TRSTn (3) and RSTn (25).

Table 16. I/O buffers DC characteristics

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|------------------|----------------------------------|---------------------------|------------------|------|------------------|------|
| $V_{IL}^{(1)}$ | Logical input low level voltage | $V_{DDIO} = 1.8\text{ V}$ | -0.3 | — | $0.3 * V_{DDIO}$ | V |
| | | $V_{DDIO} = 3.3\text{ V}$ | -0.3 | — | 0.8 | V |
| $V_{IH}^{(1)}$ | Logical input high level voltage | $V_{DDIO} = 1.8\text{ V}$ | $0.7 * V_{DDIO}$ | — | $V_{DDIO} + 0.3$ | V |
| | | $V_{DDIO} = 3.3\text{ V}$ | 2.0 | — | $V_{DDIO} + 0.3$ | V |
| $V_{HYST}^{(2)}$ | Schmitt-trigger hysteresis | — | 50 | — | | mV |

Table 16. I/O buffers DC characteristics (continued)

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|-----------------|---------------------------|---------------------------|-------------------------|------|------|------|
| V _{OL} | Low level output voltage | V _{DDIO} = 1.8 V | | — | 0.4 | V |
| | | V _{DDIO} = 3.3V | | — | 0.4 | V |
| V _{OH} | High level output voltage | V _{DDIO} = 1.8 V | V _{DDIO} - 0.4 | — | | V |
| | | V _{DDIO} = 3.3V | V _{DDIO} - 0.4 | — | | V |

1. Excludes oscillator inputs RTC_XTI and XTAL_IN. Refer to oscillator electrical specifications.
2. Apply to all digital inputs unless specified otherwise.

Table 17 lists the DC characteristics for the 1.0 V IO digital buffers input buffers: STBYn (24), STDBY_OUT (23), WAKEUP (26), TRSTn (3) and RSTn (25).

Table 17. 1.0 V I/O buffers DC characteristics

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|-----------------|----------------------------------|-------------------------|------------------------|------|------------------------|------|
| V _{IL} | Logical input low level voltage | V _{OB} = 1.0 V | -0.3 | — | 0.35 * V _{OB} | V |
| V _{IH} | Logical input high level voltage | V _{OB} = 1.0 V | 0.65 * V _{OB} | — | V _{OB} + 0.3 | V |
| V _{OL} | Low level output voltage | V _{OB} = 1.0 V | | — | 0.2 | V |
| V _{OH} | High level output voltage | V _{OB} = 1.0 V | V _{OB} - 0.2 | — | | V |

4.8 AC characteristics

4.8.1 RF electrical specifications

Table 18. RFCHAIN – GALGPS filter and VGA

| Symbol | Parameter | Test conditions | Min | Typ | Max | Unit |
|--------------------|--|--|-----|------------------|-----|------|
| S11 ⁽¹⁾ | Input return loss | GPS band | — | -8 | | dB |
| f _{IF} | IF frequency | PLL in default condition with 26Mhz as reference | — | 4.045 | | MHz |
| NF | Noise figure | NF overall chain with AGC set at 0 dB | — | 2 ⁽¹⁾ | | dB |
| C _G | Conversion gain from RF input to ADC input | VGA at max gain | — | 119 | | dB |
| | | VGA at min gain | — | 69 | | dB |
| IP _{1dB} | RF-IF-VGA input compression point | VGA min | — | -80 | | dBm |
| IRR | Image rejection ratio | | — | 20 | | dB |
| BW _{GPS} | -3dB IF bandwidth | GPS mode | — | 2.4 | | MHz |
| BW _{GAL} | | Galileo mode | — | 4.8 | | MHz |

Table 18. RFCHAIN – GALGPS filter and VGA (continued)

| Symbol | Parameter | Test conditions | Min | Typ | Max | Unit |
|-------------------|---------------------------------|---------------------------------|-----|-----|--------------------|------|
| ATT | Alias frequency rejection | F = 60 MHz (fs = 65.474 MHz) | — | 30 | | dB |
| T _{gGPS} | IF filter group delay variation | GPS mode | — | | 200 ⁽¹⁾ | ns |
| T _{gGAL} | | Galileo mode | — | | 30 ⁽¹⁾ | ns |

1. Not tested in production.

Table 19. RFCHAIN – GLONASS/BeiDou filter and VGA

| Symbol | Parameter | Test conditions | Min | Typ | Max | Unit |
|------------------------|--|---|-----|------------------|-------------------|------|
| S11 ⁽¹⁾ | Input return loss | GLONASS band | | -10 | | dB |
| | | BeiDou band | | -7 | | |
| f _{IFGNS/BDU} | IF frequency for GLONASS | PLL in default condition with 26 Mhz as reference | — | 8.519 | | MHz |
| | IF frequency for BeiDou | | — | 10.277 | | |
| NF | Noise figure | NF overall chain with AGC set at 0 dB | — | 2 ⁽¹⁾ | | dB |
| C _G | Conversion gain from RF input to ADC input | VGA at max gain | — | 118 | | dB |
| | | VGA at min gain | — | 68 | | dB |
| IP _{1dB} | RF-IF-VGA input compression point | VGA min | — | -80 | | dBm |
| IRR | Image rejection ratio | | — | 25 | | dB |
| BW _{GNS/BDU} | -3dB IF bandwidth | | — | 10 | | MHz |
| ATT | Alias frequency rejection | F = 53 MHz (fs = 65.474 MHz) | — | 30 | | dB |
| T _{gGNS/BDU} | IF filter group delay variation | | — | | 20 ⁽¹⁾ | ns |

1. Not tested in production.

Table 20. Synthesizer

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|------------------------|---|------|----------|------|------|
| F _{TCXO_XTAL} | Input frequency for xtal amplifier ⁽¹⁾ | 10 | | 52 | MHz |
| R _{DIV} | Reference divider range | 1 | | 63 | |
| N _{DIV} | Loop divider range | 56 | | 2047 | |
| F _{LO} | LO operating frequency | | 3142.656 | | MHz |

1. That amplifier can be used also like TCXO input buffer

4.8.2 Oscillator electrical specifications

This device contains two oscillators:

- a 32.768 kHz oscillator/buffer for RTC circuit.
- an OSCI oscillator/buffer in the RF Front-End

When used in oscillator mode, each oscillator requires a specific crystal, with parameters that must be as close as possible to the following recommended values. When used in input buffer mode, an external clock source must be applied.

32.768 kHz OSCI32 oscillator specifications

The 32.768 kHz OSCI32 oscillator is connected between RTC_XTI (oscillator amplifier input) and RTC_XTO (oscillator amplifier output). It also requires two external capacitors of 18 pF^(a), as shown on [Figure 3](#).

OSCI32 is disabled by default and must be enabled by setting bit28-OSCI_EN of PRCC_BACKUP_REG0 to have 32.768KHz oscillation when an XTAL pi-network is connected to RTC_XTI/RTC_XTO pins.

The recommended oscillator specifications are shown in [Table 21](#):

Table 21. Crystal recommended specifications

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---------------------|--|------|--------|------|------|
| F _{SXTAL} | Crystal frequency ⁽¹⁾ | — | 32.768 | — | kHz |
| LM _{SXTAL} | Motion inductance ⁽¹⁾ | — | 5 | — | kH |
| CM _{SXTAL} | Motional capacitance ⁽¹⁾ | — | 5.0 | — | fF |
| CO _{SXTAL} | Shunt capacitance ⁽¹⁾ | — | 1.3 | — | pF |
| ESR | Resonance resistance ⁽¹⁾ | — | — | 80 | kΩ |
| CL | External load capacitance ⁽¹⁾ | — | 18 | — | pF |

1. Not tested in production.

The oscillator amplifier specifications are shown in following table:

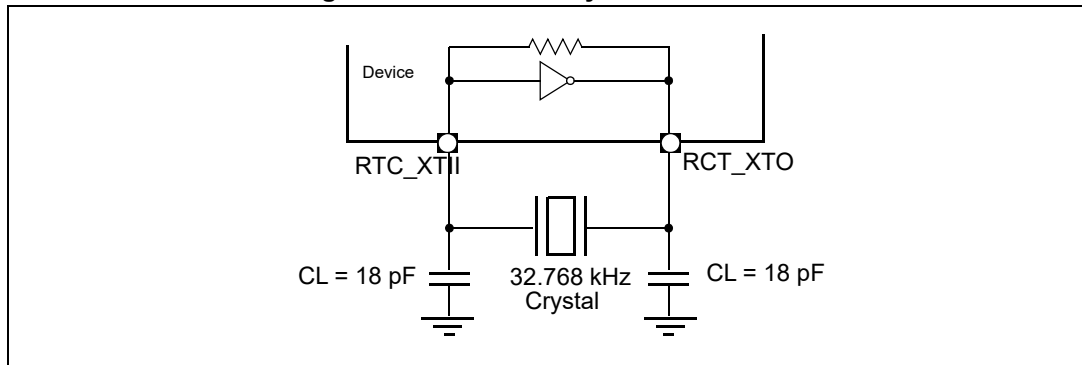
Table 22. Oscillator amplifier specifications

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|----------------|--|------|------|------|------|
| T _S | Startup time ⁽¹⁾ | — | 0.3 | 0.6 | s |
| DL | Drive level ⁽¹⁾ | — | — | <0.1 | μW |
| RLC | Required load capacitance ⁽¹⁾ | — | 12.5 | — | pF |
| GM | Startup transconductance | 22.5 | 33.6 | — | μA/V |

1. Not tested in production.

a. Using crystal with recommended characteristics as per [Table 21](#).

Figure 3. 32.768 kHz crystal connection



To drive the 32.768 kHz crystal pins from an external clock source:

- Disable the oscillator (bit28-OSCI_EN = 0b in PRCC_BACKUP_REG0 register). This disables the internal inverter, thus reducing the power consumption to minimum.
- Drive the RTC_XTI pin with a square signal or a sine wave.

Table 23. Characteristics of external slow clock input

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|------------------------|-----------------------|------|------|------|------|
| T _{JIT} (cc) | Cycle-to-cycle jitter | -70 | — | 70 | ps |
| T _{JIT} (per) | Period jitter | -70 | — | 70 | ps |
| | Variation | -500 | — | 500 | ppm |
| T _{DUTY} | Duty cycle | 45 | — | 55 | % |

4.8.3 OSCI oscillator specifications

Default supported values are 16.368 MHz, 24 MHz, 26 MHz and 48 MHz.

To enable USB peripheral the 48 MHz is mandatory

4.8.4 ADC specifications

This section gives the AC specification of the 10 bit Successive Approximation Register ADC embedded in STA8089GA device. It is controlled by the ARM9 MCU through a wrapper and an APB bridge as depicted in [Figure 4](#) and it has a maximum conversion rate of 1MSPS with 8 muxed analog input channels capability. An internal voltage reference is used and analog/digital power supplies connections are implemented inside the device without any needs of dedicated external pins.

Figure 4. SARADC connections

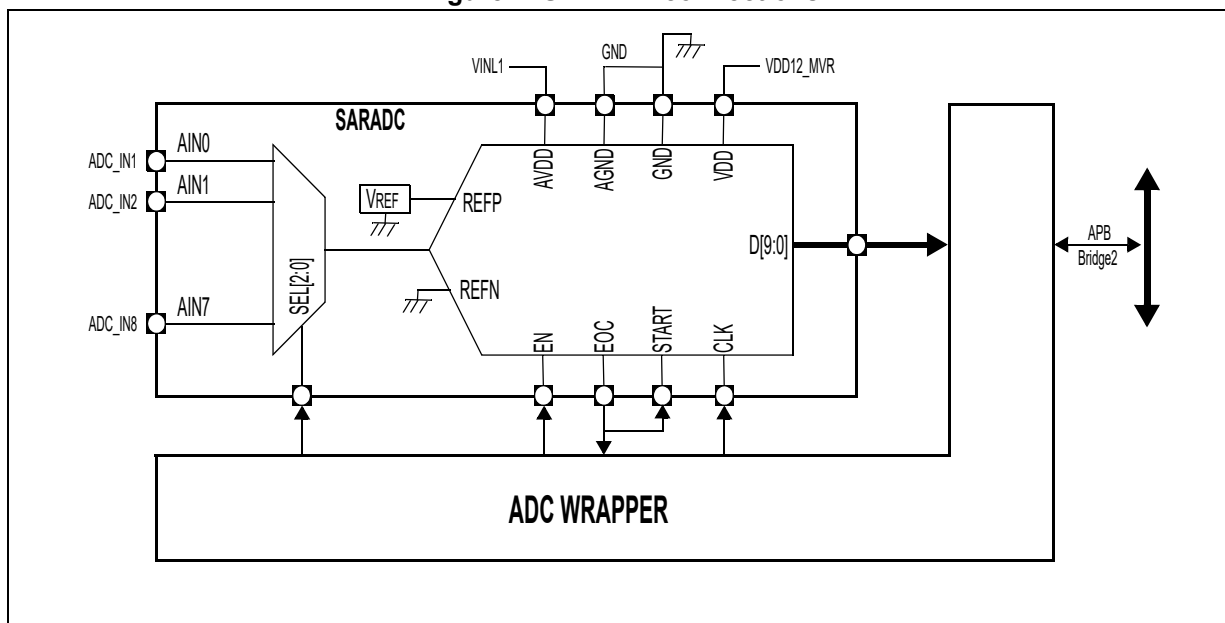


Table 24. SARADC specifications

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|----------------|--|---------------|------|-------------------|------------|
| V_{ADCIN} | ADC_IN input range | $V_{GND}-0.3$ | — | $V_{DD_ADC}+0.3$ | V |
| V_{ADCCR} | Conversion range | V_{GND} | — | V_{REF} | V |
| V_{REF} | Voltage reference | 1.35 | 1.4 | 1.45 | V |
| C_{IN} | Input capacitance ⁽¹⁾ | 5.5 | 7.0 | 8.5 | pF |
| R_{IN} | Input mux resistance (total equivalent sampling resistance) ⁽²⁾ | 1.5 | 2.0 | 2.5 | k Ω |
| F_{CLK} | Clock frequency | 2.5 | | 15 | MHz |
| δ_{CLK} | Clock duty cycle | 45 | 50 | 55 | % |
| T_{SUP} | Start up time ⁽¹⁾⁽³⁾ | — | — | 20 | μ s |
| T_C | Conversion time | — | 14 | — | cycles |
| T_S | Sampling time | — | 3 | | cycles |
| INL | Performance | — | — | < ± 2 | LSB |
| DNL | | — | — | < ± 2 | LSB |

1. Not tested in production.
2. Pad input capacitance included.
3. From EN = 1.

5 Package and packing information

5.1 ECOPACK packages

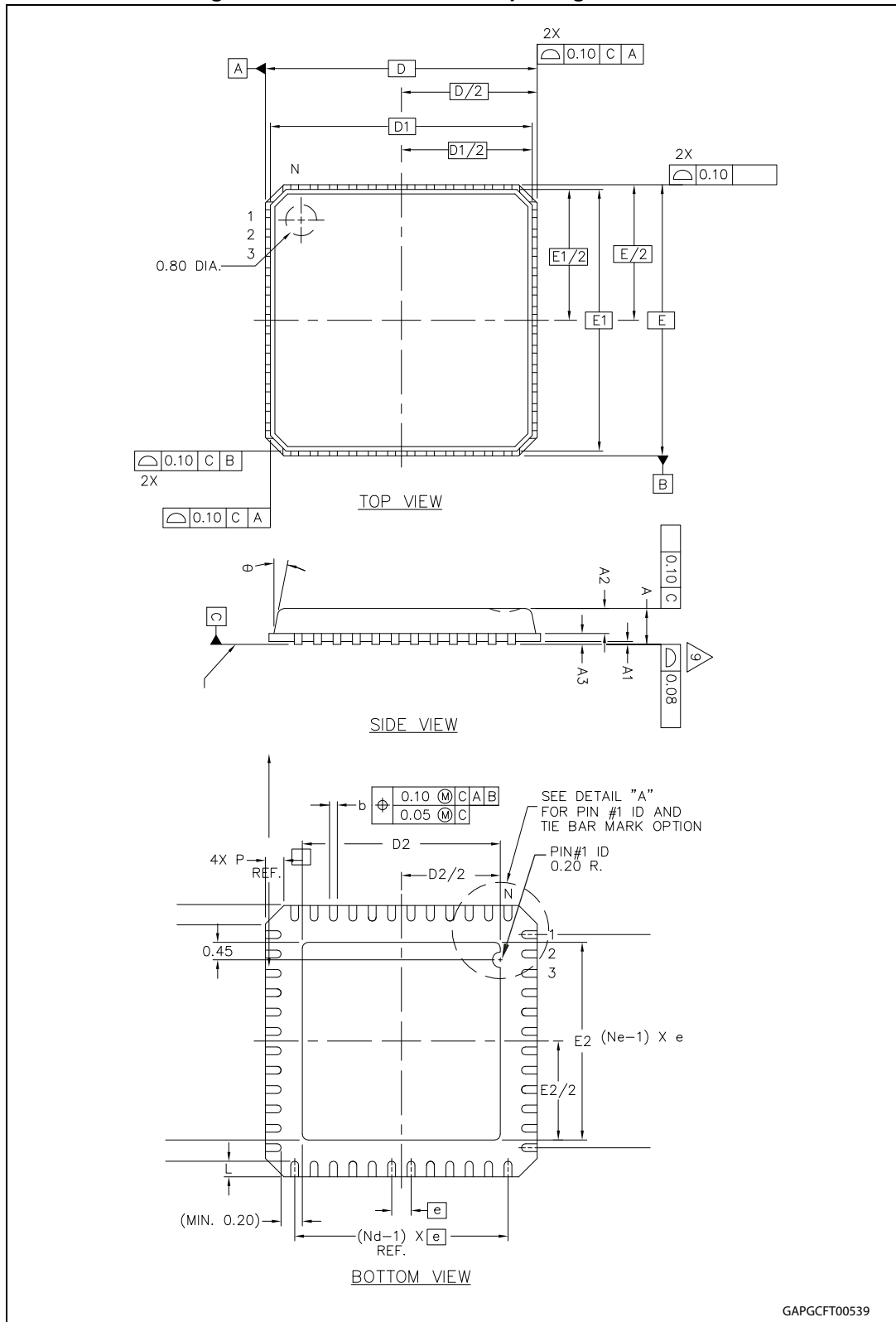
In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK packages, depending on their level of environmental compliance. ECOPACK specifications, grade definitions and product status are available at: www.st.com. ECOPACK is an ST trademark.

5.2 VFQFPN56 7 x 7 mm package information

Table 25. VFQFPN56 7 x 7 mm package dimensions

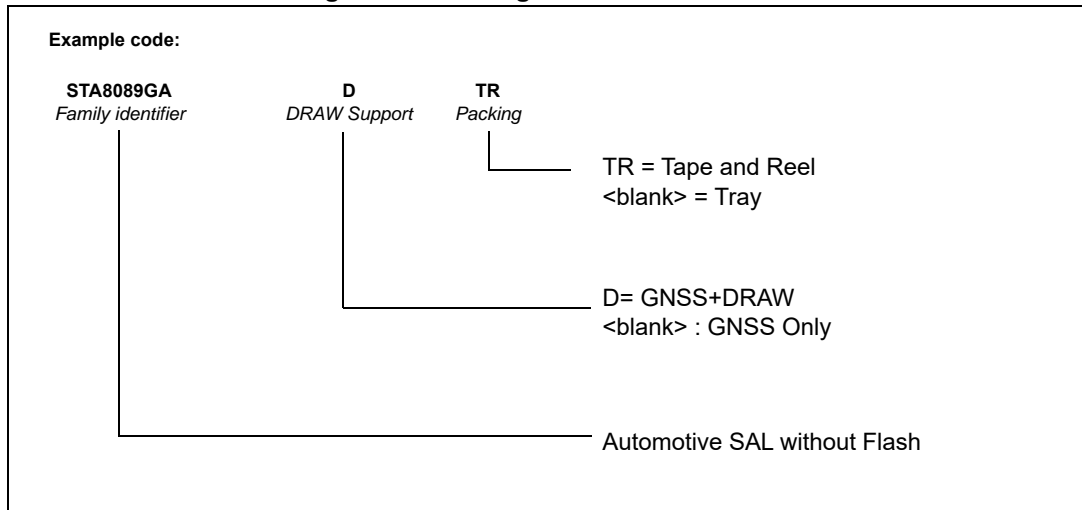
| Symbol | Min. | Typ. | Max |
|--------------------------|----------|------|------|
| Common dimensions | | | |
| A | 0.80 | 0.85 | 0.90 |
| A1 | 0 | 0.01 | 0.05 |
| A2 | 0.60 | 0.65 | 0.70 |
| A3 | 0.20 REF | | |
| b | 0.15 | 0.20 | 0.25 |
| D | 7.00 BSC | | |
| D1 | 6.75 BSC | | |
| D2 | 5.0 | 5.1 | 5.2 |
| E | 7.00 BSC | | |
| E1 | 6.75 BSC | | |
| E2 | 5.0 | 5.1 | 5.2 |
| e | 0.40 BSC | | |
| θ | 0° | | 12° |
| L | 0.30 | 0.40 | 0.50 |
| N | 56 | | |
| Nd | 14 | | |
| Ne | 14 | | |
| P | 0.24 | 0.42 | 0.60 |

Figure 5. VFQFPN56 7 x 7 mm package dimension



6 Ordering information

Figure 6. Ordering information scheme



7 Revision history

Table 26. Document revision history

| Date | Revision | Changes |
|-------------|----------|--|
| 25-Mar-2015 | 1 | Initial release. |
| 30-Jun-2015 | 2 | <p><i>Table 2: Power supply pins:</i> – VDDD, VOL1: updated description</p> <p><i>Table 4: Test/emulated dedicated pins:</i> – TRSTn: updated I/O voltage value</p> <p><i>Table 13: LDO1 DC characteristics:</i> – V_{OL1}: set min and max values as TBD, removed condition for Output voltage at 1.0 V</p> <p><i>Table 14: LDO2 DC characteristics:</i> – V_{OL2}: set min and max values as TBD</p> <p><i>Table 15: Low voltage detection thresholds:</i> – Output LVD main VR: removed condition for Output voltage at 1.0 V</p> <p><i>Table 18: RFCHAIN – GALGPS filter and VGA:</i> – C_G: updated typical values</p> <p><i>Table 19: RFCHAIN – GLONASS/BeiDou filter and VGA:</i> – C_G: updated typical values</p> |
| 24-Nov-2015 | 3 | <p><i>Table 8: Voltage characteristics:</i> – V_{ESD-HBM}, V_{ESD-CDM}: updated values</p> |
| 25-Nov-2015 | 4 | Updated package data |
| 08-Jun-2016 | 5 | <p>Updated <i>Features and Description</i></p> <p>Updated <i>Overview</i>: Changed form STA8089GA to STA8089GAD</p> <p>Updated <i>Section 4.2: Minimum and maximum values</i></p> <p>Updated <i>Section 4.6: Recommended DC operating conditions</i></p> <p>Updated <i>Section 6: Ordering information</i></p> |
| 24-May-2017 | 6 | <p>Updated:</p> <p>– <i>Table 9: Thermal characteristics on page 20</i> (R_{j-amb} value);</p> <p>– <i>Table 11: Power consumption</i>: removed I_{DSLEEP} and added I_{DStandby} and I_{DDeepStandby} parameters.</p> |
| 03-Jun-2020 | 7 | Minor text changes. |
| 06-Dec-2022 | 8 | Updated Table 3: Main function pins . |

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