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# MGC3030/3130 3D Tracking and Gesture Controller Data Sheet

## Introduction

Microchip's MGC3X30 are 3D gesture recognition and motion tracking controller chips based on Microchip's patented GestIC® technology. They enable user-command input with natural hand and finger movements. Applying the principles of electrical near-field sensing, the MGC3X30 contain all the building blocks to develop robust 3D gesture input sensing systems. Implemented as a low-power mixed-signal configurable controller, they provide a large set of smart functional features with integrated signal driver, a frequency adaptive input path for automatic noise suppression and a digital signal processing unit. Microchip's on-chip Colibri Suite obsoletes processing needs at the host, reduces system power consumption resulting in low software development efforts for short time-to-market success. The MGC3XXX family represents a unique solution that provides gesture information of the human hand in real time. Dedicated chip family members add position data, touch or multi touch information to the free space gesture sensing. The MGC3XXX allow the realization of a new generation of user interfaces across various industry markets.

## Applications

- Audio Products
- Notebooks/Keyboards/PC Peripherals
- Home Automation
- White Goods
- Switches/Industrial Switches
- Medical Products
- Game Controllers
- Audio Control

## Power Features

- Variety of Several Power Operation modes include:
  - Processing mode: 20 mA @ 3.3V, typical
  - Programmable Self Wake-up: 110 µA @ 3.3V
  - Deep Sleep: 9 µA @ 3.3V, typical

## Key Features

- Recognition of 3D Hand Gestures and x, y, z Positional Data (MGC3130)
- Proximity and Touch Sensing
- Built-in Colibri Gesture Suite (running on chip)
- Advanced 3D Signal Processing Unit
- Detection Range: 0 to 10 cm
- Receiver Sensitivity: <1 fF
- Position Rate: 200 positions/sec
- Spatial Resolution: up to 150 dpi
- Carrier Frequency: 44 kHz to 115 kHz
- Channels Supported:
  - Five receive (Rx) channels
  - One transmit (Tx) channel
- On-chip Auto Calibration
- Low Noise Radiation due to Low Transmit Voltage and Slew Rate Control
- Noise Susceptibility Reduction:
  - On-chip analog filtering
  - On-chip digital filtering
  - Automatic frequency hopping
- Enables the use of Low-Cost Electrode Material including:
  - Printed circuit board
  - Conductive paint
  - Conductive foil
  - Laser Direct Structuring (LDS)
  - Touch panel ITO structures
- Field Upgrade Capability
- Operating Voltage: 3.3V (+/-5%) (single supply)
- Temperature Range: -20°C to +85°C

## Peripheral Features

- 1x $I^2C$™ Interface for Configuration and Sensor output streaming
- Five Gesture Port pins for individual mapping of gesture to EIOs

| **Note:** | This data sheet applies to parts MGC3030 and MGC3130. Throughout this document the term MGC3X30 will be representative for these two parts. |
|---|---|

**TABLE 1: MGC3X30 AVAILABLE PACKAGES**

| Part number | Available Package | Pins | Contact/Lead Pitch | Dimensions |
|---|---|---|---|---|
| MGC3030 | SSOP | 28 | 0.65 | 7.80x10.50 |
| MGC3130 | QFN | 28 | 0.5 | 5x5 |

> **Note:** All dimensions are in millimeters (mm) unless specified.

**TABLE 2: MGC3X30 FEATURE OVERVIEW**

| | Gesture Recognition | Position Tracking | Raw Data Streaming | Multi Touch Finger Tracking | Wake-up on Approach | Deep Sleep | Gesture Port Pins | Rx Receive Electrodes | $I^2C$™ Ports |
|---|---|---|---|---|---|---|---|---|---|
| MGC3030 | Yes | No | Yes | No | Yes | Yes | 5 | 5 | 1 |
| MGC3130 | Yes | Yes | Yes | No | Yes | Yes | 5 | 5 | 1 |

## Pin Diagrams

**FIGURE 1: 28-PIN DIAGRAM (MGC3130)**

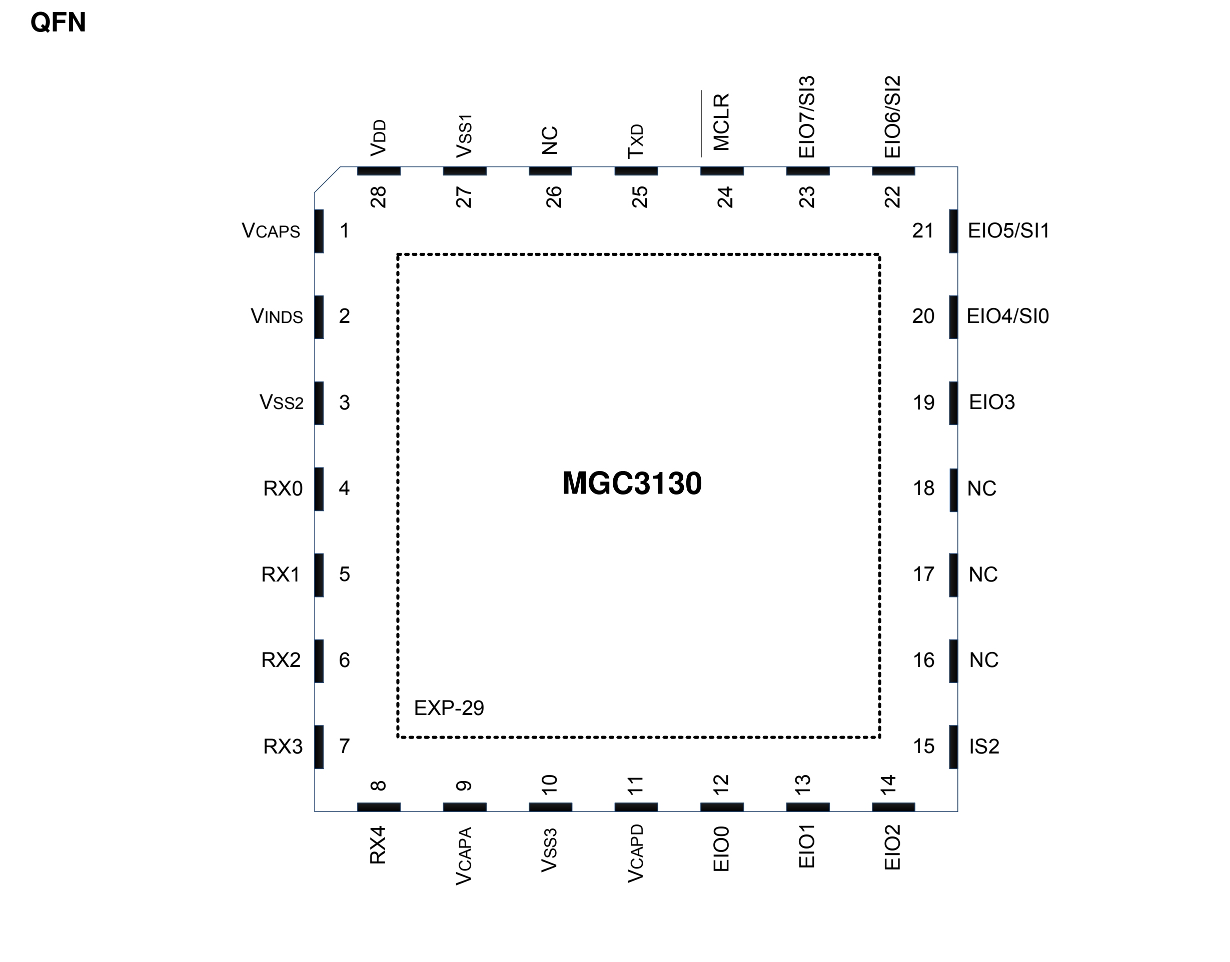
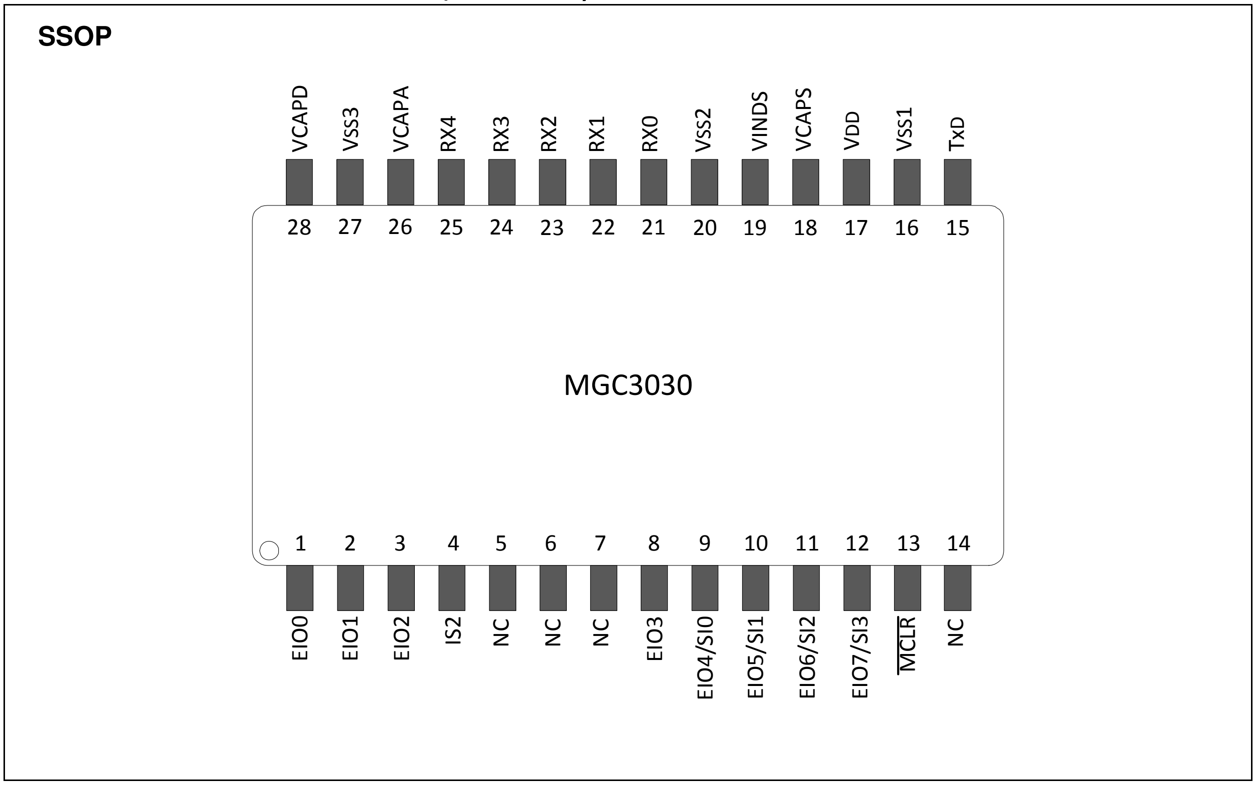


**FIGURE 2: 28-PIN DIAGRAM (MGC3030)**




 Advance Information 

**TABLE 3: PIN SUMMARY**

| Pin Name | Pin Number | | Pin Type | Buffer Type | Description |
|---|---|---|---|---|---|
| | 28-QFN | 28-SSOP | | | |
| VCAPS | 1 | 18 | P | — | Reserved: Connect to VDD. |
| VINDS | 2 | 19 | P | — | Reserved: Do not connect. |
| VSS2 | 3 | 20 | P | — | Ground. |
| RX0 | 4 | 21 | I | Analog | Analog input channels: Receive electrode connection. |
| RX1 | 5 | 22 | I | Analog | |
| RX2 | 6 | 23 | I | Analog | |
| RX3 | 7 | 24 | I | Analog | |
| RX4 | 8 | 25 | I | Analog | |
| VCAPA | 9 | 26 | P | — | External filter capacitor (4.7 µF) connection for internal analog voltage regulator (3V). |
| VSS3 | 10 | 27 | P | — | Common ground reference for analog and digital domain. |
| VCAPD | 11 | 28 | P | — | External filter capacitor (4.7 µF) connection for internal digital voltage regulator (1.8V). |
| EIO0 | 12 | 1 | I/O | ST | Extended IO0 (EIO0)/Transfer Status (TS). TS line requires external 10 kΩ pull-up. |
| EIO1 | 13 | 2 | I/O | ST | Extended IO1 (EIO1)/Interface Selection Pin 1 (IS1). |
| EIO2 | 14 | 3 | I/O | ST | Extended IO2 (EIO2)/IRQ0. |
| IS2 | 15 | 4 | I | ST | Interface Selection Pin 2 (IS2). |
| NC | 16 | 5 | — | — | Reserved: do not connect. |
| NC | 17 | 6 | — | — | Reserved: do not connect. |
| NC | 18 | 7 | — | — | Reserved: do not connect. |
| EIO3 | 19 | 8 | I/O | ST | Extended IO3 (EIO3)/IRQ1. |
| EIO4/SI0 | 20 | 9 | I/O | ST | Extended IO4 (EIO4)/Serial Interface 0 (SI0): I$^2$C™_SDA0. When I$^2$C™ is used, this line requires an external 1.8 kΩ pull-up. |
| EIO5/S11 | 21 | 10 | I/O | ST | Extended IO5 (EIO5)/Serial Interface 1 (SI1): I$^2$C™_SCL0. When I$^2$C™ is used, this line requires an external 1.8 kΩ pull-up. |
| EIO6/S12 | 22 | 11 | I/O | ST | Extended IO6 (EIO6). |
| EIO7/S13 | 23 | 12 | I/O | ST | Extended IO7 (EIO7). |
| $\overline{MCLR}$ | 24 | 13 | I/P | ST | Master Clear (Reset) input. This pin is an active-low Reset to the device. It requires external 10 kΩ pull-up. |
| TXD | 25 | 15 | O | Analog | Transmit electrode connection. |

**Legend:** P = Power; ST = Schmitt Trigger input with CMOS levels; O = Output; I = Input; — = N/A

**TABLE 3: PIN SUMMARY**

| Pin Name | Pin Number | | Pin Type | Buffer Type | Description |
|---|---|---|---|---|---|
| | 28-QFN | 28-SSOP | | | |
| NC | 26 | 14 | — | — | Reserved: do not connect. |
| $V_{SS1}$ | 27 | 16 | P | — | Common ground reference for analog and digital domains. |
| $V_{DD}$ | 28 | 17 | P | — | Positive supply for peripheral logic and I/O pins. It requires an external filtering capacitor (100 nF). |
| EXP | 29 | — | P | — | Exposed pad. It should be connected to Ground. |

**Legend:** P = Power; ST = Schmitt Trigger input with CMOS levels; O = Output; I = Input; — = N/A

## Table of Contents



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## 1.0 THEORY OF OPERATION: ELECTRICAL NEAR-FIELD (E-FIELD) SENSING

Microchip's GestIC is a 3D sensor technology which utilizes an electric field (E-field) for advanced proximity sensing. It allows realization of new user interface applications by detection, tracking and classification of a user's hand gestures in free space.

E-fields are generated by electrical charges and propagate three-dimensionally around the surface, carrying the electrical charge.

Applying direct voltages (DC) to an electrode results in a constant electric field. Applying alternating voltages (AC) makes the charges vary over time and thus, the field. When the charge varies sinusoidal with frequency f, the resulting electromagnetic wave is characterized by wavelength $\lambda = c/f$, where c is the wave propagation velocity — in vacuum, the speed of light. In cases where the wavelength is much larger than the electrode geometry, the magnetic component is practically zero and no wave propagation takes place. The result is quasi-static electrical near field that can be used for sensing conductive objects such as the human body.

Microchip's GestIC technology uses transmit (Tx) frequencies in the range of 100 kHz which reflects a wavelength of about three kilometers. With electrode geometries of typically less than fourteen by fourteen centimeters, this wavelength is much larger in comparison. GestIC systems work w/o wave propagation.

In case a person's hand or finger intrudes the electrical field, the field becomes distorted. The field lines are drawn to the hand due to the conductivity of the human body itself and shunted to ground. The three-dimensional electric field decreases locally. Microchip's GestIC technology uses a minimum number of four receiver (Rx) electrodes to detect the E-field variations at different positions to measure the origin of the electric field distortion from the varying signals received. The information is used to calculate the position, track movements (MGC3130) and to classify movement patterns (gestures, MGC3X30).

Figure 1-1 and Figure 1-2 show the influence of an earth-grounded body to the electric field. The proximity of the body causes a compression of the equipotential lines and shifts the Rx electrode signal levels to a lower potential which is measured.

**FIGURE 1-1: EQUIPOTENTIAL LINES OF AN UNDISTORTED E-FIELD**

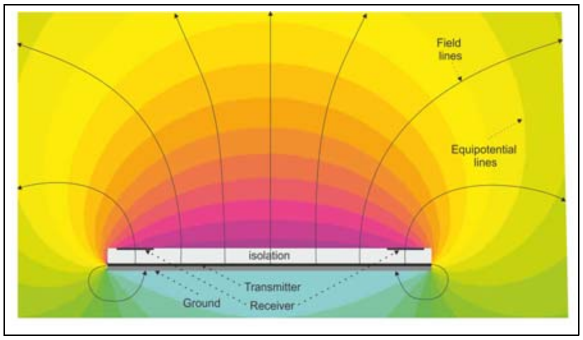
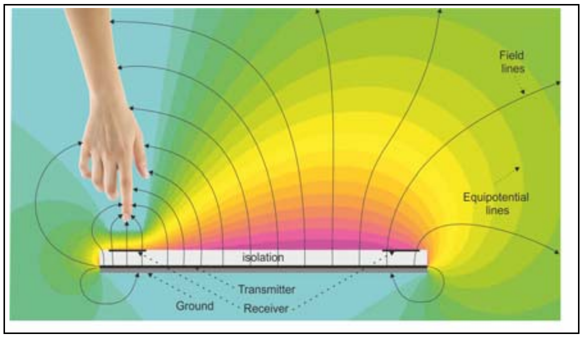



**FIGURE 1-2: EQUIPOTENTIAL LINES OF A DISTORTED E-FIELD**



## 1.1 GestIC Technology Benefits

- GestIC E-field sensors are not impacted by ambient influences such as light or sound, which have a negative impact to the majority of other 3D technologies.
- GestIC technology allows gesture/position tracking processing on chip – no host processing needed. Algorithms are included in the Colibri gesture suite which runs on chip and is provided my Microchip.
- The GestIC technology has a high immunity to noise, provides high update rates and resolution, low latency and is also not affected by clothing, surface texture or reflectivity.
- A carrier frequency in the range of 44-115 kHz is being used with the benefit of being outside the regulated radio frequency range. In the same manner, GestIC is not affected by radio interference.
- Usage of thin low-cost materials as electrodes allow low system cost at slim industrial designs.
- The further use of existing capacitive sensor structures such as a touch panel's ITO coating allow additional cost savings and ease the integration of the technology.
- Electrodes are invisible to the users' eye since they are implemented underneath the housing surface or integrated into a touch panel's ITO structure.
- GestIC works centrically over the full sensing space. Thus, it provides full surface coverage without any detection blind spots.
- Only one GestIC transmitter electrode is used for E-field generations. The benefit is an overall low power consumption and low radiated EMC noise.
- Since GestIC is basically processing raw electrode signals and computes them in real time into pre-processed gestures and x, y, z positional data, it provides a highly flexible user interface technology for any kind of electronic devices.

# 2.0 FEATURE DESCRIPTION

## 2.1 Gesture Definition

A hand gesture is the movement of the hand to express an idea or meaning. The GestIC® technology accurately allows sensing of a user's free space hand motion for contact free position tracking, as well as 3D gesture recognition based on classified movement patterns.

## 2.2 GestIC Library

MGC3X30 is being provided with a GestIC Library loader which is stored on the chip's Flash memory. Using this loader, a GestIC Library can be flashed on the MGC3X30 via $I^2C$™ with (e.g., Aurea GUI) (see **Section 7.1 "Aurea Software Package"**) or an embedded host controller. The GestIC Library includes:

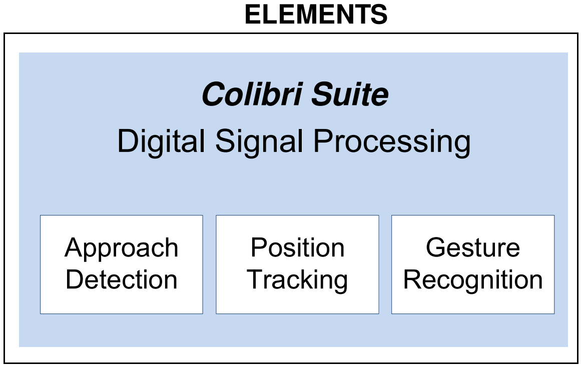
- Colibri Suite: Digital Signal Processing (DSP) algorithms and feature implementations.
- System Control: MGC3X30 hardware control features such as Analog Front End (AFE) access, interface control and parameters storage.
- Library Loader: GestIC Library update through the application host's interface.

### 2.2.1 COLIBRI SUITE

The Colibri Suite combines data acquisition, digital signal processing and interpretation.

The Colibri Suite functional features are illustrated in Figure 2-1 and described in the following sections.

**FIGURE 2-1: COLIBRI SUITE CORE ELEMENTS**




#### 2.2.1.1 Position Tracking (MGC3130)

The Colibri Suite's Position Tracking feature provides three-dimensional hand position over time and area. The absolute position data is provided according to the defined origin of the Cartesian coordinate system (x, y, z). Position Tracking data is continuously acquired in parallel to Gesture Recognition. With a position rate of up to 200 positions/sec., a maximum spatial resolution of 150 dpi is achieved.

#### 2.2.1.2 Gesture Recognition (MGC3X30)

The Colibri Suite's gesture recognition model detects and classifies hand movement patterns performed inside the sensing area.

Using advanced stochastic classification based on Hidden Markov Model (HMM), industry best gesture recognition rate is being achieved.

The Colibri Suite includes a set of predefined hand gestures which contains flick, circular and symbol gestures as the ones outlined below:

- **Flick gestures**

**FIGURE 2-2: FLICK GESTURES**


A flick gesture is a unidirectional gesture in a quick flicking motion. An example may be a hand movement from West to East within the sensing area, from South to North, etc.

- **Circular gestures**

**FIGURE 2-3: CIRCLE GESTURES**


A circular gesture is a round-shaped hand movement defined by direction (clockwise/counterclockwise) without any specific start position of the user's hand. Two types of circular gestures are distinguished by GestIC technology:

1. Discrete Circles

Discrete Circles are recognized after performing a hand movement inside the sensing area. The recognition result (direction: clockwise/ counterclockwise) is provided after the hand movement stops or the hand exits the detection area. The Discrete Circles are typically used as dedicated application control commands.

2. AirWheel

An AirWheel is the recognition of continuously-performed circles inside the sensing area and provides information about the rotational movement in real time. It provides continuously counter information which increments/decrements according to the movement's direction (clockwise/counterclockwise). The AirWheel can be adjusted for convenient usage in various applications (e.g., volume control, sensitivity adjustment or light dimming).

- **Sensor Touch Gestures**

**FIGURE 1: SENSOR TOUCH GESTURES**


A Sensor Touch is a multi-zone gesture that reports up to five concurrently-performed touches on the system's electrodes.

The Sensor Touch provides information about touch and tapping:

1. Touch

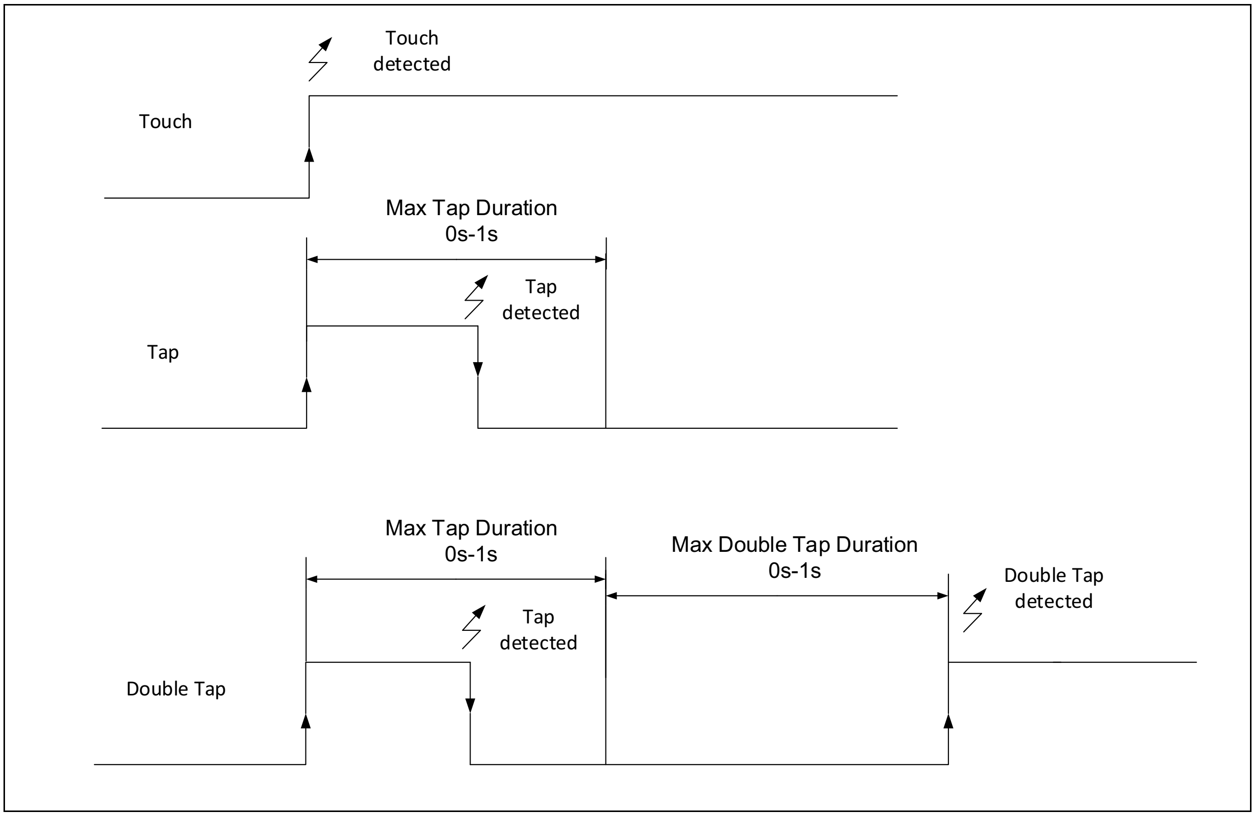
The Sensor Touch indicates an event during which a GestIC electrode is touched. This allows distinction between short and long touches.

2. Tap and Double Tap

The Tap and Double Tap signalize short taps and double taps on each system electrode. The tap length and double tap interval are adjustable.

- Single Tap Delay: A single tap is detected when touching the surface of an electrode first and after the hand is pulled out of the touch area. The Single Tap is only detected when the timing between the touch and the release of the touch event is smaller than the adjusted delay. Increasing the time allows the user more time to perform the tap. The range for the adjusted delay can be between 0s and 1s.
- Double Tap Delay: The double tap is detected when two taps are performed within the adjusted delay. The range for the adjusted delay can be between 0s and 1s. The smaller the selected delay is, the faster the two taps have to be executed.

**FIGURE 2-4: SENSOR TOUCH DIAGRAM**




### 2.2.1.3 Gesture Port

**FIGURE 2: GESTURE PORT**


The Gesture Port enables a flexible mapping of Colibri Suite feature events to certain output signals at dedicated pins of the MGC3X30. The individual feature events can be mapped to one of five EIO Pins and trigger a variety of signal changes (Permanent high, Permanent low, Toggle, Pulse (100 ms), High Active, Low Active). The Gesture Port simplifies and enhances embedded system integration. It enables host-free integration based on EIOs.

#### 2.2.1.4 Approach Detection

**FIGURE 3: APPROACH DETECTION**


Approach Detection is an embedded power-saving feature of Microchip's Colibri Suite. It sends MGC3X30 to Sleep mode and scans periodically the sensing area to detect the presence of a human hand.

Utilizing the in-built Self Wake-up mode, Approach Detection alternates between Sleep and Scan phases. During the Scan phases, the approach of a human hand can be detected while very low power is consumed. For more details, please see **Section 4.2.4.3 "Self Wake-up Mode"**.

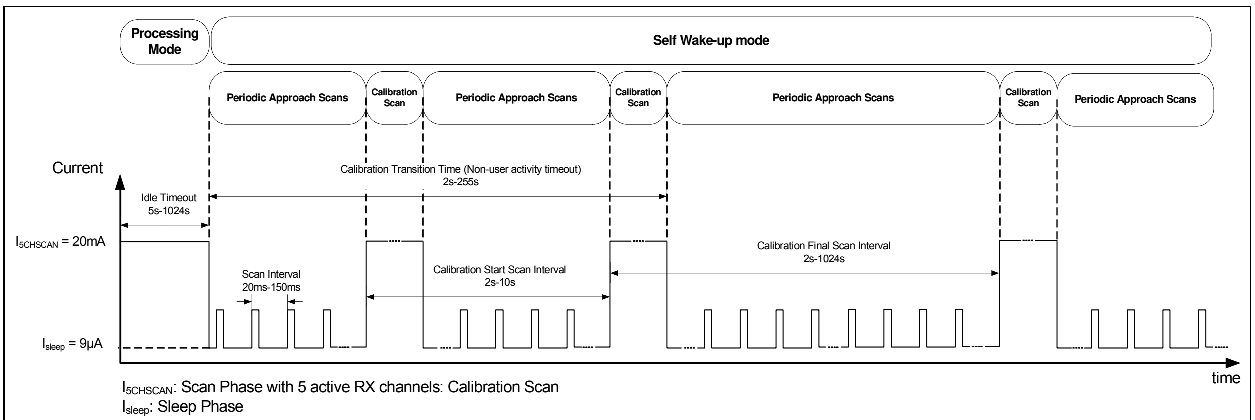
A detected approach of a user exceeding configured threshold criteria will alternate the MGC3X30 from Self Wake-up to Processing mode or even the application host in the overall system.

Within the Approach Detection sequence, the following scans are performed:

- **Approach Scan**: An Approach scan is performed during the scan phase of the MGC3X30's Self Wake-up mode. Typically, one Rx channel is active but more channels can be activated via the GestIC Library. The time interval (Scan Interval) between two consecutive Approach scans is configurable. For typical applications, the scan cycle is in a range of 20 ms to 150 ms. During the Approach scan, the activated Rx channels are monitored for signal changes which are caused by, for example, an approaching human hand and exceeding the defined threshold. This allows an autonomous wake-up of the MGC3X30 and host applications at very low-power consumption.
- **Calibration Scan**(1): The Approach Detection feature includes the possibility to perform additional Calibration scans for the continuous adaptation of the electrode system to environmental changes.
  A Calibration scan is performed during the scan phase of the MGC3X30's Self Wake-up mode. Five Rx channels are active to calibrate the sensor signals. The Calibration scan is usually performed in configurable intervals from 2s to 1024s.
  To reduce the power consumption, the number of scans per second can be decreased after a certain time of non-user activity. Colibri Suite provides a full user flexibility to configure the starting Calibration Scans rate (Calibration Start Scan Interval), non-user activity time-out (Calibration Transition Time) and the Calibration scans rate (Calibration Final Scan Interval) which will be used afterwards. A typical implementation uses Calibration scans every 2s during the first two minutes, and every 10s afterwards, until an approach is detected.

The timing sequence of the Approach Detection feature is illustrated in Figure 2-5.

**FIGURE 2-5: APPROACH DETECTION SEQUENCE**



## 3.0 SYSTEM ARCHITECTURE

MGC3X30 are mixed-signal configurable controllers. The entire system solution is composed of three main building blocks (see Figure 3-1):

- MGC3X30 Controller
- GestIC® Library
- External Electrodes

### 3.1 MGC3X30 Controller

The MGC3X30 feature the following main building blocks:

- Low Noise Analog Front End (AFE)
- Digital Signal Processing Unit (SPU)
- Communication Interfaces

The MGC3X30 provide a transmit signal to generate the E-field, conditions the analog signals from the receiving electrodes and processes these data digitally on the SPU. Data exchange between the MGC3X30 and the host is conducted via the controller's communication interface or the Gesture Port. For details, please refer to **Section 4.0 "Functional Description"**.

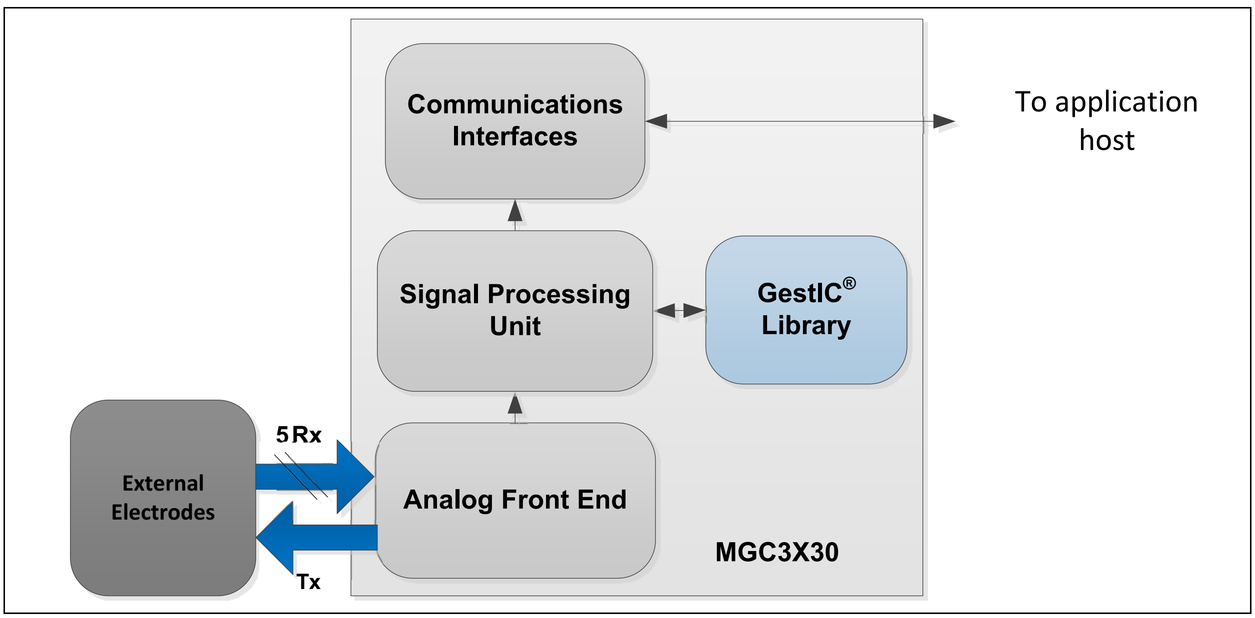
### 3.2 GestIC® Library

The embedded GestIC Library is optimized to ensure continuous and real-time free-space Gesture Recognition and Motion tracking (MGC3130) concurrently. It is fully-configurable and allows required parameterization for individual application and external electrodes.

### 3.3 External Electrodes

Electrodes are connected to MGC3X30. An electrode needs to be individually designed following the guide lines from the 'GestIC Design Guide' for optimal E-field distribution and detection of E-field variations inflicted by a user.

**FIGURE 3-1: MGC3X30 CONTROLLER SYSTEM ARCHITECTURE**

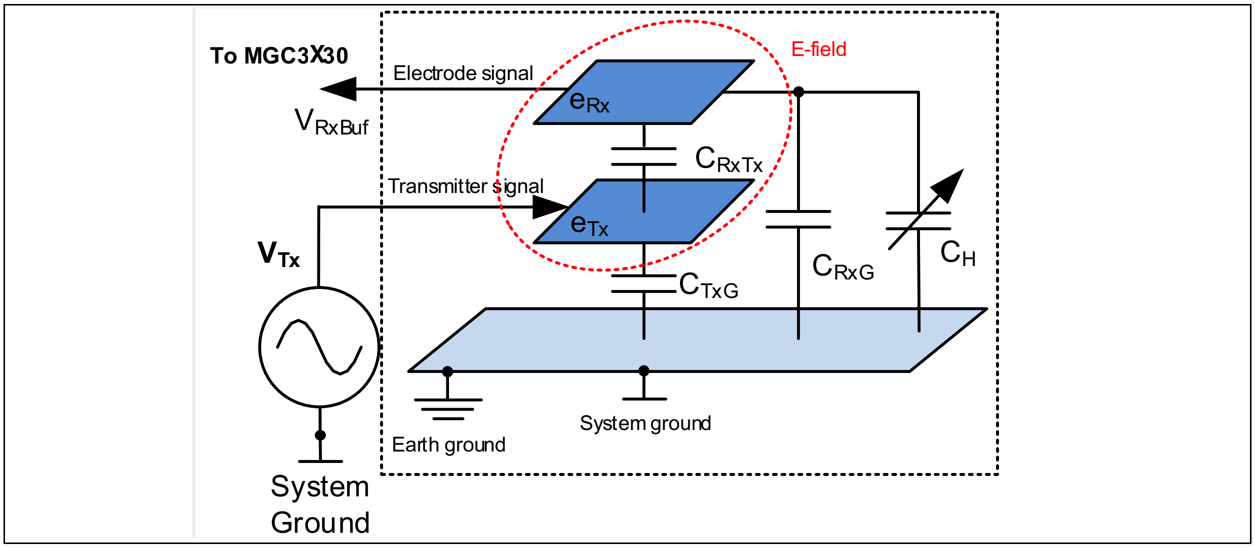


### 3.3.1 ELECTRODE EQUIVALENT CIRCUIT

The hand Position Tracking and Gesture Recognition capabilities of a GestIC system depends on the electrodes design and their material characteristics.

A simplified equivalent circuit model of a generic GestIC electrode system is illustrated in Figure 3-2.

**FIGURE 3-2: ELECTRODES CAPACITIVE EQUIVALENT CIRCUITRY EARTH GROUNDED**




- $V_{Tx}$: Tx electrode voltage
- $V_{RxBuf}$: MGC3X30 Rx input voltage
- $C_H$: Capacitance between receive electrode and hand (earth ground). The user's hand can always be considered as earth-grounded due to the comparable large size of the human body.
- $C_{RxTx}$: Capacitance between receive and transmit electrodes
- $C_{RxG}$: Capacitance of the receive (Rx) electrode to system ground + input capacitance of the MGC3X30 receiver circuit
- $C_{TxG}$: Capacitance of the transmit (Tx) electrode to system ground
- $e_{Rx}$: Rx electrode
- $e_{Tx}$: Tx electrode

The Rx and Tx electrodes in a GestIC electrode system build a capacitance voltage divider with the capacitances $C_{RxTx}$ and $C_{RxG}$ which are determined by the electrode design. $C_{TxG}$ represents the Tx electrode capacitance to system ground driven by the Tx signal. The Rx electrode measures the potential of the generated E-field. If a conductive object (e.g., a hand) approaches the Rx electrode, $C_H$ changes its capacitance. This minuscule change in the femtofarad range is detected by the MGC3X30 receiver.

The equivalent circuit formula for the earth-grounded circuitry is described in Equation 3-1.

**EQUATION 3-1: ELECTRODES EQUIVALENT CIRCUIT**

$$V_{RxBuf} = V_{Tx} \times \frac{C_{RxTx}}{C_{RxTx} + C_{RxG} + C_H}$$

A common example of an earth-grounded device is a notebook, even with no ground connection via power supply or ethernet connection. Due to its larger form factor, it presents a high earth-ground capacitance in the range of 50 pF and thus, it can be assumed as an earth-grounded GestIC system.

A brief overview of the typical values of the electrodes capacitances is summarized in Table 3-1.

**TABLE 3-1: ELECTRODES CAPACITANCES TYPICAL VALUES**

| Capacity | Typical Value |
|---|---|
| $C_{RxTx}$ | 10...30 pF |
| $C_{TxG}$ | 10...1000 pF |
| $C_{RxG}$ | 10...30 pF |
| $C_H$ | <1 pF |

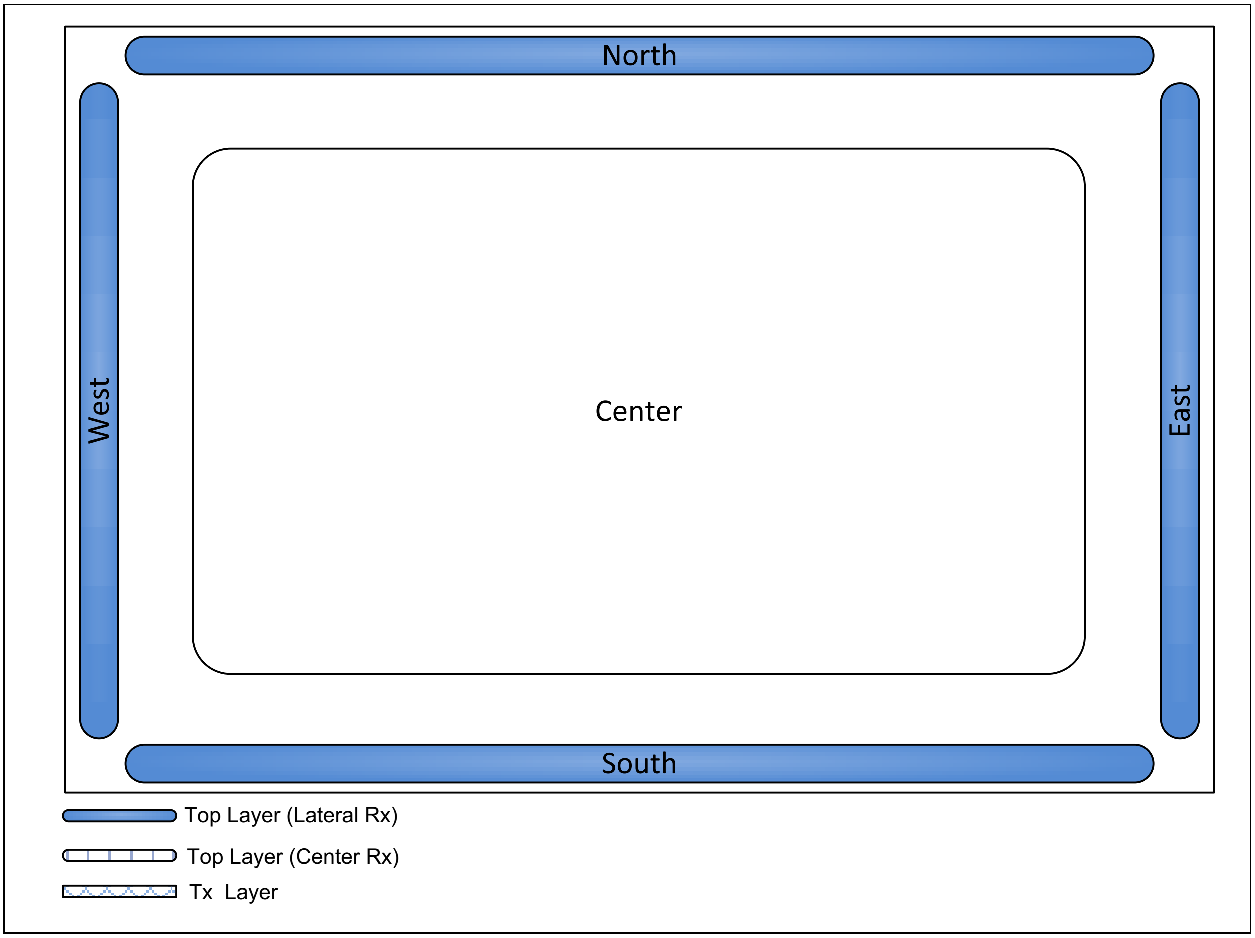
| Note: | Ideal designs have low $C_{RxTx}$ and $C_{RxG}$ to ensure higher sensitivity of the electrode system. Optimal results are achieved with $C_{RxTx}$ and $C_{RxG}$ values being in the same range. |
|---|---|

### 3.3.2 STANDARD ELECTRODE DESIGN

The MGC3X30 electrode system is typically a double-layer design with a Tx transmit electrode at the bottom layer to shield against device ground and thus, ensure high receive sensitivity. Up to five comparably smaller Rx electrodes are placed above the Tx layer providing the spatial resolution of the GestIC system. Tx and Rx are separated by a thin isolating layer. The Rx electrodes are typically arranged in a frame configuration as shown in Figure 3-3. The frame defines the inside sensing area with maximum dimensions of 14x14 centimeters. An optional fifth electrode in the center of the frame may be used to improve the distance measurement and add simple touch functionality.

The electrodes' shapes can be designed solid or structured. In addition to the distance and the material between the Rx and Tx electrodes, the shape structure density also controls the capacitance $C_{RxTx}$ and thus, the sensitivity of the system.

**FIGURE 3-3: FRAME SHAPE ELECTRODES**



## 4.0 FUNCTIONAL DESCRIPTION

Microchip Technology's MGC3X30 configurable controller uses up to five E-field receiving electrodes. Featuring a Signal Processing Unit (SPU), a wide range of 3D gesture applications are being pre-processed on the MGC3X30, which allows short development cycles, as no host processing is needed.

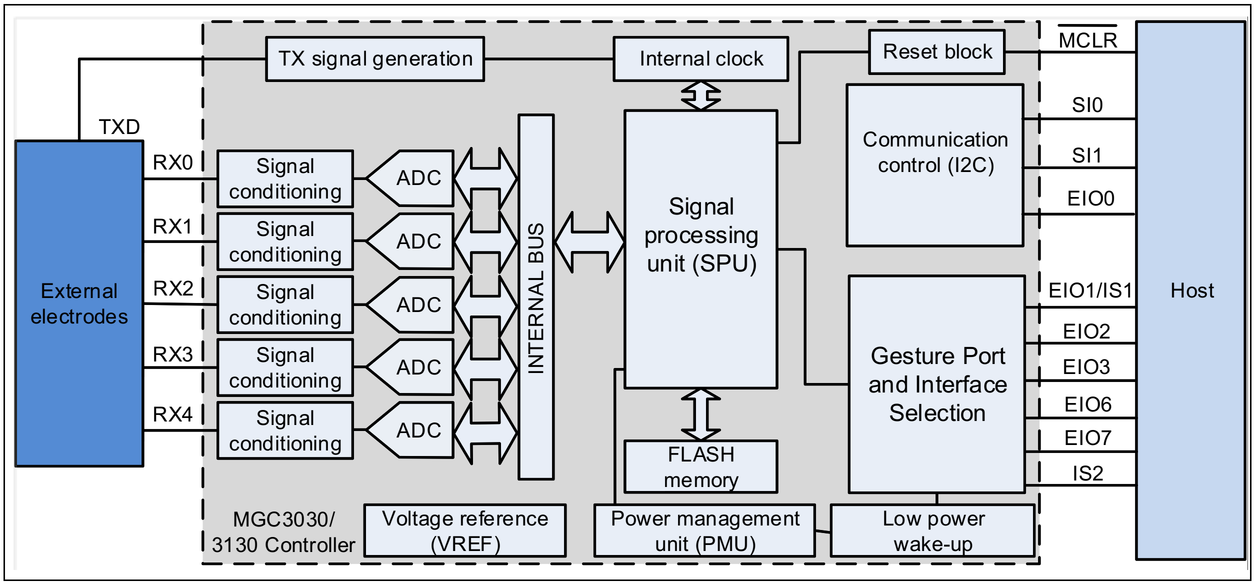
Always-on 3D sensing, even for battery-driven mobile devices, is enabled due to the chip's low-power design and variety of programmable power modes. A Self Wake-up mode triggers interrupts to the application host reacting to interaction of a user with the device and supporting the host system in overall power reduction.

The MGC3X30 offers one enhanced $I^2C$™ interface in including SDA, SCL and TS line (EIO0) for data exchange with a host controller.

GestIC® sensing electrodes are driven by a low-voltage signal with a frequency in the range of 100 kHz, which allows their electrical conductive structure to be made of any low-cost material. Even the reuse of existing conductive structures, such as a display's ITO coating, is feasible, making the MGC3X30 an overall, very cost-effective system solution.

Figure 4-1 provides an overview of the main building blocks of MGC3X30. These blocks will be described in the following sections.

**FIGURE 4-1: MGC3X30 CONTROLLER BLOCK DIAGRAM**



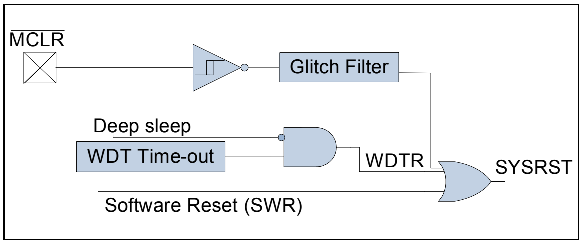
## 4.1 Reset Block

The Reset block combines all Reset sources. It controls the device system's Reset signal (SYSRST). The following is a list of device Reset sources:

- MCLR: Master Clear Reset pin
- SWR: Software Reset available through GestIC Library Loader
- WDTR: Watchdog Timer Reset

A simplified block diagram of the Reset block is illustrated in Figure 4-2.

**FIGURE 4-2: SYSTEM RESET BLOCK DIAGRAM**




## 4.2 Power Control and Clocks

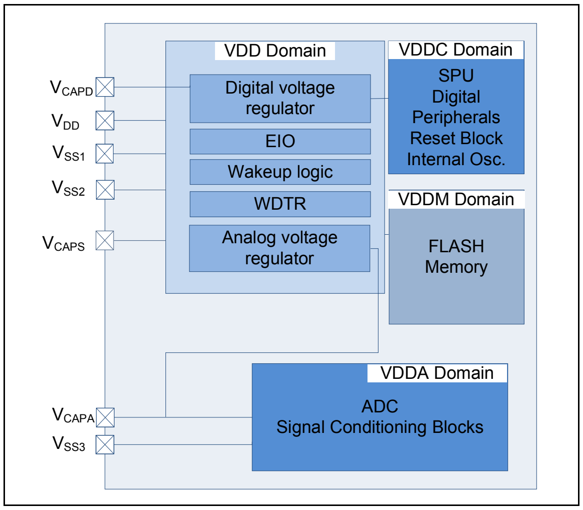
### 4.2.1 POWER MANAGEMENT UNIT (PMU)

The device requires a 3.3V ±5% supply voltage at VDD.

According to Figure 4-3, the used power domains are as follows:

- **VDD Domain**: This domain is powered by VDD = 3.3V ±5% (typical VDD = 3.3V). VDD is the external power supply for EIO, wake-up logic, WDTR and internal regulators.
- **VDDC Domain**: This domain is powered by VDDC = 1.8V. It is generated by an embedded low-impedance and fast linear voltage regulator. The voltage regulator is working under all conditions (also during Deep Sleep mode) preserving the MGC3X30 data context. VDDC is the internal power supply voltage for digital blocks, Reset block and RC oscillators. An external block capacitor, CEFCD, is required on VCAPD pin.
- **VDDA Domain**: This domain is powered by VDDA = 3.0V. It is generated by an embedded low-impedance and fast linear voltage regulator. During Deep Sleep mode, the analog voltage regulator is switched off. VDDA is the internal analog power supply voltage for the ADCs and the signal conditioning. An external block capacitor, CEFCA, is required on VCAPA pin.
- **VDDM Domain**: This domain is powered by VDDM = 3.3V. VDDM is the internal power supply voltage for the internal Flash memory. VDDM is directly powered through VDD=3.3V.

**FIGURE 4-3: POWER SCHEME BLOCK DIAGRAM**

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### 4.2.2 POWER SUPERVISORS

During the Power-up sequence, the system is kept under Reset condition for approximately 200 µs (Reset delay: $t_{RSTDLY}$) after the VDD =1.5V voltage is reached (1.2V minimum). During this delay, the system Reset will remain low and the VDD should reach typically 2V.

When the Reset delay is elapsed, the system Reset is released (high) and the system starts the Power-up/ Time-out ($t_{PWRT}$) sequence. The system start depends on the used VDD voltage. The Power-up/Time-out period ($t_{PWRT}$) after Reset takes 36 LSO cycles. (see Table 4-3).

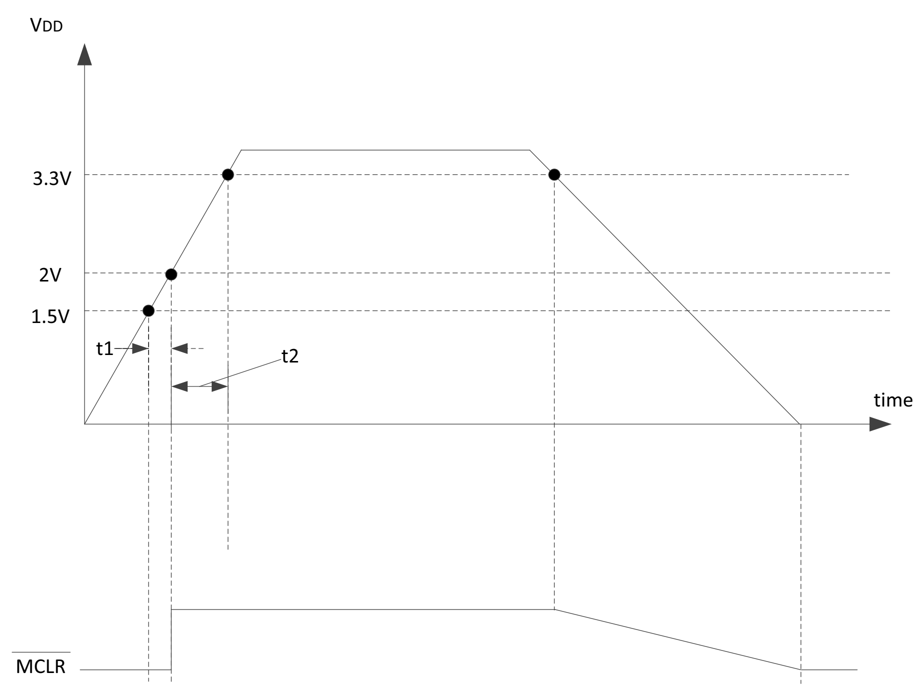
The system starts when (see Figure 4-4):

- Power-up/Time-out period ($t_{PWRT}$) is elapsed
- VDD = 3.3V is already reached before the end of $t_{PWRT}$ timing

The power-up sequence begins by increasing the voltage on the VDD pin (from 0V). If the slope of the VDD rise time is faster than 4.5 V/ms, the system starts correctly.

If the slope is less than 4.5 V/ms, the $\overline{MCLR}$ pin must be held low, by external circuitry, until a valid operating VDD level is reached.

**FIGURE 4-4: POWER SUPERVISORS**




t1: $t_{RSTDLY}$: Reset delay typically 200 µs, 120 µs minimum
t2: $t_{PWRT}$: Power-up Time-out

#### 4.2.3 CLOCKS

The MGC3X30 is embedding two internal oscillators, high speed and low speed. The High-Speed Oscillator (HSO) is factory-trimmed, achieving high accuracy.

- **High-Speed Oscillator (HSO)**:

The MGC3X30 is clocked by an internal HSO running at 22.5 MHz ±10% and consuming very low power. This clock is used to generate the Tx signal, to trigger the ADC conversions and to run the SPU. During Deep Sleep mode, the HSO clock is switched off.

- **Low-Speed Oscillator (LSO)**:

This low-speed and ultra-low-power oscillator is typically 32 kHz with a tolerance of ±10 kHz. It is used during power-saving modes.

#### 4.2.4 OPERATION MODES

MGC3X30 offers three operation modes that allow the user to balance power consumption with device functionality. In all of the modes described in this section, power saving is configured by GestIC Library messages.

##### 4.2.4.1 Processing Mode

In this mode, all power domains are enabled and the SPU is running continuously. All peripheral digital blocks are active. Gesture Recognition and Position Tracking require the Processing Operation mode.

##### 4.2.4.2 Deep Sleep Mode

During the Deep Sleep mode, $V_{DDM}$ and $V_{DDA}$ are turned off, and $V_{DDC}$ is still powered to retain the data of the SPU.

The mode includes the following characteristics:

- The SPU is halted
- The High-Speed Oscillator is shut down
- The Low-Speed Oscillator is running
- The Watchdog is switched off
- Host interface pins are active for wake-up

This leads to the lowest possible power consumption of MGC3X30.

The MGC3X30 will resume from Deep Sleep if one of the following events occurs:

- External Interrupt (IRQ0) or $I^2C0$ Start Bit Detection
- On $\overline{MCLR}$ Reset

The Deep Sleep mode can be enabled by GestIC Library messages.

##### 4.2.4.3 Self Wake-up Mode

The Self Wake-up mode is a Low-Power mode allowing an autonomous wake-up of the MGC3X30 and application host. In this mode, the MGC3X30 is automatically and periodically alternating between Sleep and Scan phases.

The MGC3X30's fast wake-up, typically below 1 ms, allows to perform scans in very efficient periods and to maximize the Sleep phase.

The periodic Wake-up sequence is triggered by a programmable wake-up timer running at LSO frequency and which can be adjusted by the Approach Detection feature.

The MGC3X30 enters the Self Wake-up mode by a GestIC Library message or by a non-activity time-out. Non-activity means no user detection within the sensing area.

The MGC3X30 will resume from Self Wake-up on one of the following events:

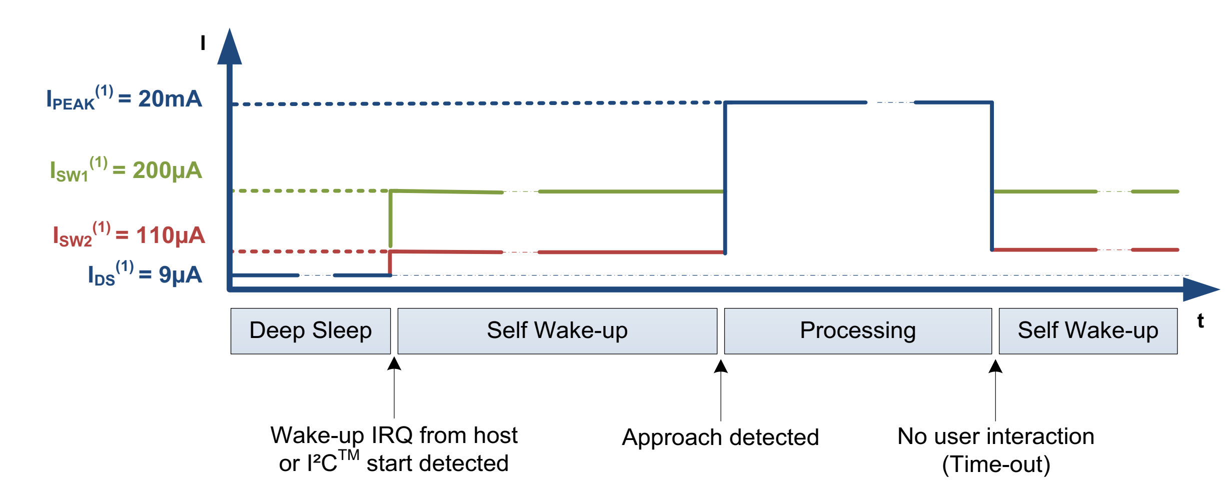
- Wake-up timer overflow event
- External Interrupt (IRQ0) or $I^2C0$ Start Bit detection
- On $\overline{MCLR}$ or WDTR

#### 4.2.4.4 MGC3X30 Power Profile

The MGC3X30 power profile is illustrated in Figure 4-5.

**FIGURE 4-5: MGC3X30 POWER PROFILE**




$I_{PEAK}$: Processing mode with 5 Rx Channels
$I_{SW1}$: Self Wake-up with 150 ms Approach Scan and 10s Calibration Scan
$I_{SW2}$: Self Wake-up with 150 ms Approach Scan and without Calibration Scan
$I_{DS}$: Deep Sleep
(1) These are preliminary values @ 3.3V, typical

MGC3X30 current consumption for the different operation modes are summarized in Table 4-1.

**TABLE 4-1: CURRENT CONSUMPTION OVERVIEW**

| Mode | Current Consumption | Conditions |
|---|---|---|
| Processing mode | 20 mA | VDD = 3.3V<br>5 Rx Channels activated |
| Self Wake-up mode | 110 µA | VDD = 3.3V<br>No Calibration Scan<br>1 Rx Channel active |
| | 200 µA | VDD = 3.3V<br>Calibration Scan each 10s<br>1 Rx Channel active |
| Deep Sleep mode | 9 µA | VDD = 3.3V |

> **Note:** In Processing mode, there are always five Rx channels activated. Choosing only four Rx channels in Aurea does not have an impact on the current consumption during Processing mode.

The Self Wake-up mode current consumption depends on the number of active channels during Self Wake-up mode, Approach Scan and Calibration Scan repetition period. Changing these parameters results in different current consumption values.

Figure 4-6 and Figure 4-7 describe the Self Wake-up mode current consumption according to the Approach Scan and Calibration Scan period change.

**FIGURE 4-6: CURRENT CONSUMPTION FOR VARYING TIME INTERVALS BETWEEN APPROACH SCANS AND CALIBRATION SCANS**

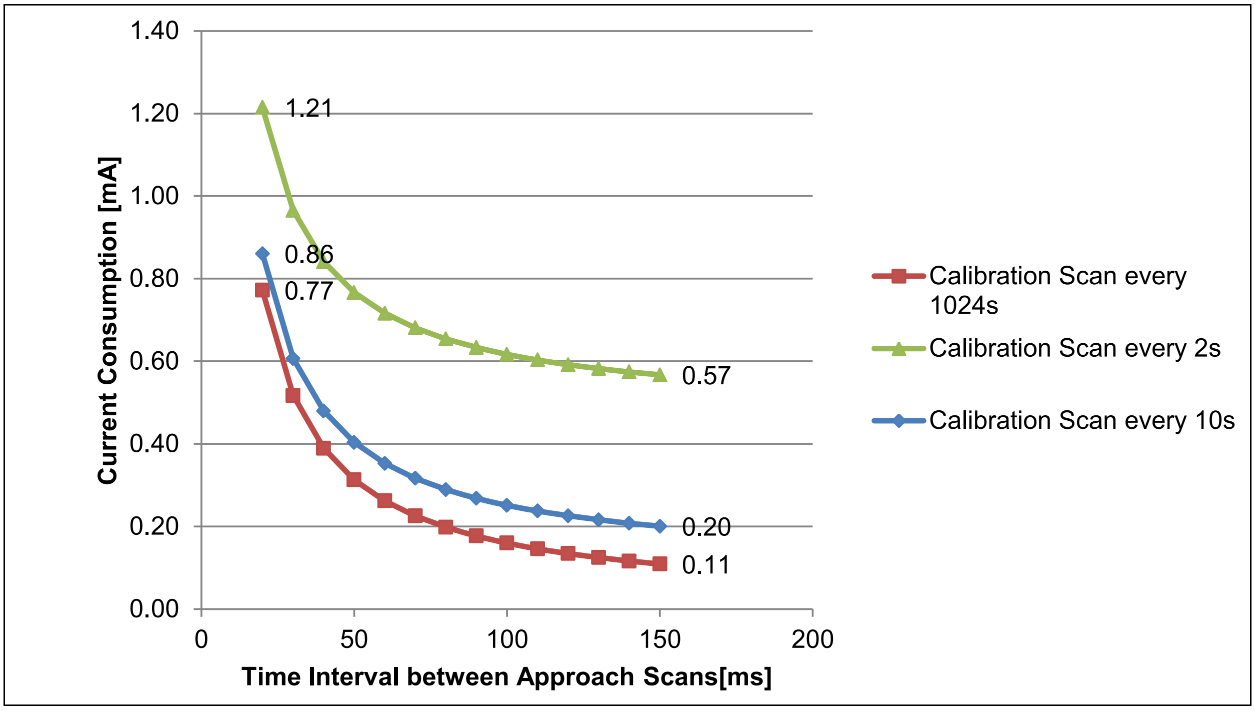
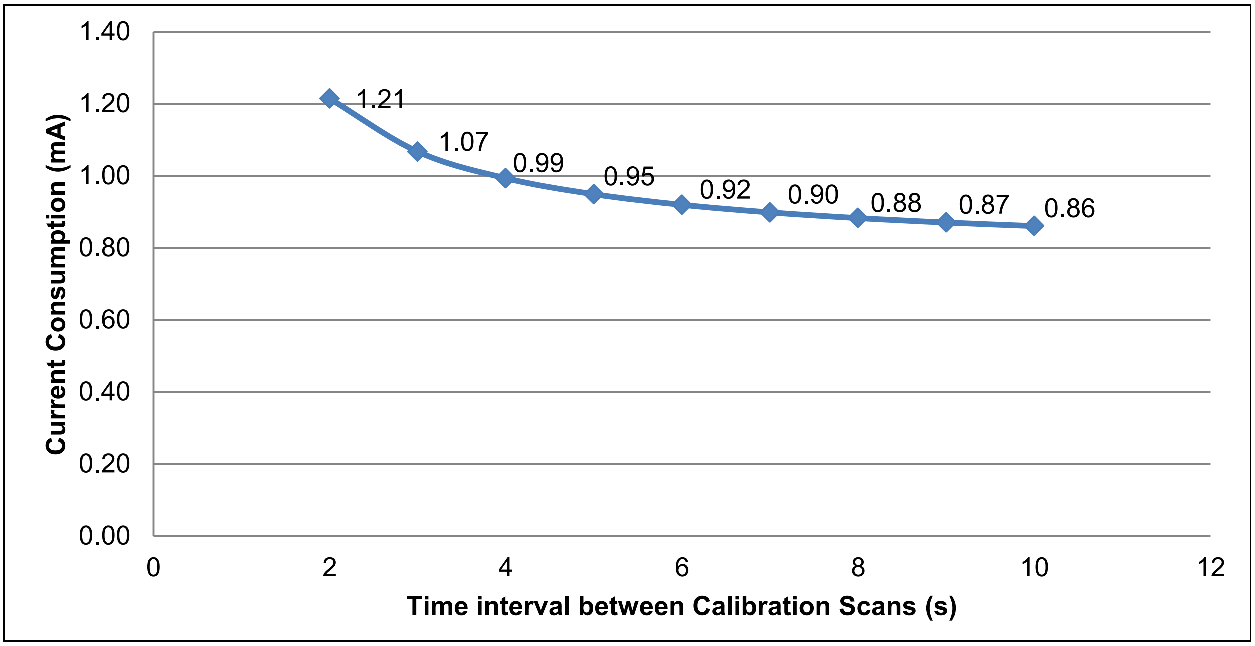



**FIGURE 4-7: CURRENT CONSUMPTION FOR A FIXED TIME INTERVAL BETWEEN APPROACH SCANS OF 20 ms**

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### 4.2.4.5 Operation Modes Summary

Table 4-2 summarizes the MGC3X30 operation modes.

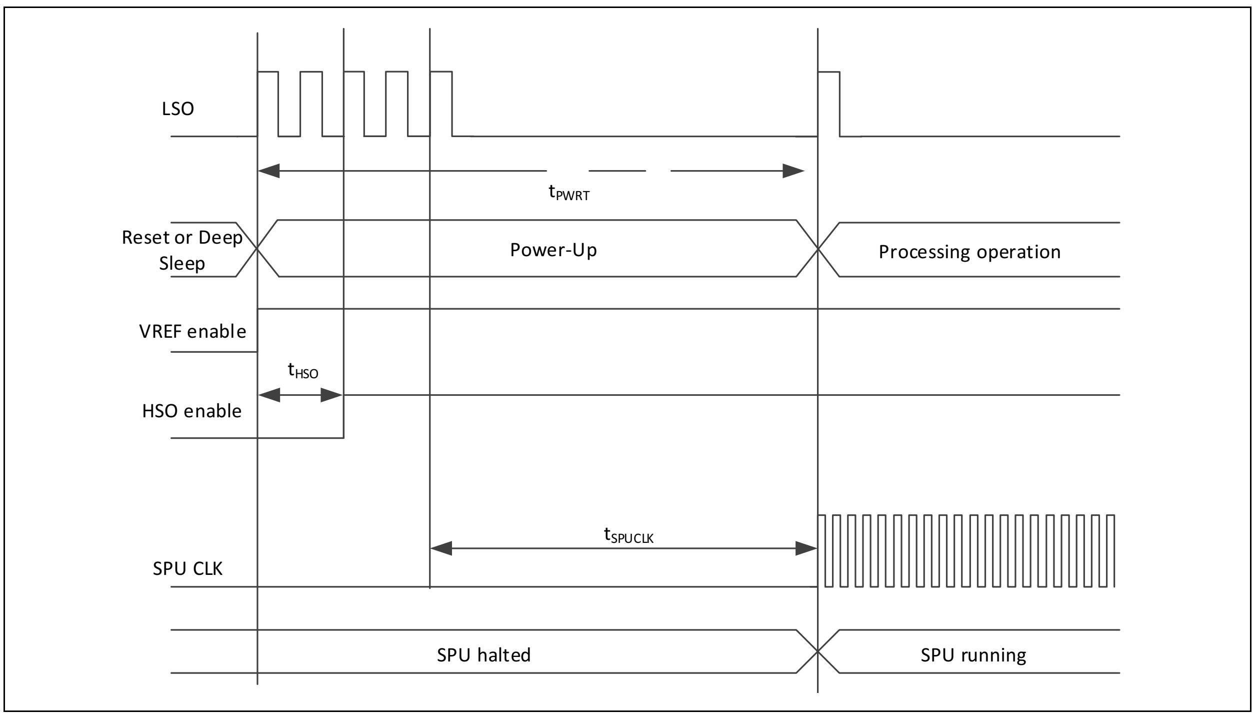
**TABLE 4-2: OPERATION MODES SUMMARY**

| Mode | Entry | Exit | Comments |
|---|---|---|---|
| Processing | I2C™0/IRQ0/Approach/ MCLR/WDTR/SW Reset | GestIC® Library Message/Non-Activity Time-out/WDTR | - Processing mode with up to five electrodes continuously running<br>- Full positioning and Gesture Recognition capabilities |
| Self Wake-up | Time-out/GestIC® Library Message | I2C™0/IRQ0/Wake-up Timer/ MCLR/WDTR | - Scan phase with a configurable number of Rx active channels, wake-up timer is used to resume the system<br>- Approach detection capability<br>- Fast wake-up time<br>- Very low-power consumption |
| Deep Sleep | GestIC® Library Message | I2C™0/IRQ0/MCLR | - SPU halted, Analog Voltage Regulator OFF, Watchdog OFF<br>- No positioning or gesture detection<br>- Extreme low-power consumption<br>- Needs trigger from application host to switch into Self Wake-up or Processing mode |

### 4.2.5 POWER-UP/DOWN SEQUENCE

Figure 4-8 represents the power-up sequence timings after a Reset or Deep Sleep state.

**FIGURE 4-8: POWER-UP SEQUENCE TIMINGS**



### Power-up Phases

- Reset or Deep Sleep: The system is kept in Reset or is in Deep Sleep mode
- Power-up: Phase when the system starts up after Reset/Deep Sleep has been released
- Processing operation: Processing mode is started
- Power-up Time-out

**TABLE 4-3: POWER-UP TIME-OUT ($t_{PWRT}$)**

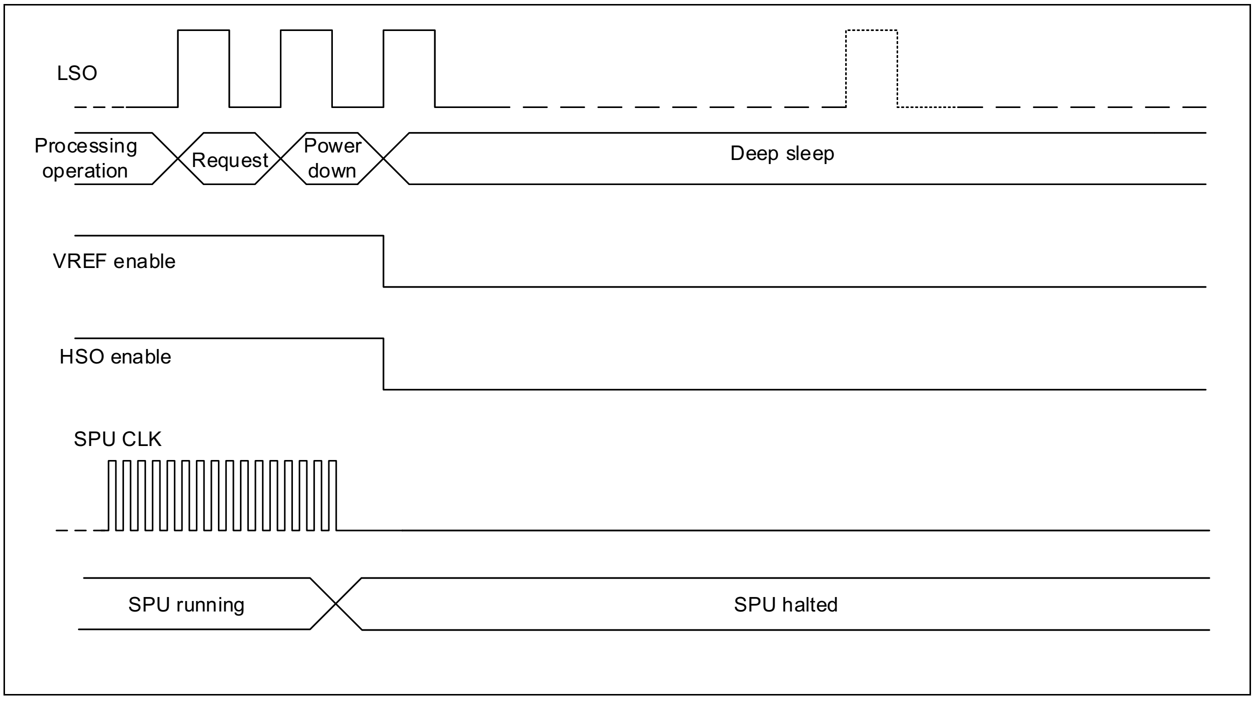
| Signal | Symbol | Delay in LSO Cycles | |
|---|---|---|---|
| | | After Reset | After Deep Sleep |
| VREF Enable | $t_{VREF}$ | 0 | 0 |
| HSO Enable | $t_{HSO}$ | 2 | 2 |
| SPU CLK | $t_{SPUCLK}$ | 30 | 8 |
| Power-Up Time-Out | $t_{PWRT}$ | 36 | 10 |

### Signal References

- LSO: Low-Speed Oscillator clock
- HSO: High-Speed Oscillator clock
- VREF Enable: Voltage Reference enable signal
- HSO Enable: High-Speed Oscillator enable signal

Figure 4-9 illustrates the power-down sequence timings.

**FIGURE 4-9: POWER-DOWN SEQUENCE TIMINGS**

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### Power-down Phases

- Processing Operation: Processing mode is activated
- Request: Request to enter Deep Sleep mode
- Power-down: Power-down state (all analog signals are down)
- Deep Sleep: Deep Sleep mode has been entered

### Signal References

- LSO: Low-Speed Oscillator clock
- HSO: High-Speed Oscillator clock
- $V_{REF}$ Enable: Voltage Reference enable signal
- HSO Enable: High-Speed Oscillator enable signal

## 4.3 Transmit Signal Generation

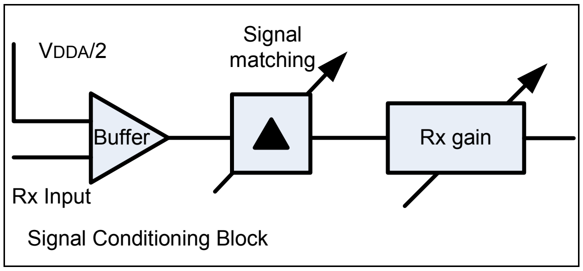
The Tx signal generation block provides a bandwidth limited square wave signal for the transmit electrode. Frequency hopping adjusts automatically the Tx carrier frequency in the range of 44-115 kHz, depending on the environmental noise conditions. GestIC Library automatically selects the lowest noise working frequency in case the sensor signal is compromised. Frequencies can be enabled/disabled via the GestIC Library.

## 4.4 Receive (Rx) Channels

There are five identical Rx channels that can be used for five respective receive electrodes. Four receive electrodes are required for Position Tracking and Gesture Recognition. A fifth electrode can be used for touch detection and to improve distance measurement. Each channel has its own analog signal conditioning stage, followed by a dedicated ADC. For specific features such as Approach Detection, individual Rx channels can be activated or deactivated via the GestIC Library. According to the electrode characteristics, the channels have to be parameterized.

The signal conditioning block contains analog filtering and amplification as shown in Figure 4-10.

**FIGURE 4-10: SIGNAL CONDITIONING BLOCK**




For individual electrode characteristics, the Rx channels can be configured as follows:

- **Signal matching**: The received signal is sampled at a sampling rate, equal to twice the Tx frequency providing a high and low ADC sample. The signal matching block adjusts the received signal towards the same value of high and low ADC samples. The offset can be adjusted accordingly.
- **The matched signal** output is amplified using a programmable gain amplifier to achieve a better sensitivity.

## 4.5 Analog-to-Digital Converter (ADC)

As outlined in **Section 4.4 "Receive (Rx) Channels"**, each Rx channel features a dedicated ADC with a trigger derived from the internal clock. ADC samples are synchronous with twice the Tx transmit frequency.

## 4.6 Signal Processing Unit (SPU)

The MGC3X30 features a Signal Processing Unit (SPU) to control the hardware blocks and process the advanced DSP algorithms included in the GestIC Library. It provides filtered sensor data, continuous position information and recognized gestures to the application host. The host combines the information and controls its application.

## 4.7 Parameters Storage

The MGC3X30 provides an embedded 32 kBytes Flash memory which is dedicated for the GestIC Library and storage of the individual configuration parameters. These parameters have to be set according to the individual electrode design and application. The GestIC Library and parameters are loaded into MGC3X30 with the provided software tools or, alternatively, via GestIC Library messages by the application host. For more details on the MGC3X30 tools, please refer to **Section 7.0 "Development Support"**.