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## Single-Zone 3D Tracking and Gesture Controller Data Sheet

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### Introduction:

The MGC3130 is a three-dimensional (3D) gesture recognition and tracking controller chip based on Microchip's patented GestIC<sup>®</sup> technology. It enables user command input with natural hand and finger movements. Utilizing the principles of electrical near-field sensing, the MGC3130 contains all the building blocks to develop robust 3D input sensing systems. Implemented as a low-power mixed-signal configurable controller, it provides 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 minimizes processing needs, reduces system power consumption and results in low software development efforts for fast time-to-market success. The MGC3130 is a unique solution that provides gesture information as well as positional data of the human hand in real time and allows realization of a new generation of user interfaces across various industries.

### Applications:

- Displays
- Notebooks/Keyboards/PC Peripherals
- Mobile Phones
- Tablet Computers
- Electronic Readers
- Remote Controls
- Game Controllers

### Power Features:

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

### Key Features:

- Recognition of 3D Hand Gestures and x, y, z Positional Data
- Proximity and Touch Sensing Capabilities
- Built-in Colibri Gesture Suite
- Advanced 3D Signal Processing Unit
- Detection Range: 0 to 15 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
- Small Outline, 28-lead QFN package, 5x5 mm
- Operating Voltage: 2.5V to 3.465V (single supply)
- Temperature Range: -20°C to +85°C

### Peripheral Features:

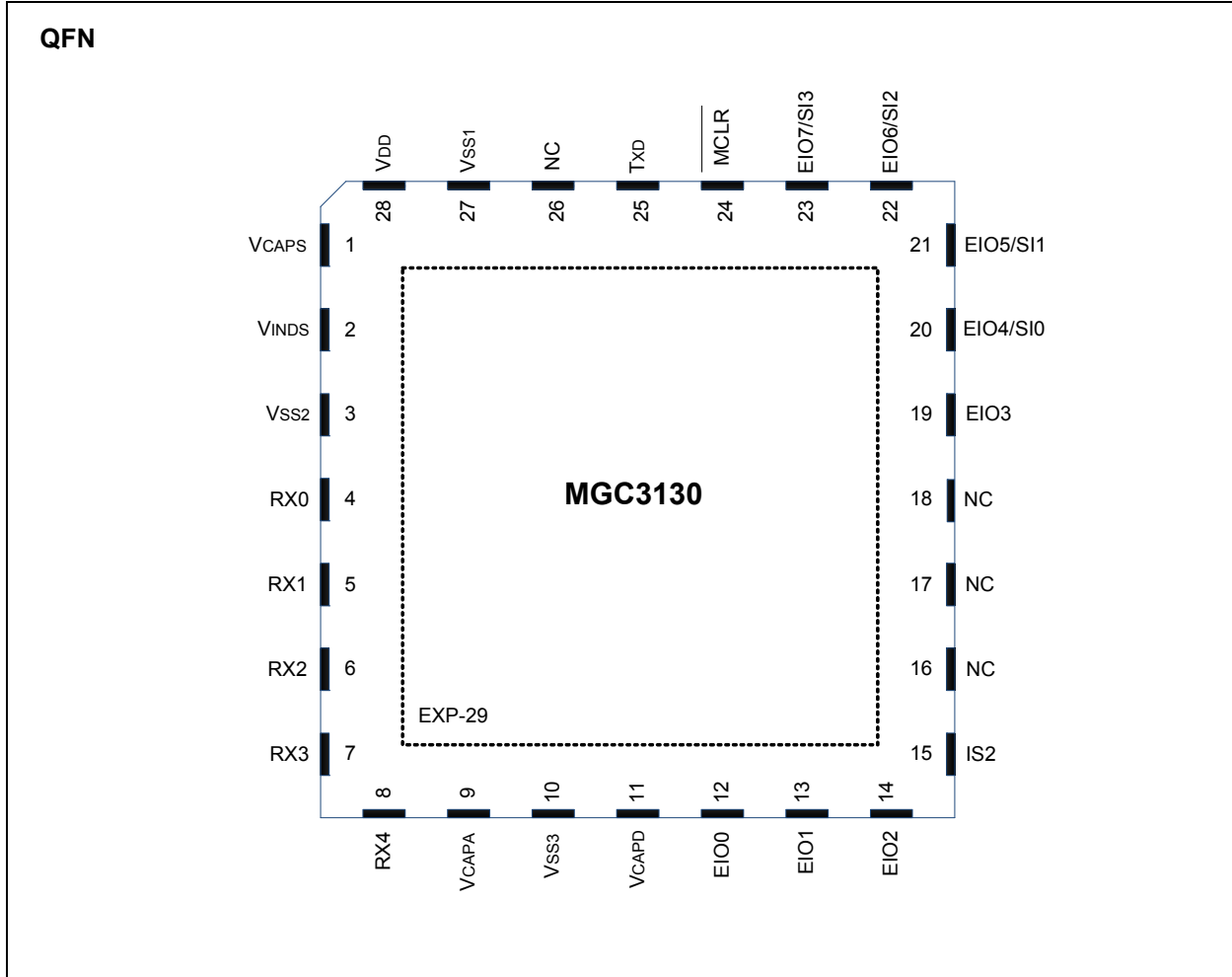
- 2x I<sup>2</sup>C™ or SPI Interface for Configuration and Streaming of Positional and Gesture Data
- Multi-zone Support via Master/Slave Architecture

# MGC3130

## Package Type

The device is available in 28-lead QFN packaging (see [Figure 1](#)).

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



**TABLE 1: 28-PIN QFN PINOUT DESCRIPTION**

Pin Name	Pin Number	Pin Type	Buffer Type	Description
VCAPS	1	P	—	External filter capacitor (10 $\mu$ F) connection for internal STEP-UP converter (optional).
VINDS	2	P	—	External inductor (4.7 $\mu$ H) + Schottky diode connection for internal STEP-UP converter usage (optional).
VSS2	3	P	—	Ground reference for the STEP-UP converter.
RX0	4	I	Analog	Analog input channels: Receive electrode connection.
RX1	5	I	Analog	
RX2	6	I	Analog	
RX3	7	I	Analog	
RX4	8	I	Analog	
VCAPA	9	P	—	External filter capacitor (4.7 $\mu$ F) connection for internal analog voltage regulator (3V).
VSS3	10	P	—	Common ground reference for analog and digital domain.
VCAPD	11	P	—	External filter capacitor (4.7 $\mu$ F) connection for internal digital voltage regulator (1.8V).
EIO0	12	I/O	ST	Extended IO0 (EIO0)/Transfer Status (TS). TS line requires external 10 k $\Omega$ pull-up.
EIO1	13	I/O	ST	Extended IO1 (EIO1)/Interface Selection Pin 1 (IS1).
EIO2	14	I/O	ST	Extended IO2 (EIO2)/IRQ0.
IS2	15	I	ST	Interface Selection Pin 2 (IS2).
NC	16	—	—	Reserved: do not connect.
NC	17	—	—	Reserved: do not connect.
NC	18	—	—	Reserved: do not connect.
EIO3	19	I/O	ST	Extended IO3 (EIO3)/IRQ1/SYNC.
EIO4/SI0	20	I/O	ST	Extended IO4 (EIO4)/Serial Interface 0 (SI0): I <sup>2</sup> C™_SDA0/SPI_MISO. When I <sup>2</sup> C™ is used, this line requires an external 1.8 k $\Omega$ pull-up.
EIO5/SI1	21	I/O	ST	Extended IO5 (EIO5)/Serial Interface 1 (SI1): I <sup>2</sup> C™_SCL0/SPI_MOSI. When I <sup>2</sup> C™ is used, this line requires an external 1.8 k $\Omega$ pull-up.
EIO6/SI2	22	I/O	ST	Extended IO6 (EIO6)/Serial Interface 2 (SI2): I <sup>2</sup> C™_SDA1/SPI_CS. When I <sup>2</sup> C™ is used, this line requires an external 1.8 k $\Omega$ pull-up.
EIO7/SI3	23	I/O	ST	Extended IO7 (EIO7)/Serial Interface 3 (SI3): I <sup>2</sup> C™_SCL1/SPI_SCLK. When I <sup>2</sup> C™ is used, this line requires an external 1.8 k $\Omega$ pull-up.
MCLR	24	I/P	ST	Master Clear (Reset) input. This pin is an active-low Reset to the device. It requires external 10 k $\Omega$ pull-up.
TXD	25	O	Analog	Transmit electrode connection.
NC	26	—	—	Reserved: do not connect.
VSS1	27	P	—	Common ground reference for analog and digital domains.
VDD	28	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

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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 or finger motion 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.

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 and to classify movement patterns (gestures).

The simulation results in [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 can be measured.

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

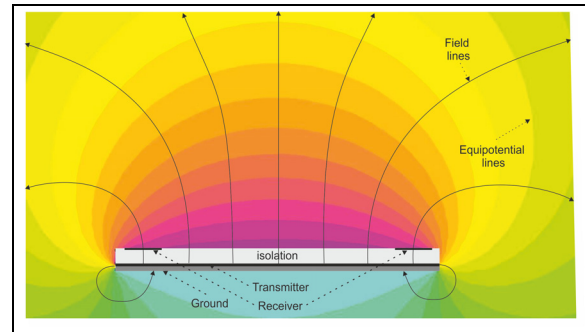
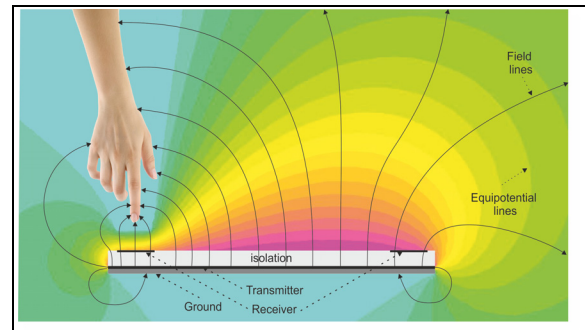


FIGURE 1-2: EQUIPOTENTIAL LINES OF A DISTORTED E-FIELD



## 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.
- 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 housing 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 centrally 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 accurate 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 three-dimensional (3D) gesture recognition based on classified movement patterns.

### 2.2 GestIC Library

MGC3130 is being provided with a GestIC Library, stored on the chip's Flash memory. The library includes:

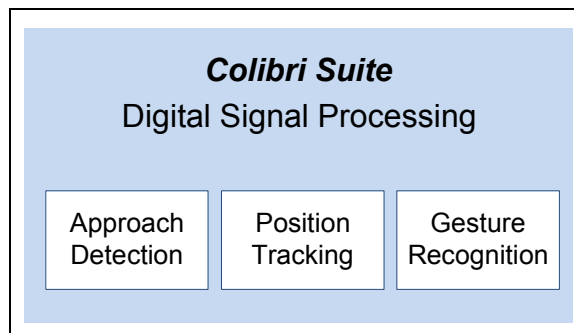
- Colibri Suite: Digital Signal Processing (DSP) algorithms and feature implementations.
- System Control: MGC3130 hardware control features such as Analog Front End (AFE) access, interface control and parameters storage.
- Library Loader: GestIC Library update through the application host's interface.

#### 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

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

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. In addition, there are some gestures derived from the combination of Gesture Recognition and spatial information.

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

- **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**

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 starts after at least one quadrant of a circle is recognized and 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**

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

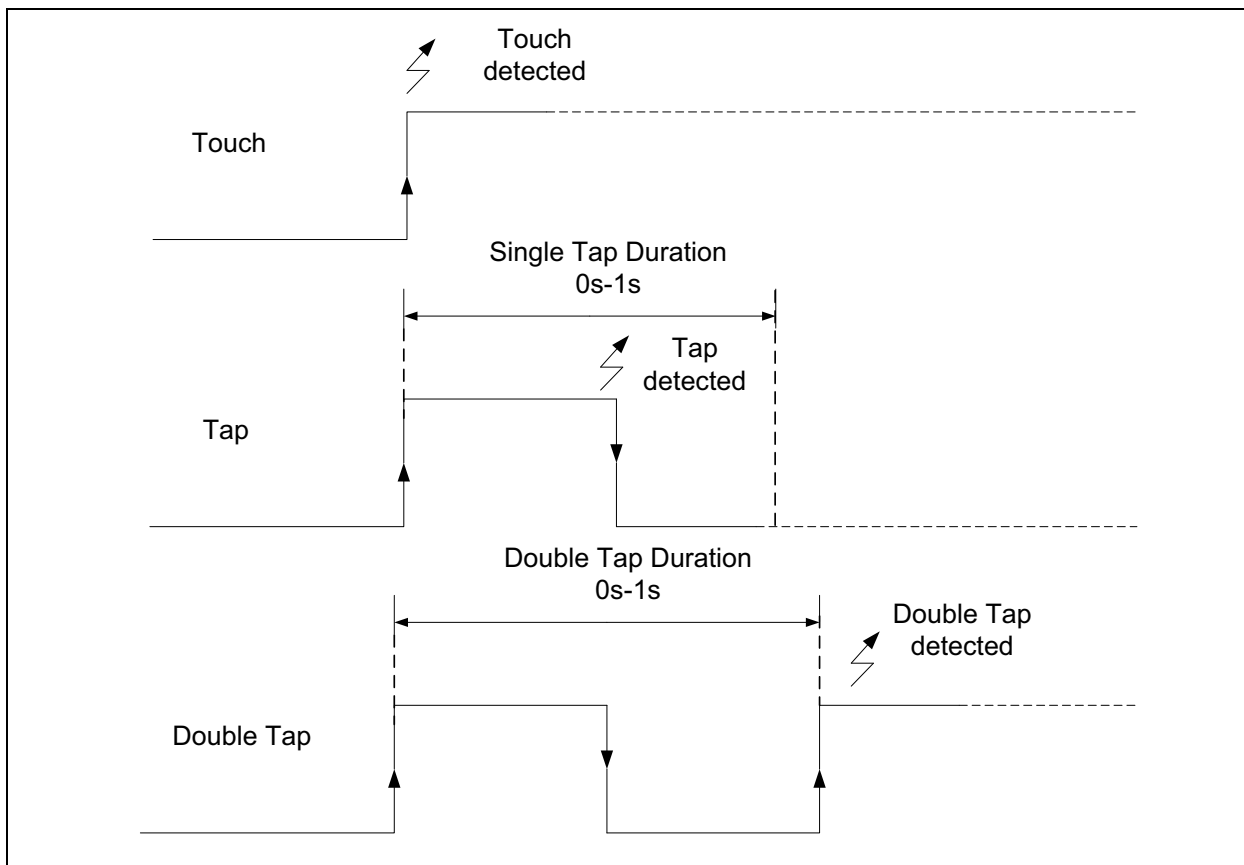
# MGC3130

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 2-2: SENSOR TOUCH DIAGRAM**



## • **Gesture Port**

The Gesture Port enables a flexible mapping of Colibri Suite feature events to certain output signals at defined MGC3130's pins. 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 (5 ms), High Active, Low Active). The Gesture Port simplifies and enhances embedded system integration.



## 2.2.1.3 Approach Detection

Approach Detection is an embedded power-saving feature of Microchip's Colibri Suite. It sends MGC3130 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 MGC3130 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 MGC3130's Self Wake-up mode. Typically, 1 Rx channel is active but more channels can be activated via 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 MGC3130 and host applications at very low-power consumption.

- Calibration Scan<sup>(1)</sup>:** The Approach Detection feature includes the possibility to perform additional Calibration Scans for the continuous adaptation of the electrode system to environmental changes.

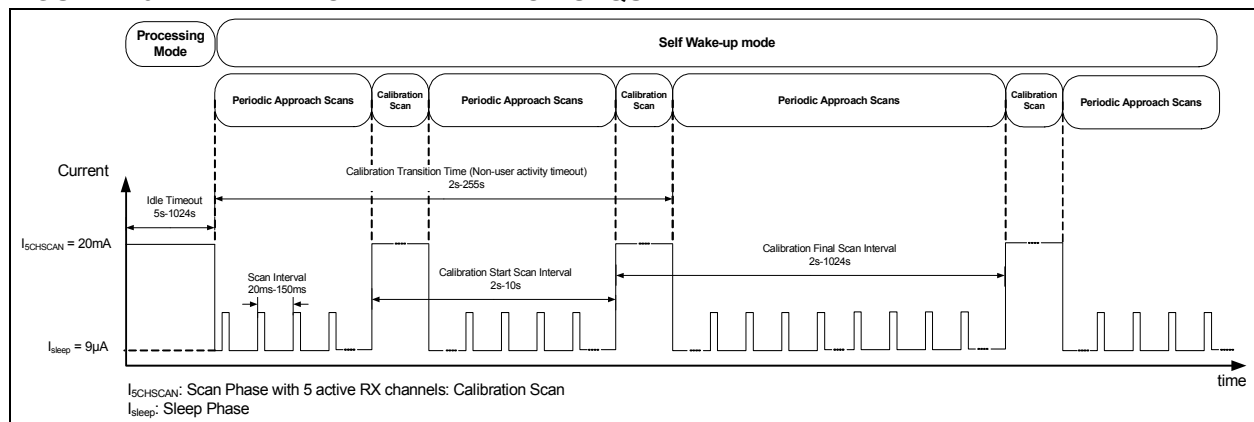
A Calibration Scan is performed during the Scan phase of the MGC3130's Self Wake-up mode. Five Rx channels are active to calibrate the sensor signals. The Calibration Scan is usually performed in configurable intervals from 2s to 1024s.

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.

**Note 1:** The Calibration Scan is only needed for applications using the Position Tracking feature.

The timing sequence of the Approach Detection feature is illustrated in [Figure 2-3](#).

**FIGURE 2-3: APPROACH DETECTION SEQUENCE**



# MGC3130

## 3.0 SYSTEM ARCHITECTURE

The MGC3130 is the first product based on Microchip's GestIC technology. It is developed as a mixed-signal configurable controller. The entire system solution is composed by three main building blocks (see [Figure 3-1](#)):

- MGC3130 Controller
- GestIC Library
- External Electrodes

### 3.1 MGC3130 Controller

The MGC3130 features the following main building blocks:

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

It provides 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 MGC3130 and the host is conducted via the controller's communication interface. For details, please refer to [Section 4.0 "Functional Description"](#).

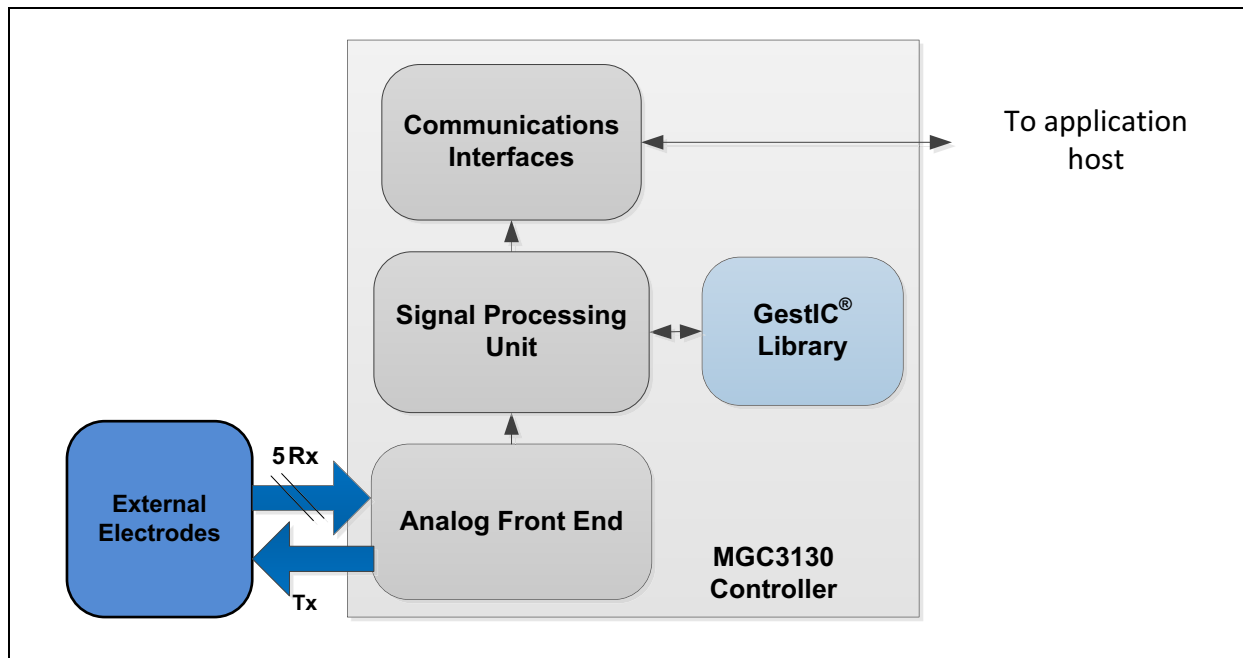
### 3.2 GestIC Library

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

### 3.3 External Electrodes

Electrodes are connected to MGC3130. An electrode needs to be individually designed for optimal E-field distribution and detection of E-field variations inflicted by a user.

**FIGURE 3-1: MGC3130 CONTROLLER SYSTEM ARCHITECTURE**

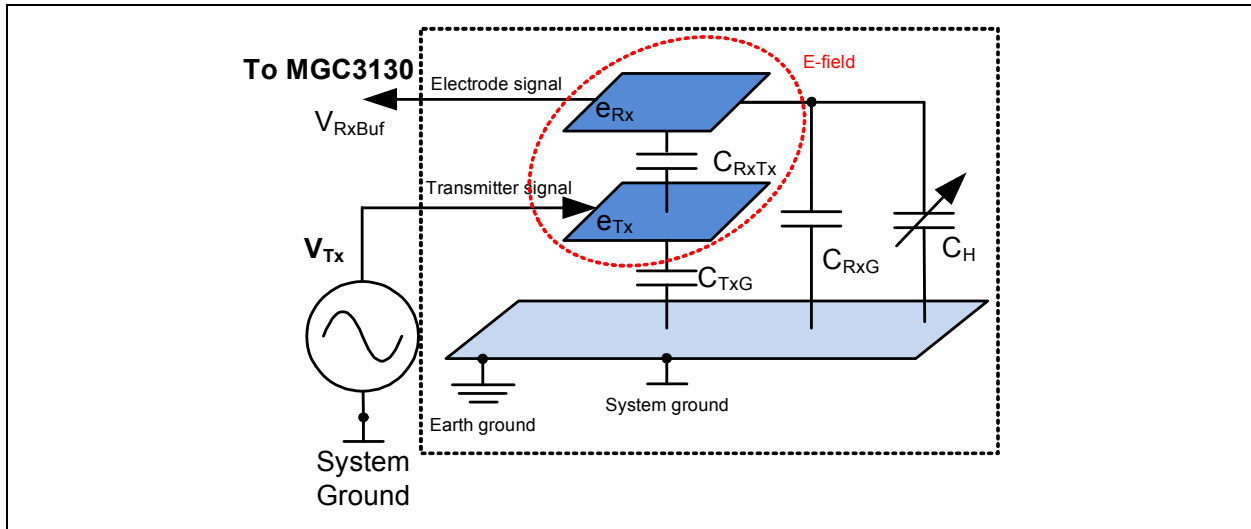


## 3.3.1 ELECTRODE EQUIVALENT CIRCUIT

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
- $V_{RxBuf}$ : MGC3130 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 MGC3130 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 MGC3130 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

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**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.

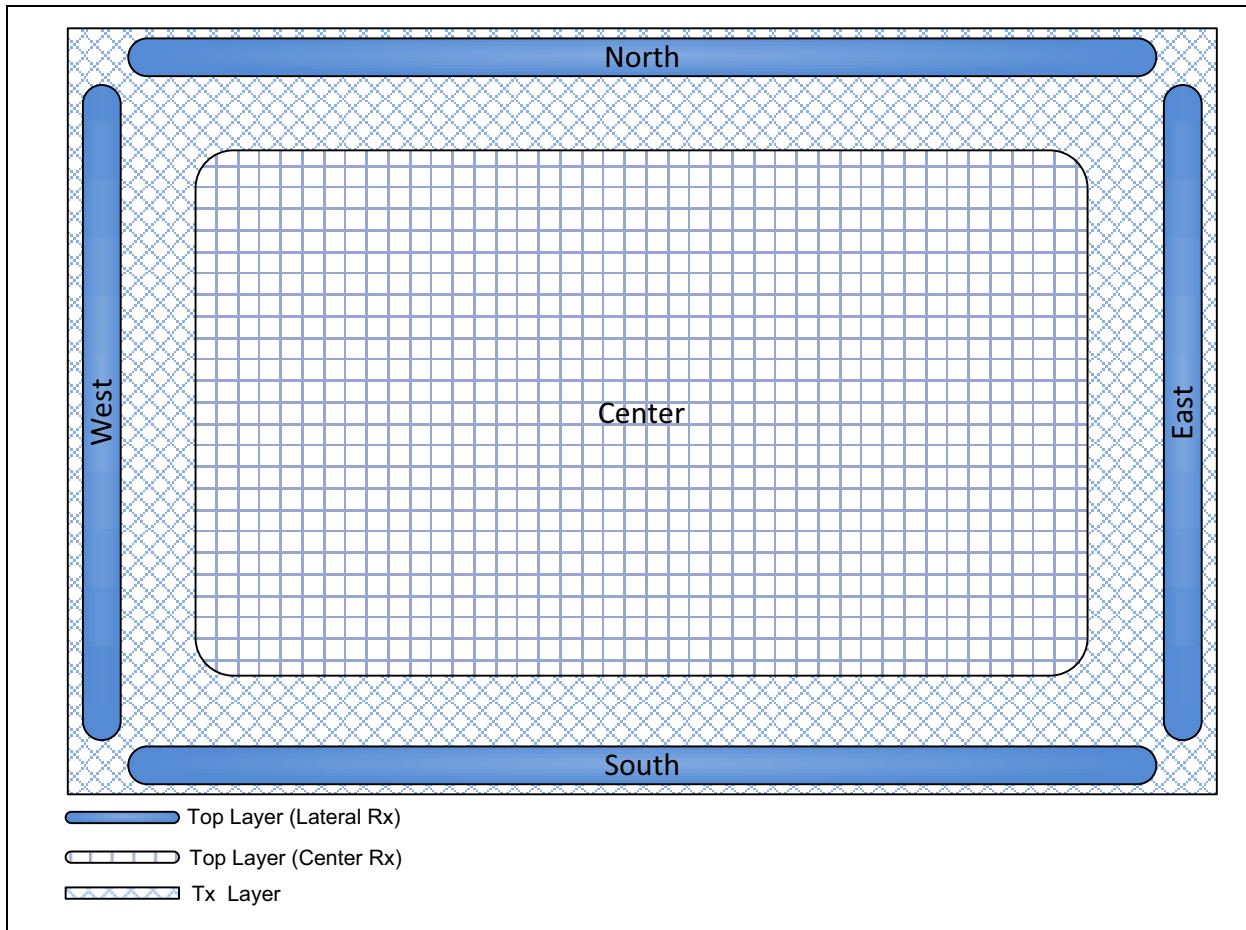
## 3.3.2 STANDARD ELECTRODE DESIGN

The MGC3130 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 MGC3130 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 MGC3130, which allows short development cycles.

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.

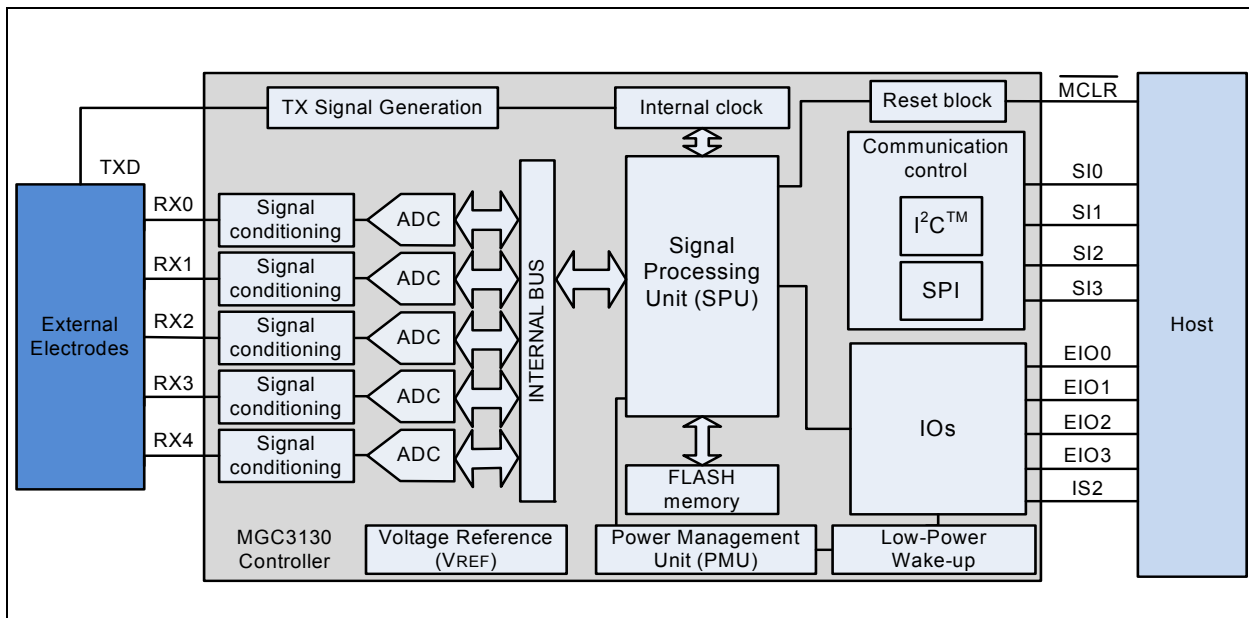
Featuring a programmable 4-pin digital interface, the MGC3130 matches a multitude of hardware requirements. Developers have the choice of data exchange via I<sup>2</sup>C or SPI. Since the device provides two I<sup>2</sup>C interfaces, developers have the option to set up a master-slave architecture between two MGC3130 devices to add an additional sensing area (e.g., Two-

Zone Design) or a single MGC3130 and another circuit with a corresponding interface, such as a touch screen 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 MGC3130 an overall, very cost-effective system solution.

Figure 4-1 provides an overview of the main building blocks of MGC3130. These blocks will be described in the following sections.

**FIGURE 4-1: MGC3130 CONTROLLER BLOCK DIAGRAM**



# MGC3130

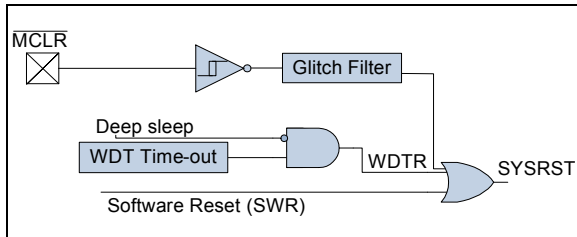
## 4.1 Reset Block

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
- **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)

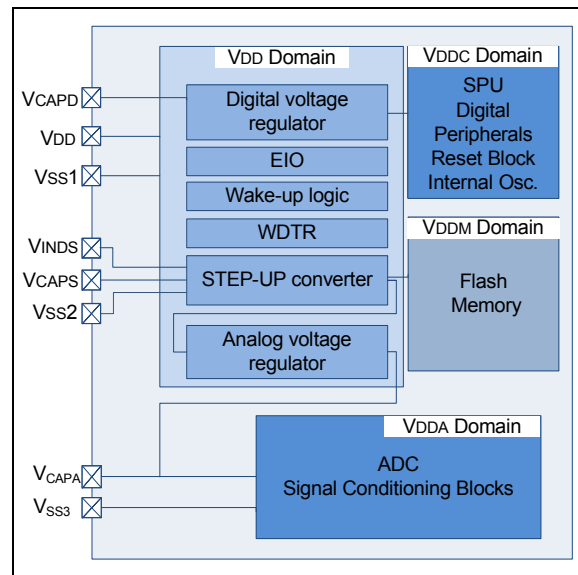
The device requires a 3.3V  $\pm 5\%$  supply voltage at VDD. Enabling the internal STEP-UP converter extends the voltage range to 2.5 to 3.465V.

According to [Figure 4-3](#), the used power domains are as follows:

- **VDD Domain**: This domain is powered by VDD = 2.5V to 3.465V (typical VDD = 3.3V). VDD is the external power supply for EIO, wake-up logic, WDTR, internal regulators and STEP-UP converter. It is provided externally through the VDD pin.
- **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 MGC3130 data context. VDDC is the internal power supply voltage for digital blocks, Reset block and RC oscillators. An external block capacitor, CEFC, 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, CECA, 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. This power supply is depending on VDD voltage range. If VDD  $\geq$  3.3V, the memory is directly powered through the VDD pin. In case of VDD < 3.3V, the Flash power supply is generated internally by an embedded STEP-UP converter.

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



- **STEP-UP Converter**: The STEP-UP converter is generating 3.3V from the connected supply voltage VDD (if it is lower than 3.3V). This voltage is required by the internal Flash memory. The required voltage reference is taken from the voltage reference block. During Deep Sleep mode, the converter is switched off. It requires an external connected inductor, a filtering capacitor and a Schottky diode connected to the VINDS and VCAPS pins. If the supply voltage is high enough, the STEP-UP converter will be disabled. Please refer to [Section 9.0 "Electrical Specifications"](#) for more details.

## 4.2.2 POWER SUPERVISORS

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

When the Reset delay is elapsed, the system Reset is released (high) and the system starts Power-up/Time-out ( $t_{\text{PWRT}}$ ) sequence. The system start depends on the target application (if the STEP-UP will be used or not) and on the used  $V_{\text{DD}}$  voltage. The Power-up/Time-out period ( $t_{\text{PWRT}}$ ) after Reset takes 36 LSO cycles. (see [Table 4-3](#)).

**STEP-UP applications ( $2.5\text{V} \leq V_{\text{DD}} < 3.3\text{V}$ ):**

The system starts when (see [Figure 4-5](#)):

- Power-up/Time-out period ( $t_{\text{PWRT}}$ ) is elapsed
- $V_{\text{DD}} = 2.5\text{V}$  is already reached before the end of  $t_{\text{STEP-UP}}$  during the  $t_{\text{PWRT}}$  (See [Table 4-3](#)). 2.5V is the minimum voltage needed to power the STEP-UP.

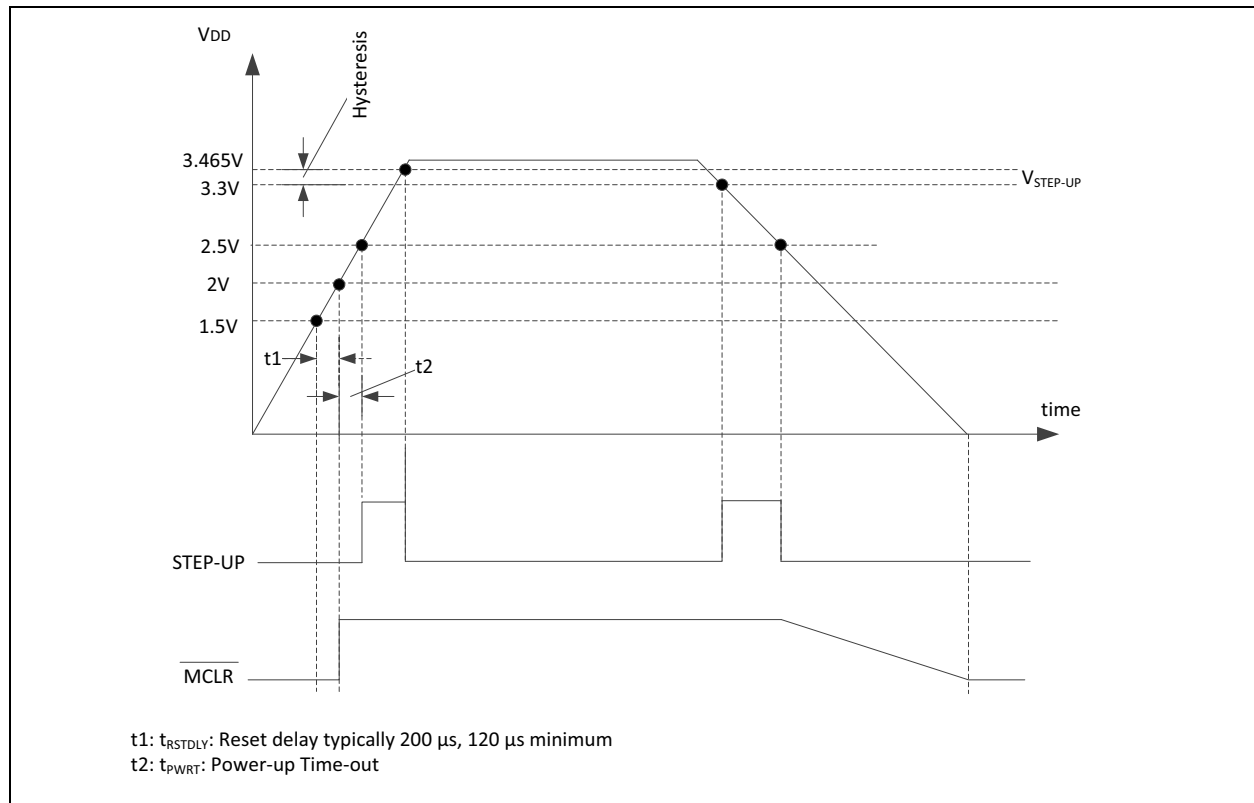
The STEP-UP converter starts automatically from 2.5V if the external STEP-UP components are assembled. It stays activated until a 3.465V  $V_{\text{DD}}$  voltage level is reached.

For  $V_{\text{DD}}$  input beyond this level, the STEP-UP converter will automatically stop operating and the GestIC Library can disable it. For more details, please refer to [Figure 4-5](#).

The power-up sequence begins by increasing the voltage on the  $V_{\text{DD}}$  pin (from 0V). If the slope of the  $V_{\text{DD}}$  rise time is faster than 6 V/ms, the system starts correctly.

If the slope is less than 6 V/ms, the  $\overline{\text{MCLR}}$  pin should be held low, by external circuitry, until a valid operating  $V_{\text{DD}}$  level is reached.

**FIGURE 4-4: STEP-UP APPLICATIONS START-UP**



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Standard applications (without STEP-UP) ( $3.3V \leq V_{DD} \leq 3.465V$ ):

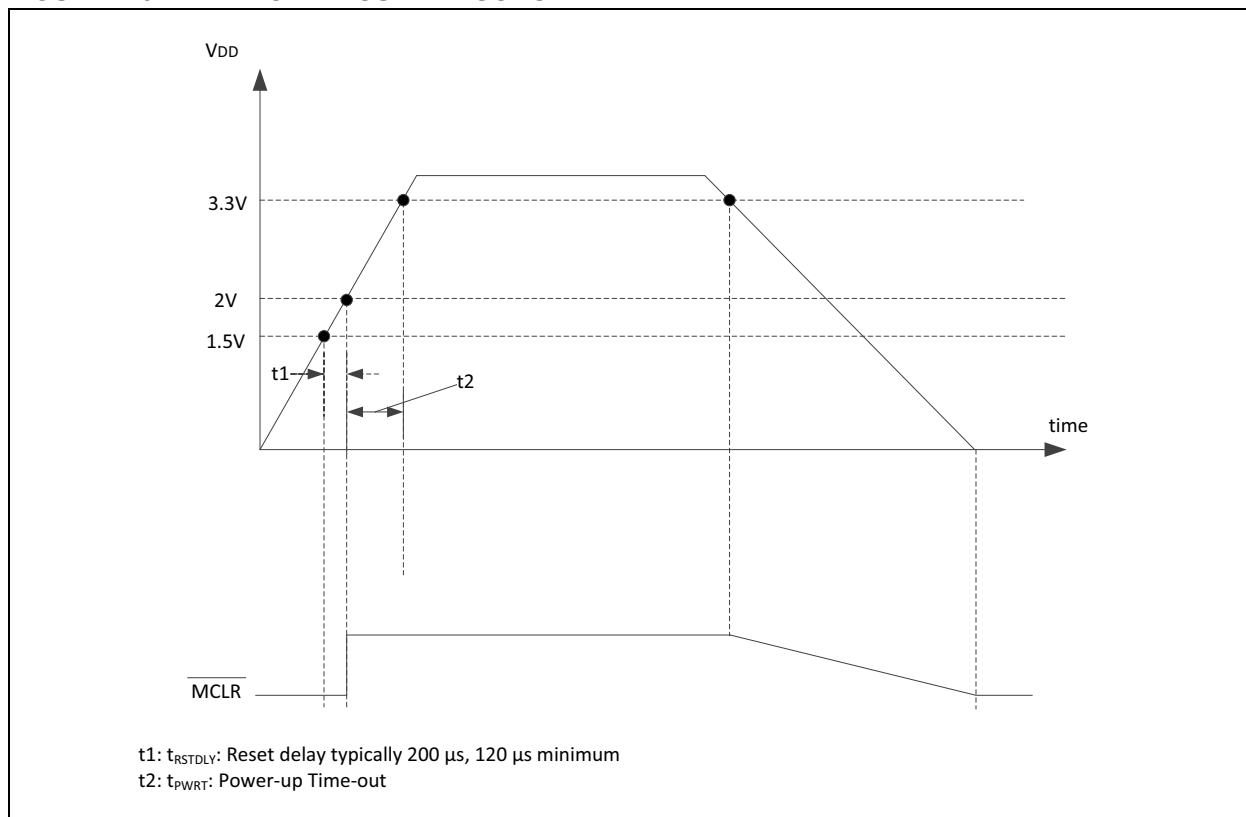
The system starts when (see Figure 4-5):

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

The power-up sequence begins by increasing the voltage on the  $V_{DD}$  pin (from 0V). If the slope of the  $V_{DD}$  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  $V_{DD}$  level is reached.

**FIGURE 4-5: POWER SUPERVISORS**





## 4.2.3 CLOCKS

The MGC3130 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 MGC3130 is clocked by an internal HSO running at 22.5 MHz  $\pm$ 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  $\pm$ 10 kHz. It is used during power-saving modes.

## 4.2.4 OPERATION MODES

MGC3130 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. Each Rx channel can be activated individually by GestIC Library depending on the application. Gesture Recognition and Position Tracking require the Processing Operation mode.

### 4.2.4.2 Deep Sleep Mode

During the Deep Sleep mode, VDDM and VDDA are turned off, and VDDC 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 MGC3130.

The MGC3130 will resume from Deep Sleep if one of the following events occurs:

- External Interrupt (IRQ0) or I<sup>2</sup>C0 Start Bit Detection
- On  $\overline{\text{MCLR}}$  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 MGC3130 and application host. In this mode, the MGC3130 is automatically and periodically alternating between Sleep and Scan phases.

The MGC3130'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 MGC3130 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 MGC3130 will resume from Self Wake-up on one of the following events:

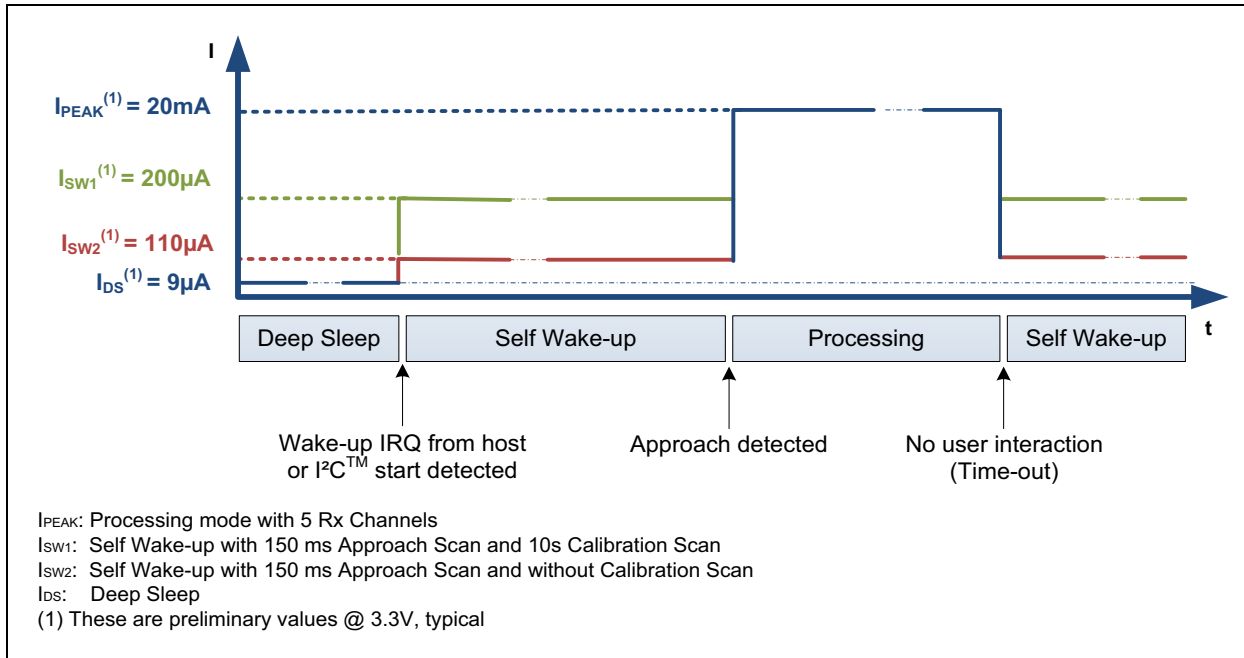
- Wake-up timer overflow event
- External Interrupt (IRQ0) or I<sup>2</sup>C0 Start Bit detection
- On  $\overline{\text{MCLR}}$  or WDTR

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## 4.2.4.4 MGC3130 Power Profile

The MGC3130 power profile is illustrated in Figure 4-6.

**FIGURE 4-6: MGC3130 POWER PROFILE**



MGC3130 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	V <sub>DD</sub> = 3.3V 5 Rx Channels activated
Self Wake-up mode	110 µA	V <sub>DD</sub> = 3.3V No Calibration Scan Approach Scan each 150 ms
	200 µA	V <sub>DD</sub> = 3.3V Calibration Scan each 10s Approach Scan each 150 ms
Deep Sleep mode	9 µA	V <sub>DD</sub> = 3.3V

The Processing mode current consumption depends on the number of active Rx channels,  $N_{RxChannels}$ , and can be determined by Equation 4-1.

**EQUATION 4-1: PROCESSING MODE CURRENT CONSUMPTION**

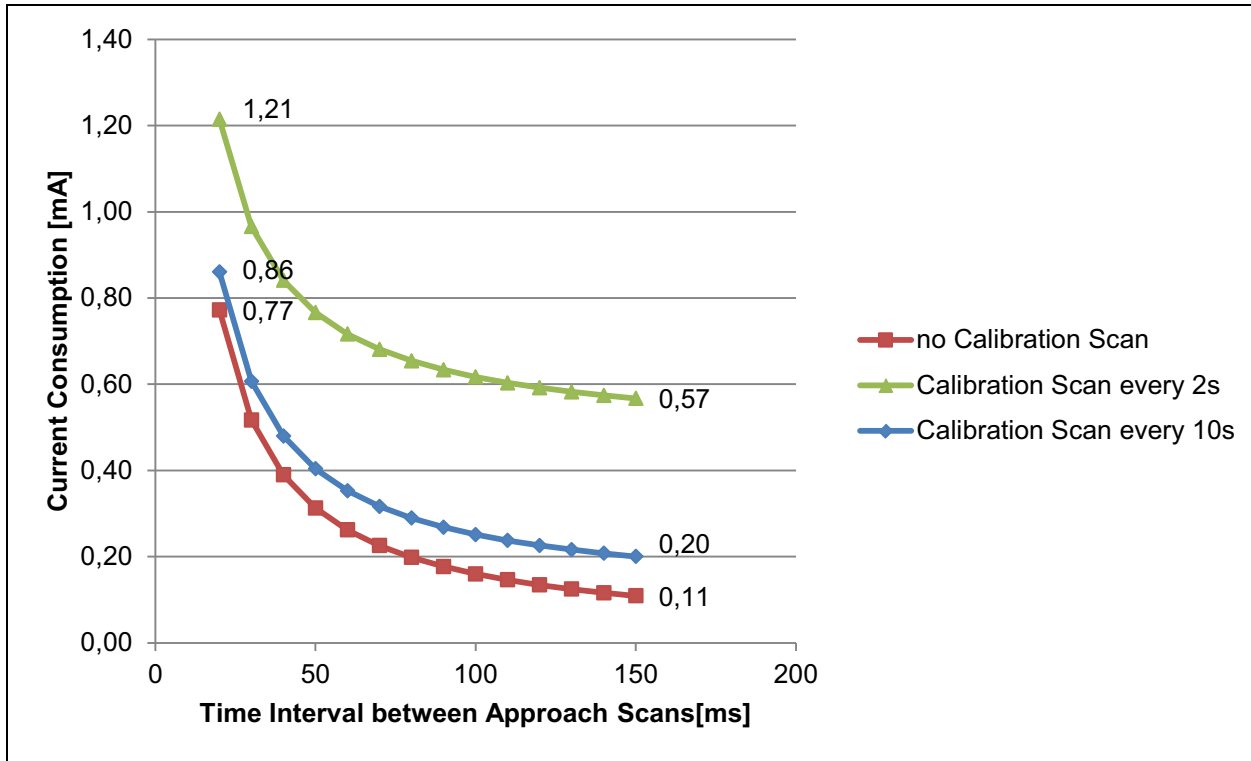
$$I_{peak} = (10 + (N_{RxChannels} \times 2))mA$$

The Self Wake-up mode current consumption depends on the Approach Detection feature configuration: Approach Scan and Calibration Scan repetition period.

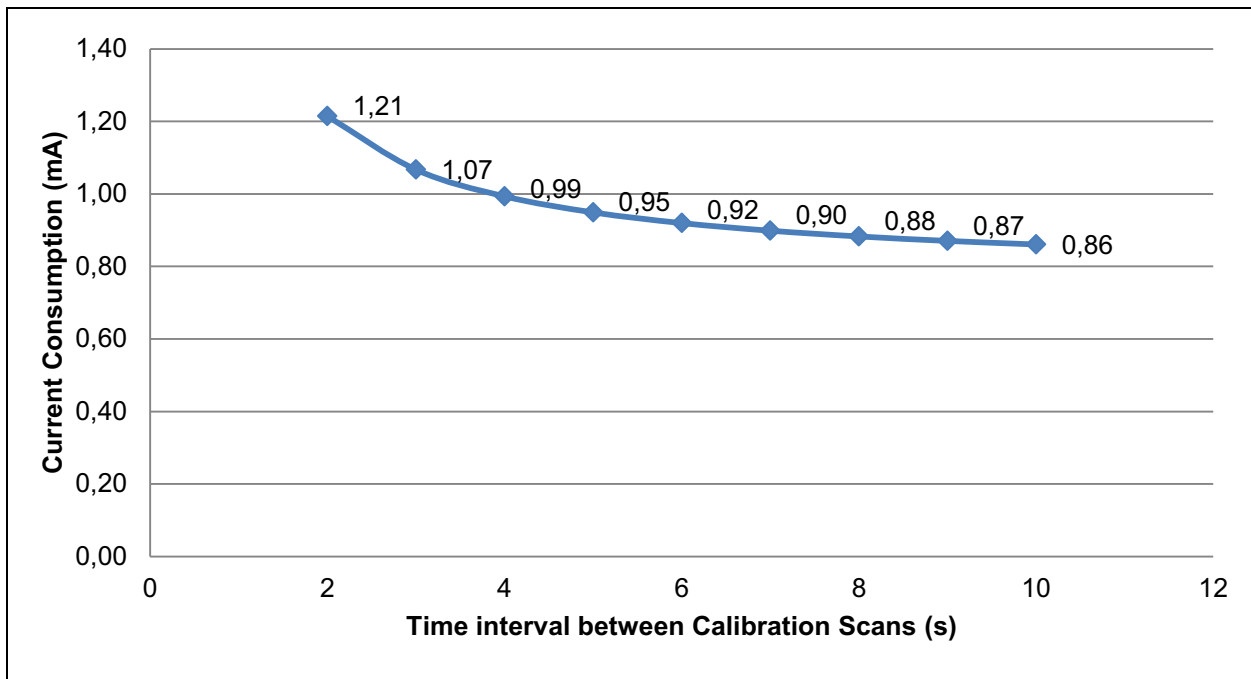
Changing these parameters results in different current consumption values.

Figure 4-7 and Figure 4-8 describe the Self Wake-up mode current consumption according to the Approach Scan and Calibration Scan period change.

**FIGURE 4-7: CURRENT CONSUMPTION FOR VARYING TIME INTERVALS BETWEEN APPROACH SCANS AND CALIBRATION SCANS**



**FIGURE 4-8: CURRENT CONSUMPTION FOR A FIXED TIME INTERVAL BETWEEN APPROACH SCANS OF 20 ms**



# MGC3130

## 4.2.4.5 Operation Modes Summary

Table 4-2 summarizes the MGC3130 operation modes.

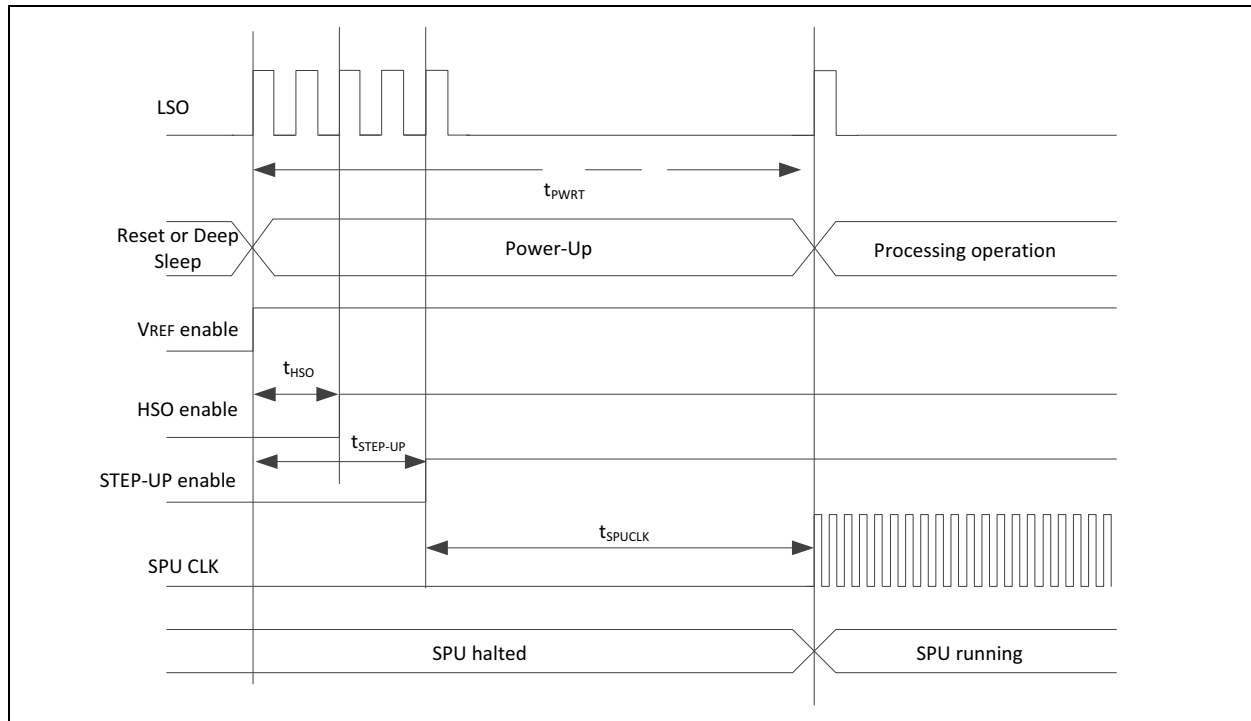
**TABLE 4-2: OPERATION MODES SUMMARY**

Mode	Entry	Exit	Comments
Processing	I <sup>2</sup> C™0/IRQ0/Approach/MCLR/WDTR/SW Reset	GestIC® Library Message/Non-Activity Time-out/WDTR	- Processing mode with up to five electrodes continuously running - Full positioning and Gesture Recognition capabilities
Self Wake-up	Time-out/GestIC® Library Message	I <sup>2</sup> C™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 - Approach detection capability - Fast wake-up time - Very low-power consumption
Deep Sleep	GestIC® Library Message	I <sup>2</sup> C™0/IRQ0/MCLR	- SPU halted, Analog Voltage Regulator OFF, STEP-UP OFF, Watchdog OFF - No positioning or gesture detection - Extreme low-power consumption - Needs trigger from application host to switch into Self Wake-up or Processing mode

## 4.2.5 POWER-UP/DOWN SEQUENCE

Figure 4-9 represents the power-up sequence timings after a Reset or Deep Sleep state.

**FIGURE 4-9: 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 ( $t_{PWRT}$ )**

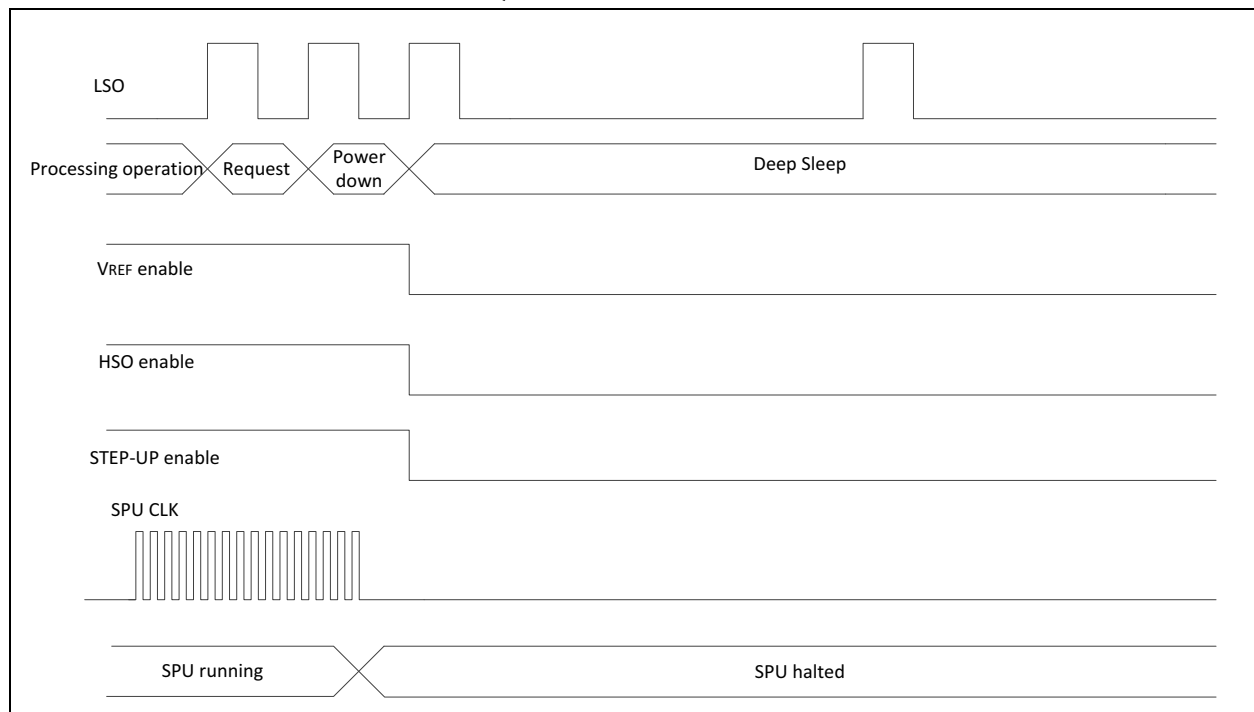
Signal	Symbol	Delay in LSO Cycles		
		After Reset	After Deep Sleep (STEP-UP On)	After Deep Sleep (STEP-UP Off)
VREF Enable	$t_{VREF}$	0	0	0
HSD Enable	$t_{HSD}$	2	2	2
STEP-UP	$t_{STEP-UP}$	4	4	x
SPU CLK	$t_{SPUCLK}$	30	30	8
Power-Up Time-Out	$t_{PWRT}$	36	36	10

## Signal References

- LSO: Low-Speed Oscillator clock
- HSD: High-Speed Oscillator clock
- VREF Enable: Voltage Reference enable signal
- HSD Enable: High-Speed Oscillator enable signal
- STEP-UP Enable: STEP-UP converter enable signal

Figure 4-10 illustrates the power-down sequence timings.

**FIGURE 4-10: POWER-DOWN SEQUENCE TIMINGS**



## 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
- VREF Enable: Voltage Reference enable signal
- HSO Enable: High-Speed Oscillator enable signal
- STEP-UP enable: STEP-UP converter enable signal

## 4.3 Transmit Signal Generation

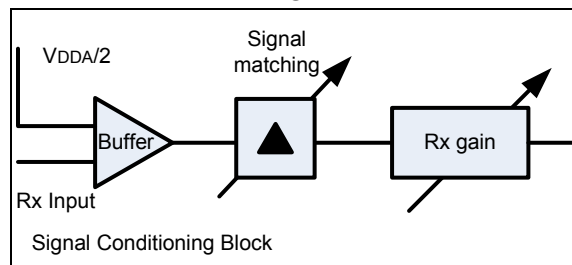
The Tx signal generation block provides a bandwidth limited square wave signal for the transmit electrode. Frequency hopping adjusts automatically the Tx carrier frequency in the range of 44-115 kHz, depending on the environmental noise conditions. GestIC Library automatically selects the lowest noise 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 4-11](#).

**FIGURE 4-11: 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. The ADC trigger source can be selected between the internal clock and an external sync signal. ADC samples are synchronous with twice the Tx transmit frequency. The external sync signal is reserved for dual chip/dual zone designs.

## 4.6 Signal Processing Unit (SPU)

The MGC3130 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 MGC3130 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 MGC3130 with the provided software tools or, alternatively, via GestIC Library messages by the application host. For more details on the MGC3130 tools, please refer to [Section 8.0 “Development Support”](#).

## 5.0 APPLICATION ARCHITECTURE

MGC3130 supports two different implementations: single-zone design and dual-zone design.

**Note:** Currently, only single-zone I<sup>2</sup>C™ Slave mode is supported. Other modes are planned for future releases of GestIC® Library. Please contact your Microchip representative for further details.

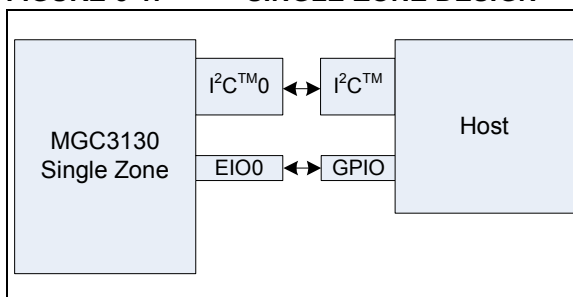
### 5.1 Single-Zone Design

The standard MGC3130 implementation is a single-zone design. This configuration is based on one MGC3130 connected to an application host. The interface can be either configured as I<sup>2</sup>C master, I<sup>2</sup>C slave, SPI master or SPI slave, depending on the overall system design (see Figure 5-1).

Data reporting and flow-control scenarios are described below for either I<sup>2</sup>C or SPI configurations:

- If MGC3130 is I<sup>2</sup>C or SPI slave and the host is I<sup>2</sup>C or SPI master:
  - Host interface is I<sup>2</sup>C0
  - EIO0 is toggled indicating that new data is available and checking whether the host has already started data reading or not.
- If MGC3130 is I<sup>2</sup>C or SPI master and the host is I<sup>2</sup>C or SPI slave:
  - Data is sent to the host automatically when ready
  - Data is sent on an EIO toggle of the host system

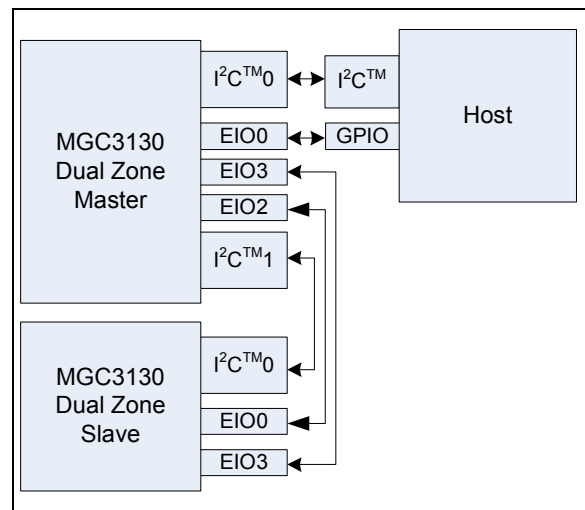
**FIGURE 5-1: SINGLE-ZONE DESIGN**



### 5.2 Dual-Zone Design

In addition to a single-zone design, the MGC3130's 4-pin digital interface also allows dual-zone designs by adding a second MGC3130, as shown in Figure 5-2. A dual-zone design allows detection of users hand motion in two independent zones (e.g., one for each hand) to expand user input options. In such a configuration, one MGC3130 acts as the dual-zone master device and the second acts as dual-zone slave device. The communication data flow is as follows: Position tracking data and recognized gestures from the dual-zone slave is transferred to the host via the MGC3130 dual-zone master.

**FIGURE 5-2: DUAL-ZONE DESIGN**



# MGC3130

## 6.0 INTERFACE DESCRIPTION

The MGC3130 supports two communication interfaces: I<sup>2</sup>C and SPI.

**Note:** Currently, only single-zone I<sup>2</sup>C™ Slave mode with I<sup>2</sup>C0 is supported. Other modes are planned for future releases of GestIC® Library. Please contact your Microchip representative for further details.

### 6.1 Interface Selection

The MGC3130 interface selection pin, IS2, is used to select I<sup>2</sup>C slave address. There are two different addresses.

**TABLE 6-1: MGC3130 INTERFACE SELECTION PINS**

IS2	IS1	Mode (Address)
0	0	I <sup>2</sup> C™0 Slave Address 1 (0x42)
1	0	I <sup>2</sup> C™0 Slave Address 2 (0x43)

### 6.2 Extended Input Output (EIO)

The MGC3130 provides four input/output pins with extended features. These pins are controlled by GestIC Library and listed in [Table 6-2](#).

**TABLE 6-2: MGC3130 EXTENDED IOS FUNCTIONS**

Pin	Pin Number	Multiplexed Functions
EIO0	12	TS
EIO1	13	IS1/Gesture Port
EIO2	14	IRQ0/Gesture Port
EIO3	19	IRQ1/SYNC/Gesture Port
EIO4	20	I <sup>2</sup> C0
EIO5	21	I <sup>2</sup> C0
EIO6	22	I <sup>2</sup> C1/Gesture Port
EIO7	23	I <sup>2</sup> C1/Gesture Port

### 6.3 Interrupt Requests

MGC3130 IRQ0 and IRQ1 interrupt lines are used by the host to wake-up the MGC3130 from Deep Sleep and Self Wake-up modes. If a wake-up event is detected on IRQ0 or IRQ1 lines, the MGC3130 switches to the Processing mode.

The IRQ0 and IRQ1 lines are only used when MGC3130 is configured as I<sup>2</sup>C master.

### 6.4 Synchronization

The MGC3130 Tx signal can be output on the SYNC pin. The SYNC pin can be also used as an ADC trigger input. In future, this configuration is used for dual-zone design implementations. The Tx signal is output on the SYNC pin of the dual-zone master and connected to the SYNC pin of the dual-zone slave.

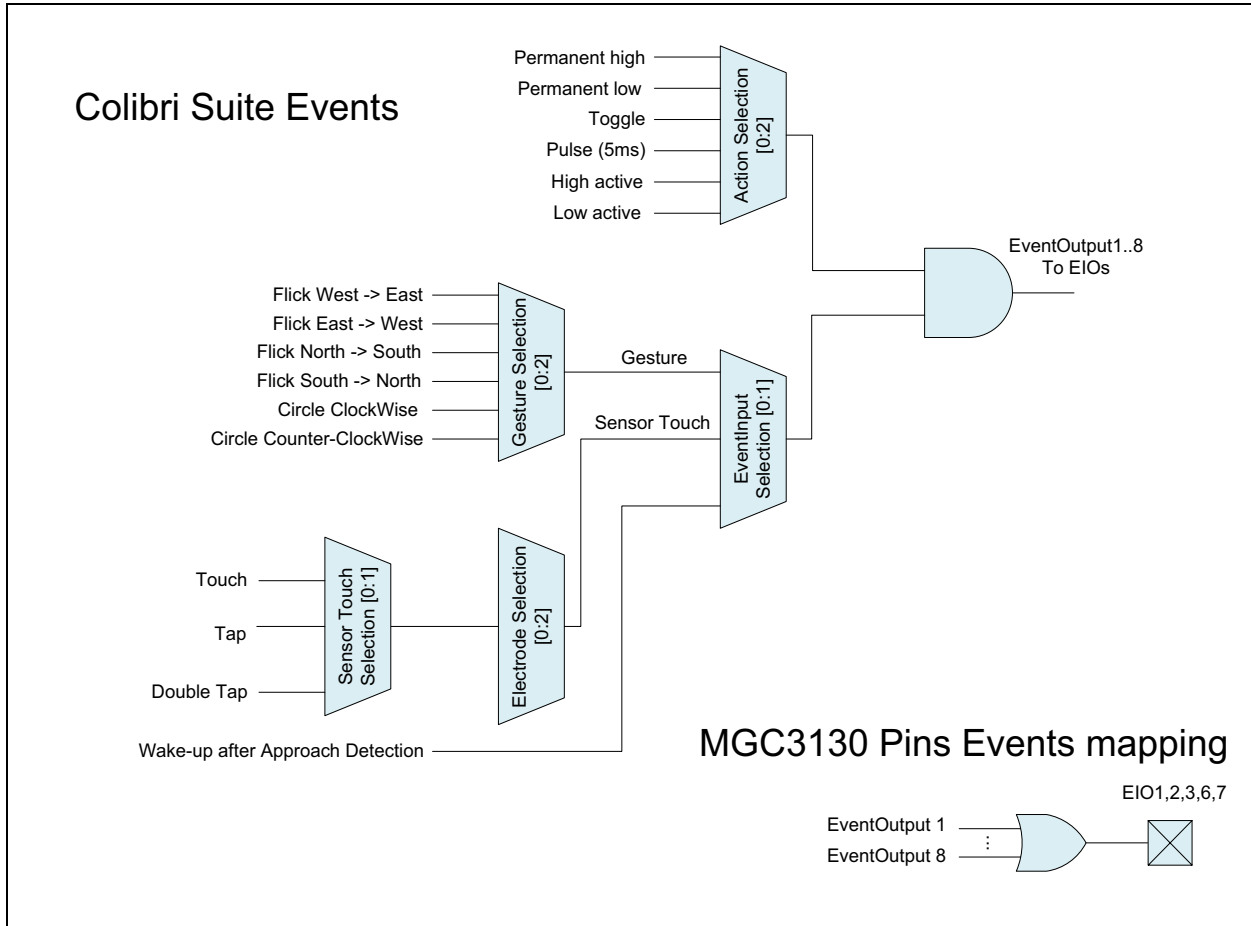
### 6.5 Gesture Port

The MGC3130 provides five output pins which can be used to output the Colibri Suite features events. These pins are controlled by GestIC Library to signal to the host that an event occurred. The host does not need to monitor the I<sup>2</sup>C bus to get GestIC Library events, but only has to monitor the Gesture Port pins. This feature is used in parallel to I<sup>2</sup>C communication.

The Colibri Suite Gesture Port feature mapping is illustrated in [Figure 6-1](#).



**FIGURE 6-1: GESTURE PORT MAPPING**

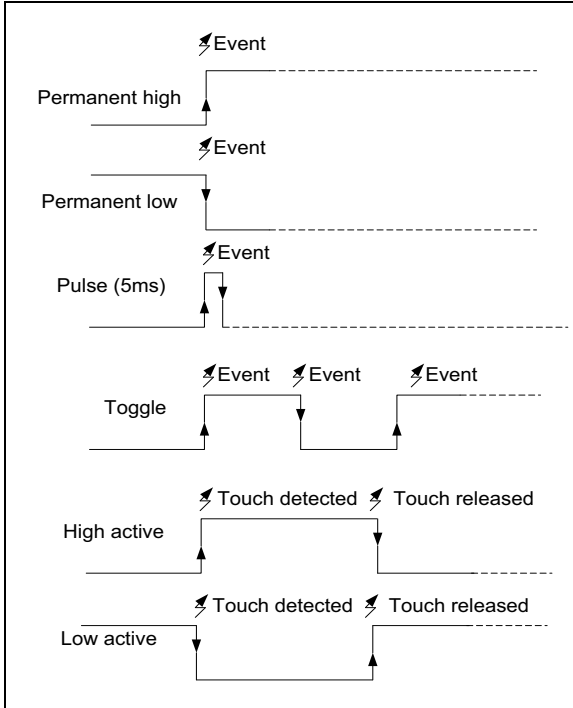


The Colibri Suite can generate up to eight event outputs which can be mapped to any EIO (1, 2, 3, 6 or 7). It is also possible to map more than one event output by one EIO.

**TABLE 6-3: COLIBRI SUITE EVENTS**

<b>Gesture Port Mapping Parameter</b>	<b>Description</b>
Gesture Selection	Selects the gestures which will be used as event. Gesture Selection can be: <ul style="list-style-type: none"><li>• Flick West/East</li><li>• Flick East/West</li><li>• Flick North/South</li><li>• Flick South/North</li><li>• Circle clockwise</li><li>• Circle Counter clockwise</li></ul>
Sensor Touch Selection	Selects the sensor touch which will be used as event. Sensor Touch Selection can be: <ul style="list-style-type: none"><li>• Touch</li><li>• Tap</li><li>• Double Tap</li></ul>
Electrode Selection	Selects the electrode which will be used for Sensor Touch. Electrode Selection can be: <ul style="list-style-type: none"><li>• West</li><li>• East</li><li>• North</li><li>• South</li><li>• Center</li></ul>
Event Input Selection	Selects the event which will trigger an event output on the EIOs. Event Input Selection can be: <ul style="list-style-type: none"><li>• Gesture</li><li>• Sensor Touch</li><li>• Wake-up after Approach Detection</li></ul>
Action Selection	Selects the signal format which will be output on the EIOs. See <a href="#">Figure 6-2</a> and <a href="#">Table 6-4</a> . Action Selection can be: <ul style="list-style-type: none"><li>• Permanent High</li><li>• Permanent Low</li><li>• Toggle</li><li>• Pulse (5 ms)</li><li>• High Active</li><li>• Low Active</li></ul>

**FIGURE 6-2: GESTURE PORT ACTION**



**TABLE 6-4: GPIO PORT ACTION MAPPING**

Event	Action					
	Permanent High	Permanent Low	Toggle	Pulse (5 ms)	High Active	Low Active
Gesture	X	X	X	X		
Touch	X	X	X	X	X	X
Single Tap	X	X	X	X		
Double Tap	X	X	X	X		
Wake-up after Approach Detection	X	X				

# MGC3130

## 6.6 Communication Interfaces

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

The MGC3130 supports two I<sup>2</sup>C interfaces. Only I<sup>2</sup>C0 is used in a single-zone configuration.

I<sup>2</sup>C0 and I<sup>2</sup>C1 features:

- Two ports: SCL0, SDA0 and SCL1, SDA1
- Master and Slave mode
- Up to 400 kHz
- 7-bit Addressing mode
- Hardware state machine for basic protocol handling
- Support for repeated start and clock stretching (Byte mode)
- No multi-master support

#### I<sup>2</sup>C Hardware Interface

A summary of the hardware interface pins is shown below in [Table 6-5](#).

**TABLE 6-5: I<sup>2</sup>C™ PIN DESCRIPTION**

MGC3130 Pin	Multiplexed Functions
SCL	Serial Clock to Master I <sup>2</sup> C™
SDA	Serial Data to Master I <sup>2</sup> C™

- SCL Pin
  - The SCL (Serial Clock) pin is electrically open-drain and requires a pull-up resistor of typically 1.8 kΩ (for a maximum bus load capacitance of 200 pF), from SCL to VDD. SCL Idle state is high.
- SDA Pin
  - The SDA (Serial Data) pin is electrically open-drain and requires a pull-up resistor of typically 1.8 kΩ (for a maximum bus load capacitance of 200 pF), from SDA to VDD.
  - SDA Idle state is high.
  - Master write data is latched in on SCL rising edges.
  - Master read data is latched out on SCL falling edges to ensure it is valid during the subsequent SCL high time.

#### I<sup>2</sup>C Addressing:

The MGC3130 Device ID 7-bit address is: 0x42 (0b1000010) or 0x43 (0b1000011) depending on the interface selection pin configuration (IS2). Please refer to [Table 6-6](#).

**TABLE 6-6: I<sup>2</sup>C™ DEVICE ID ADDRESS**

Device ID Address, 7-bit						
A6	A5	A4	A3	A2	A1	A0
1	0	0	0	0	1	IS2

**TABLE 6-7: I<sup>2</sup>C™ DEVICE WRITE ID ADDRESS (0x84 OR 0x86)**

I <sup>2</sup> C™ Device Write ID Address							
A7	A6	A5	A4	A3	A2	A1	A0
1	0	0	0	0	1	IS2	0

**TABLE 6-8: I<sup>2</sup>C™ DEVICE READ ID ADDRESS (0x85 OR 0x87)**

I <sup>2</sup> C™ Device Read ID Address							
A7	A6	A5	A4	A3	A2	A1	A0
1	0	0	0	0	1	IS2	1

#### I<sup>2</sup>C Master Read Bit Timing (MGC3130 I<sup>2</sup>C Slave)

Master read is to receive position data, gesture reports and command responses from the MGC3130. The timing diagram is shown in [Figure 6-4](#).

- Address bits are latched into the MGC3130 on the rising edges of SCL.
- Data bits are latched out of the MGC3130 on the rising edges of SCL.
- ACK bit:
  - MGC3130 presents the ACK bit on the ninth clock for address acknowledgment
  - I<sup>2</sup>C master presents the ACK bit on the ninth clock for data acknowledgment
- The I<sup>2</sup>C master must monitor the SCL pin prior to asserting another clock pulse, as the MGC3130 may be holding off the I<sup>2</sup>C master by stretching the clock.

#### I<sup>2</sup>C Communication Steps

1. SCL and SDA lines are Idle high.
2. I<sup>2</sup>C master presents Start bit to the MGC3130 by taking SDA high-to-low, followed by taking SCL high-to-low.
3. I<sup>2</sup>C master presents 7-bit address, followed by a R/W = 1 (Read mode) bit to the MGC3130 on SDA, at the rising edge of eight master clock (SCL) cycles.
4. MGC3130 compares the received address to its Device ID. If they match, the MGC3130 acknowledges (ACK) the master sent address by presenting a low on SDA, followed by a low-high-low on SCL.
5. I<sup>2</sup>C master monitors SCL, as the MGC3130 may be clock stretching, holding SCL low to indicate that the I<sup>2</sup>C master should wait.

6. I<sup>2</sup>C master receives eight data bits (MSB first) presented on SDA by the MGC3130, at eight sequential I<sup>2</sup>C master clock (SCL) cycles. The data is latched out on SCL falling edges to ensure it is valid during the subsequent SCL high time.
7. If data transfer is not complete, then:
  - I<sup>2</sup>C master acknowledges (ACK) reception of the eight data bits by presenting a low on SDA, followed by a low-high-low on SCL.
  - Go to step 5.
8. If data transfer is complete, then:
  - I<sup>2</sup>C master acknowledges (ACK) reception of the eight data bits and a completed data transfer by presenting a high on SDA, followed by a low-high-low on SCL.

### **I<sup>2</sup>C Master Write Bit Timing (MGC3130 Slave)**

I<sup>2</sup>C master write is to send supported commands to the MGC3130. The timing diagram is shown in [Figure 6-5](#).

- Address bits are latched into the MGC3130 on the rising edges of SCL.
- Data bits are latched into the MGC3130 on the rising edges of SCL.
- ACK bit:
  - MGC3130 presents the ACK bit on the ninth clock for address acknowledgment
  - I<sup>2</sup>C master presents the ACK bit on the ninth clock for data acknowledgment
- The master must monitor the SCL pin prior to asserting another clock pulse, as the MGC3130 may be holding off the master by stretching the clock.

### **I<sup>2</sup>C Communication Steps**

1. SCL and SDA lines are Idle high.
2. I<sup>2</sup>C master presents Start bit to the MGC3130 by taking SDA high-to-low, followed by taking SCL high-to-low.
3. I<sup>2</sup>C master presents 7-bit address, followed by a R/W = 0 (Write mode) bit to the MGC3130 on SDA, at the rising edge of eight master clock (SCL) cycles.
4. MGC3130 compares the received address to its Device ID. If they match, the MGC3130 acknowledges (ACK) the I<sup>2</sup>C master sent address by presenting a low on SDA, followed by a low-high-low on SCL.
5. I<sup>2</sup>C master monitors SCL, as the MGC3130 may be clock stretching, holding SCL low to indicate the I<sup>2</sup>C master should wait.
6. I<sup>2</sup>C master presents eight data bits (MSB first) to the MGC3130 on SDA, at the rising edge of eight master clock (SCL) cycles.
7. MGC3130 acknowledges (ACK) receipt of the eight data bits by presenting a low on SDA, followed by a low-high-low on SCL.
8. If data transfer is not complete, then go to step 5.
9. Master presents a Stop bit to the MGC3130 by taking SCL low-high, followed by taking SDA low-to-high.

### **6.6.2 TRANSFER STATUS LINE**

MGC3130 requires a dedicated Transfer Status line (TS) which features a data transfer status function. It is used by both I<sup>2</sup>C Master and Slave to control data flow.

The TS (Transfer Status) line is electrically open-drain and requires a pull-up resistor of typically 10 k $\Omega$ , from TS to V<sub>DD</sub>. TS Idle state is high.

The MGC3130 (I<sup>2</sup>C Slave) uses this line to inform the host controller (I<sup>2</sup>C Master) that there is data available which can be transferred. The host controller uses the TS line to indicate that data is being transferred and prevents MGC3130 from updating its data buffer.

[Table 6-9](#) shows how the TS line is used in the different states of communication.

# MGC3130

**TABLE 6-9: USAGE OF TRANSFER STATUS LINE**

MGC3130	Host Controller	TS Line	Status
Released (H)	Released (H)	High	Host finished reading data (Transfer end). No more data to be transferred to the host. MGC3130 is allowed to update the data buffer.
Asserted (L)	Released (H)	Low	Data from MGC3130 is available to be sent, but the host has not yet started reading. If the host is busy and did not start reading before the next data update (5 ms), the MGC3130 will assert the TS line high while updating the data buffer.
Asserted (L)	Asserted (L)	Low	Host starts reading. MGC3130 data buffer will not be updated until the end of transfer (host releases TS high).
Released (H)	Asserted (L)	Low	MGC3130 is ready to update the data buffer, but the host is still reading the previous data. MGC3130 is allowed to update the data only when the host releases the TS high.

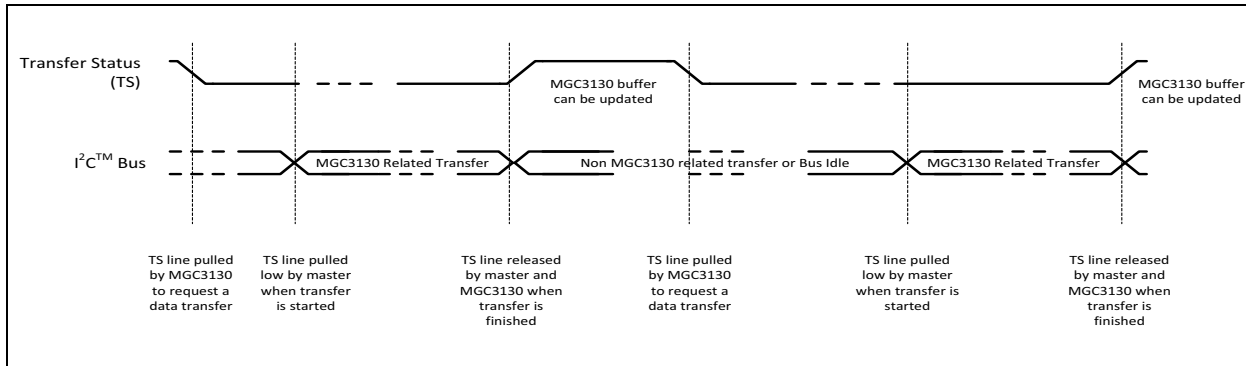
MGC3130 can update the I<sup>2</sup>C buffer only when the TS is released by both chips and a data transfer can only be started when MGC3130 pulls the TS low.

This procedure secures that:

- the host is always informed when new sensor data is available
- buffer updates in MGC3130 are always completed before data is sent to the I<sup>2</sup>C bus

Figure 6-3 shows the complete communication protocol.

**FIGURE 6-3: MGC3130 COMMUNICATION PROTOCOL**



**Note 1:** The stop condition after an I<sup>2</sup>C™ data transmission is generated by the host controller (I<sup>2</sup>C Master) after the data transfer is completed. Thus, it is recommended to verify the amount of bytes to be read in the message header (Size field).

**2:** Transfer Status is only needed for data transfer from MGC3130 to the host controller. Writing to MGC3130 does not require the additional TS signal.

In addition to the standard I<sup>2</sup>C interface, the communication between MGC3130 and the host controller requires a proper handling of the Transfer Status.

## 6.6.3 SPI

SPI features:

- One Port: SCLK, CS, MOSI, MISO
- Master and Slave mode
- Up to 3 MHz
- Support of all clock edge and polarity options

**Note:** Currently, only single-zone I<sup>2</sup>C™ Slave mode with I<sup>2</sup>C0 is supported. Other modes are planned for future releases of GestIC® Library. Please contact your Microchip representative for further details.

### SPI Hardware Interface

A summary of the hardware interface pins is shown below in [Table 6-10](#).

**TABLE 6-10: SPI PIN DESCRIPTION**

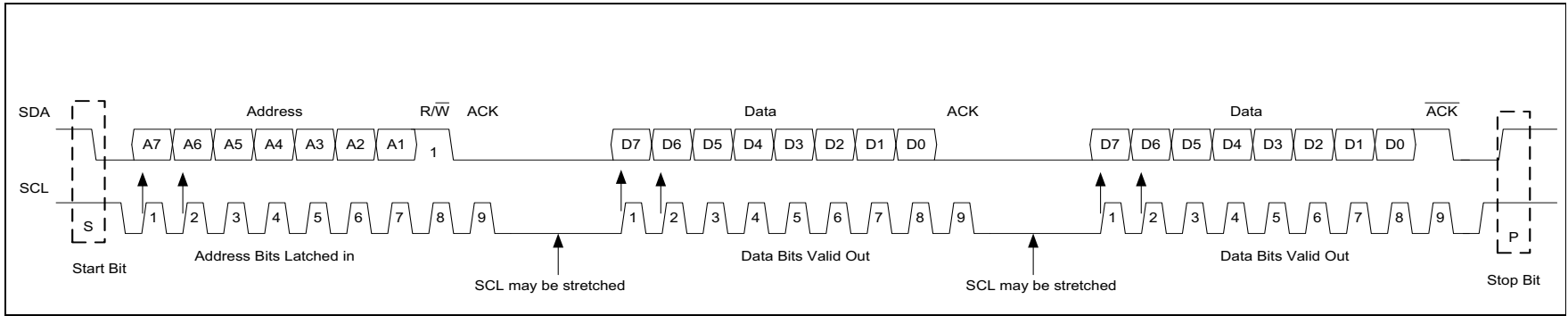
MGC3130 Pin	Description
SCLK	Master Clock
CS	Chip Select
MISO	Master Input Slave Output
MOSI	Master Output Slave Input

- SCLK Pin:
  - The MGC3130 controller's SCLK pin drives the communication bus clock.
  - The Idle state of the SCLK should be low.
  - Data is transmitted on the falling edge of SCLK.
- MOSI Pin:
  - The MGC3130 controller's MOSI pin sends/reads serial data to/from the slave/host.
- MISO Pin:
  - The MGC3130 controller's MISO pin reads/sends serial data from/to the slave/host.
- CS Pin:
  - The MGC3130 controller's  $\overline{\text{CS}}$  pin provides device selection functionality.

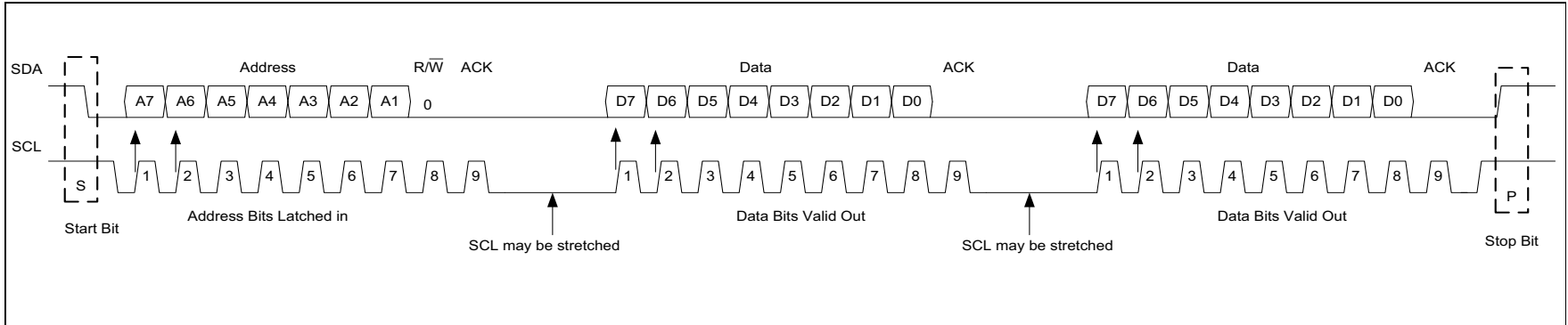
**TABLE 6-11: SPI  $\overline{\text{CS}}$  PIN DESCRIPTION**

$\overline{\text{CS}}$ Pin	Description
VSS	Active
VDD	Inactive

**FIGURE 6-4: I<sup>2</sup>C™ MASTER READ BIT TIMING DIAGRAM**



**FIGURE 6-5: I<sup>2</sup>C™ MASTER WRITE BIT TIMING DIAGRAM**





## 7.0 HARDWARE INTEGRATION

### 7.1 ESD Considerations

The MGC3130 provides Electrostatic Discharge (ESD) Voltage protection up to 2 kV (HBM). Additional ESD countermeasures may be implemented individually to meet application-specific requirements.

### 7.2 Power Noise Considerations

MGC3130 filtering capacitors are included in the reference design schematic (Please refer to [Figure 7-1](#)).

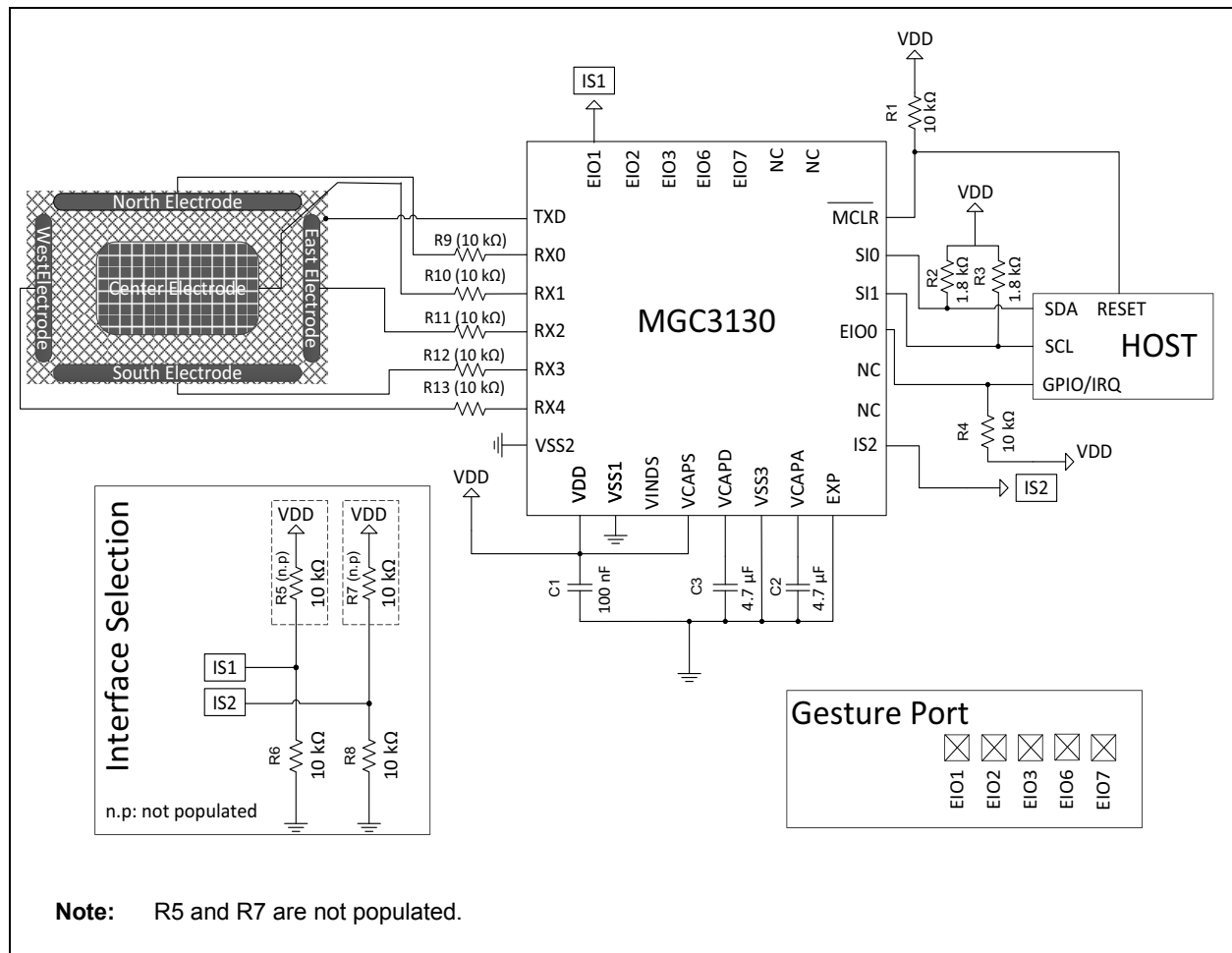
### 7.3 Irradiated High-Frequency Noise

In order to suppress irradiated high-frequency signals, the five Rx channels of the chip are connected to the electrodes via serial 10 kΩ resistors, as close as possible to MGC3130. The 10 kΩ resistor and the MGC3130 input capacitance are building a low-pass filter with a corner frequency of 3 MHz.

### 7.4 Standard Schematic (3.3V ≤ VDD ≤ 3.465V)

A standard application schematic for the 28-lead QFN package pinout is depicted below in [Figure 7-1](#). For more details, please refer to [Figure 1](#).

**FIGURE 7-1: STANDARD SCHEMATIC FOR 3.3V ≤ VDD ≤ 3.465V VOLTAGE RANGE**



# MGC3130

## 7.5 Bill of Materials ( $3.3V \leq V_{DD} \leq 3.465V$ )

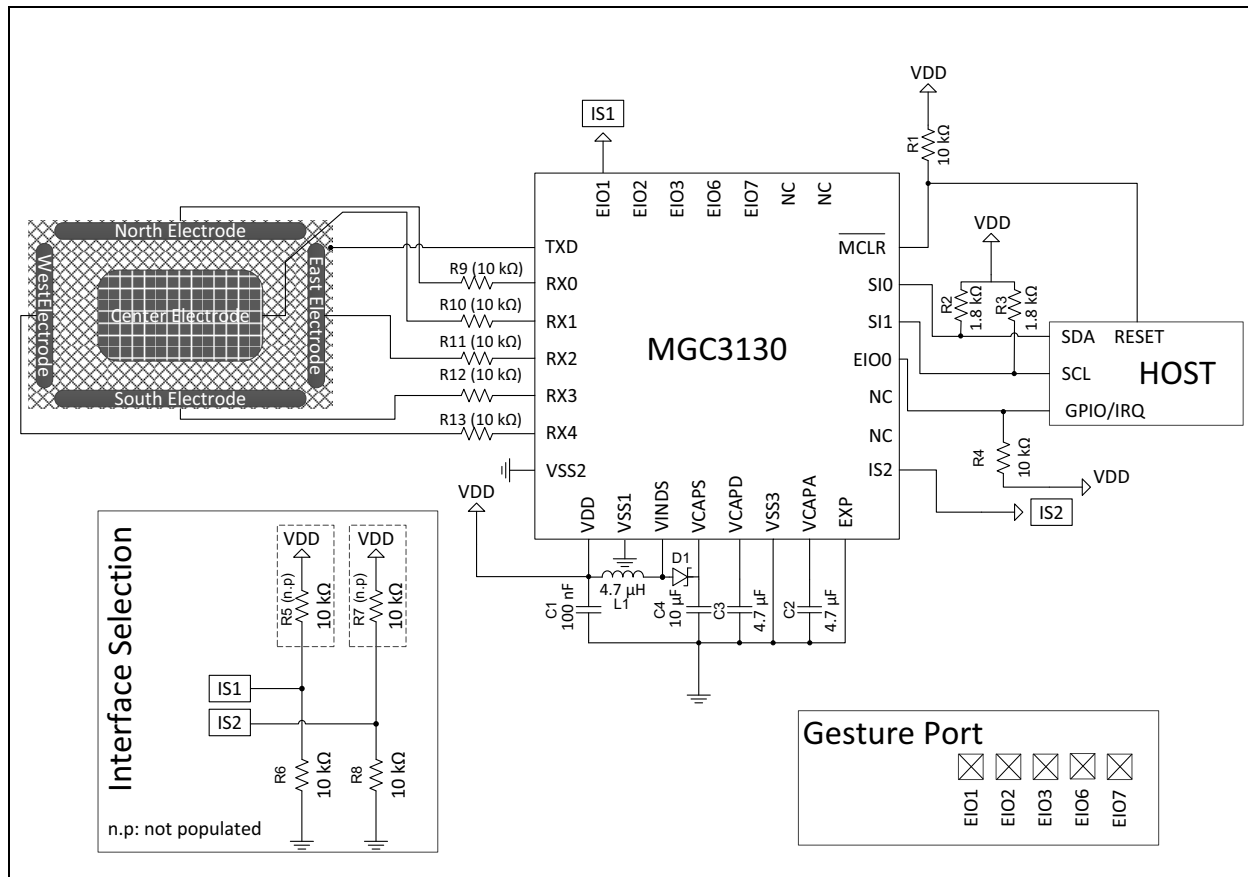
Modifying, removing or adding components may adversely affect MGC3130 performance.

**TABLE 7-1: BILL OF MATERIALS FOR  $3.3V \leq V_{DD} \leq 3.465V$**

Label	Qty	Value	Description
R1, R4, R5, R6, R7, R8	3	10 kΩ	Res Thick Film 10 kΩ 1%
C1	1	100 nF	Capacitor – Ceramic, 0.1 μF, 10%, 6.3V
C2	1	4.7 μF	Capacitor – Ceramic, 4.7 μF, 10%, 6.3V
C3	1	4.7 μF	Capacitor – Ceramic, 4.7 μF, 10%, 6.3V
R2, R3	2	1.8 kΩ	Res Thick Film 1.8 kΩ 1%
R9, R10, R11, R12, R13	5	10 kΩ	Res Thick Film 10 kΩ 1%

## 7.6 Standard Schematic Step-Up Setup ( $2.5V \leq V_{DD} \leq 3.465V$ )

**FIGURE 7-2: SCHEMATIC STEP-UP SETUP FOR  $2.5V \leq V_{DD} \leq 3.465V$  VOLTAGE RANGE**



## 7.7 Bill of Materials ( $2.5V \leq V_{DD} \leq 3.465V$ )

Modifying, removing, or adding components may adversely affect MGC3130 performance.

**TABLE 7-2: BILL OF MATERIALS FOR  $2.5V \leq V_{DD} \leq 3.465V$**

Label	Qty	Value	Description
R1, R4, R5, R6, R7, R8	3	10 k $\Omega$	Res Thick Film 10 k $\Omega$ 1%
C1	1	100 nF	Capacitor – Ceramic, 0.1 $\mu$ F, 10%, 6.3V
C2	1	4.7 $\mu$ F	Capacitor – Ceramic, 4.7 $\mu$ F, 10%, 6.3V
C3	1	4.7 $\mu$ F	Capacitor – Ceramic, 4.7 $\mu$ F, 10%, 6.3V
R2, R3	2	1.8 k $\Omega$	Res Thick Film 1.8 k $\Omega$ 1%
C4	1	10 $\mu$ F	Capacitor – Ceramic, 10 $\mu$ F, 20%, 6.3V
L1	1	4.7 $\mu$ H	Inductor, 4.7 $\mu$ H 20%
D1	1	—	Diode Schottky, 20V, 0.5A
R9, R10, R11, R12, R13	5	10 k $\Omega$	Res Thick Film 10 k $\Omega$ 1%

## 7.8 Layout Recommendation

This section will provide a brief description of layout hints for a proper system design.

The PCB layout requirements for MGC3130 follow the general rules for a mixed signal design. In addition, there are certain requirements to be considered for the sensor signals and electrode feeding lines.

The chip should be placed as close as possible to the electrodes to keep their feeding lines as short as possible. Furthermore, it is recommended to keep MGC3130 away from electrical and thermal sources within the system.

Analog and digital signals should be separated from each other during PCB layout in order to minimize crosstalk.

The individual electrode feeding lines should be kept as far as possible apart from each other.

V<sub>DD</sub> lines should be routed as wide as possible. For designs using the STEP-UP circuitry, the additional components required should be placed as close as possible to the MGC3130.

MGC3130 requires a proper ground connection on all V<sub>SS</sub> pins, including the exposed pad (pin 29).

## 8.0 DEVELOPMENT SUPPORT

Microchip provides software and hardware development tools for the MGC3130:

- Software:
  - MGC3130 Software Package – Aurea GUI and GestIC Library
  - MGC3130 Software Development Kit (SDK)
  - MGC3130 PIC18F14K50 Host Reference Code
- Schematics:
  - MGC3130 Hillstar Hardware References
- Evaluation and Development Kits:
  - MGC3130 – Sabrewing Single-Zone Evaluation Kit (DM160217)
  - MGC3130 Single-Zone Development Kit Hillstar (DM160218)

### 8.1 MGC3130 Software Package – Aurea GUI and GestIC Library

The Aurea evaluation software demonstrates Microchip's GestIC<sup>®</sup> technology and its features and applications. Aurea provides visualization of the MGC3130 generated data and access to GestIC Library controls and configuration parameters.

That contains the following:

- Visualization of hand position and user gestures
- Visualization of sensor data
- Real-time control of sensor features
- MGC3130 GestIC Library update
- Analog front end parameterization
- Colibri parameterization
- Electrode capacitance measurement
- Logging of sensor values and storage in a log file

### 8.2 MGC3130 Software Development Kit (SDK)

Microchip provides a standard C reference code with a Software Development Kit. The code will support developers to integrate the MGC3130 solution into the target application.

### 8.3 MGC3130 PIC18F14K50 Host Reference Code

Microchip provides a reference code for PIC18F14K50, including GestIC Library I<sup>2</sup>C code and basic message decoding.

## 8.4 MGC3130 Hillstar Hardware References

Microchip provides the Gerber files for Hillstar Boards and Reference electrodes.

## 8.5 Evaluation and Demonstration Kits

A variety of demonstration, development and evaluation boards allow quick application development on fully-functional systems. The demonstration and development boards can be used in teaching environments, for prototyping custom circuits and for learning about various GestIC MGC3130 applications.

The first MGC3130 evaluation board is the Sabrewing Single-Zone Evaluation Board. It contains the MGC3130 reference circuitry and built-in frame electrodes with a 140 x 90 mm sensitive area.

In combination with Aurea Visualization and Control Software, Sabrewing can be used as a starter kit. The set contains all materials required for first MGC3130 evaluation experience.

The first development board is the Hillstar Development Kit. It is designed to support an easy integration of Microchip's MGC3130 3D Tracking and Gesture Controller into the customer's applications. It provides MGC3130 system hardware modules and a set of electrode reference designs which can be used by customers to develop their own GestIC system. Aurea Visualization and Control Software provides full support of the Hillstar Development Kit and an easy parameterization of the customer's applications.

For the complete list of demonstration, development and evaluation kits, please refer to the Microchip web site (<http://www.microchip.com/GestICGettingStarted>).

## 8.6 GestIC Library Update

The MGC3130 devices are manufactured only with a built-in Library Loader to perform basic device programming operations or individual configuration parameters storage over a serial I<sup>2</sup>C interface.

The user has to download the latest GestIC Library and upload it to the MGC3130 Flash memory.

The GestIC Library can be updated through two methods:

1. Aurea Visualization and Control Software: Please refer to MGC3130 Aurea Graphical User Interface User Guide (DS40001681) for more details.
2. GestIC Library messages: Please refer to MGC3130 GestIC Library Interface Description User Guide (DS40001718) for more details.

## 9.0 ELECTRICAL SPECIFICATIONS

### 9.1 Absolute Maximum Ratings<sup>(†)</sup>

Ambient temperature under bias .....	-20°C to +85°C
Storage temperature .....	-55°C to +125°C
Voltage on pins with respect to Vss	
on VDD pin .....	-0.3V to +3.465V
on all other pins .....	-0.3V to (VDD + 0.3V)
Total power dissipation .....	100 mW
ESD protection on all pins .....	2 kV

† **NOTICE:** 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 those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

† **NOTICE:** This device is sensitive to ESD damage and must be handled appropriately. Failure to properly handle and protect the device in an application may cause partial to complete failure of the device.

† **NOTICE:** -20°C temperature operation is characterized but not tested.

ADVANCE INFORMATION

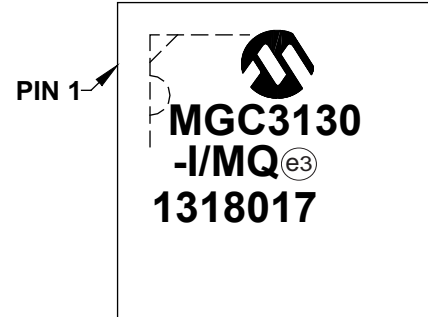
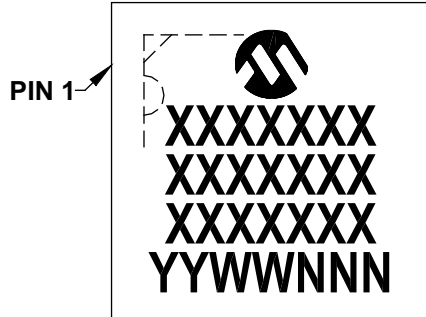
# MGC3130

## 10.0 PACKAGING INFORMATION

### 10.1 Package Marking Information

28-Lead QFN (5x5x0.9 mm)

Example



<b>Legend:</b>	XX...X	Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC <sup>®</sup> designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator (e3) can be found on the outer packaging for this package.

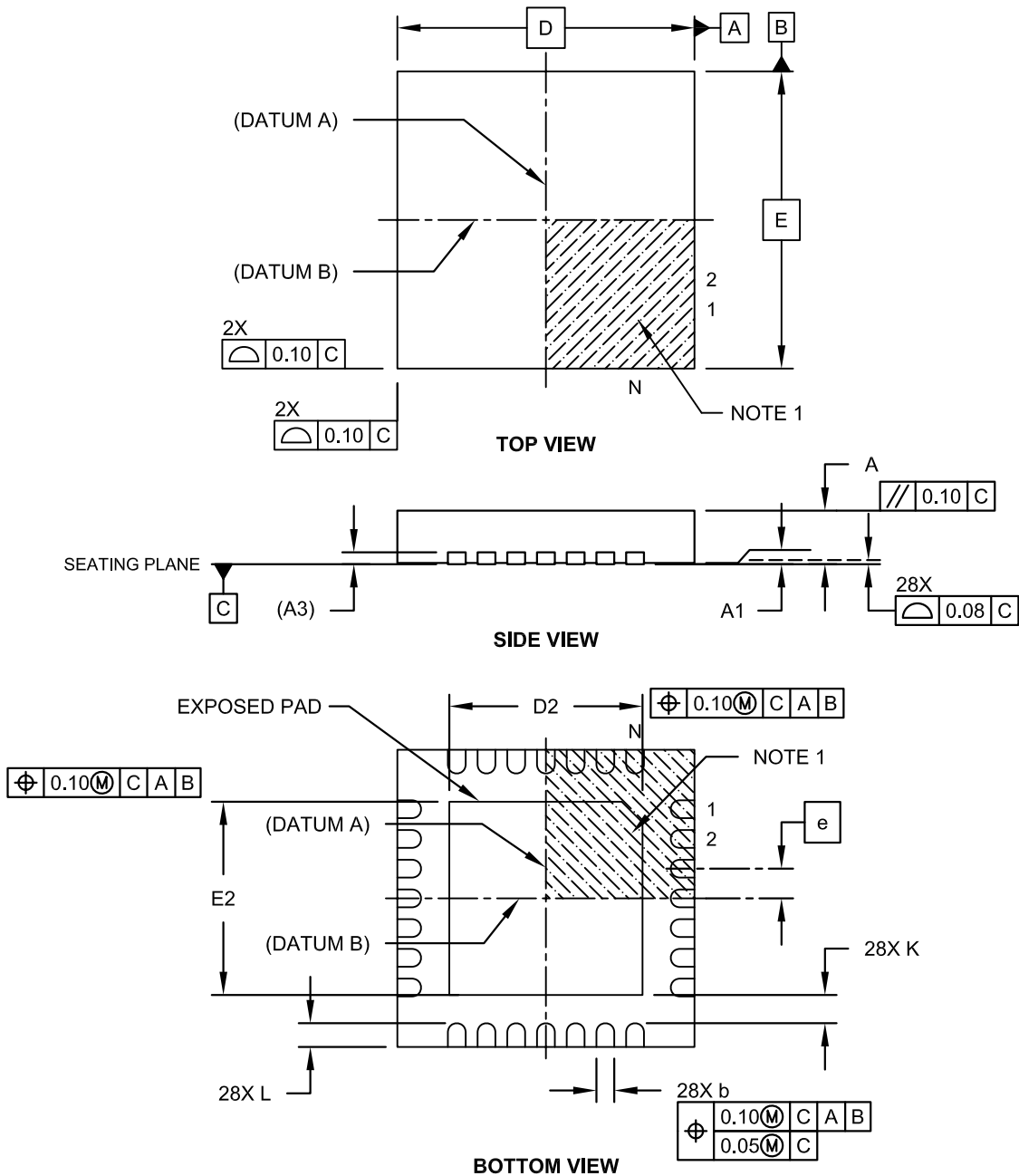
**Note:** In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information.

## 10.2 Package Details

The following sections give the technical details of the packages.

### 28-Lead Plastic Quad Flat, No Lead Package (MQ) – 5x5x0.9 mm Body [QFN]

**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>

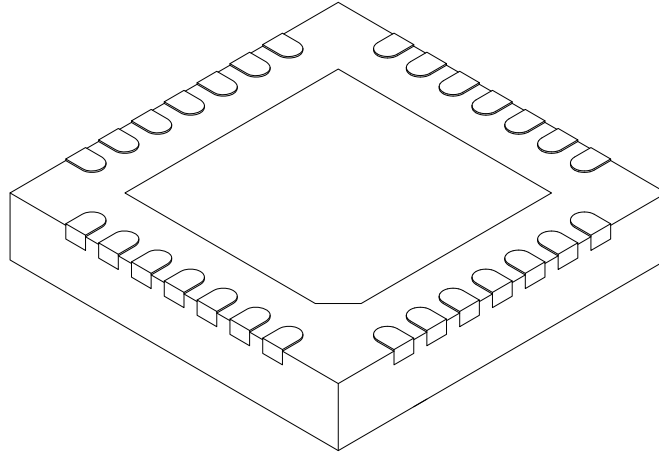


Microchip Technology Drawing C04-140B Sheet 1 of 2

# MGC3130

## 28-Lead Plastic Quad Flat, No Lead Package (MQ) – 5x5x0.9 mm Body [QFN]

**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



Dimension Limits	Units	MILLIMETERS		
		MIN	NOM	MAX
Number of Pins	N	28		
Pitch	e	0.50 BSC		
Overall Height	A	0.80	0.90	1.00
Standoff	A1	0.00	0.02	0.05
Contact Thickness	A3	0.20 REF		
Overall Width	E	5.00 BSC		
Exposed Pad Width	E2	3.15	3.25	3.35
Overall Length	D	5.00 BSC		
Exposed Pad Length	D2	3.15	3.25	3.35
Contact Width	b	0.18	0.25	0.30
Contact Length	L	0.35	0.40	0.45
Contact-to-Exposed Pad	K	0.20	-	-

**Notes:**

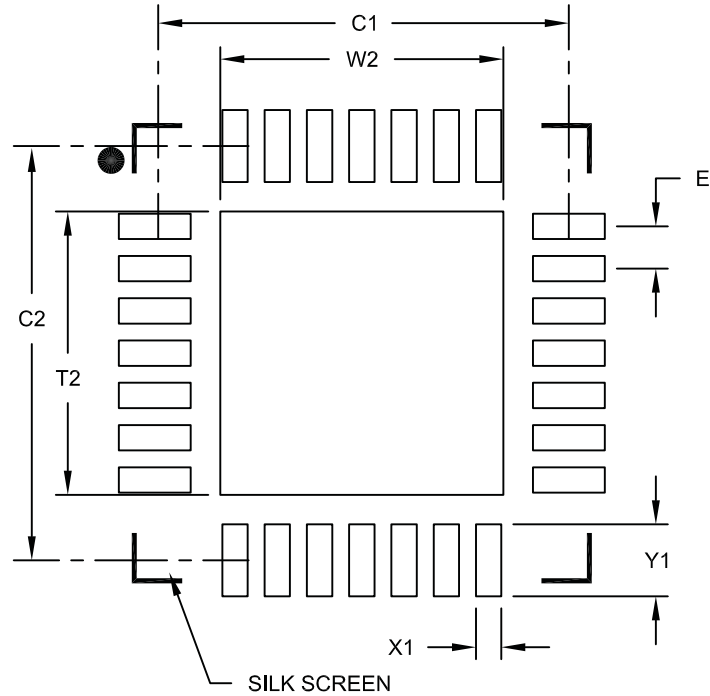
1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Package is saw singulated.
3. Dimensioning and tolerancing per ASME Y14.5M.  
BSC: Basic Dimension. Theoretically exact value shown without tolerances.  
REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-140B Sheet 2 of 2



## 28-Lead Plastic Quad Flat, No Lead Package (MQ) – 5x5 mm Body [QFN] Land Pattern With 0.55 mm Contact Length

**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



RECOMMENDED LAND PATTERN

Dimension Limits	Units	MILLIMETERS		
		MIN	NOM	MAX
Contact Pitch	E	0.50 BSC		
Optional Center Pad Width	W2			3.35
Optional Center Pad Length	T2			3.35
Contact Pad Spacing	C1		4.90	
Contact Pad Spacing	C2		4.90	
Contact Pad Width (X28)	X1			0.30
Contact Pad Length (X28)	Y1			0.85

**Notes:**

1. Dimensioning and tolerancing per ASME Y14.5M

BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing C04-2140A

## APPENDIX A: DATA SHEET REVISION HISTORY

### Revision A (11/2012)

Initial release of this data sheet.

### Revision B (08/2013)

Updated the Power Features section; Updated Table 1; Updated section 2, Feature Description; Updated section 4.2.2; Updated Figures 4-4, 4-5 and 4-6; Updated Equation 4-1, Table 4-1; Updated Figures 4-9, 5-1 and 5-2; Updated section 6, Interface Description, Updated Figures 7-1 and 7-2; Added section 7-3, Irradiated High-Frequency Noise; Updated Tables 7-1 and 7-2; Updated section 8, Development Support; Updated the Packaging Information section; Other minor corrections.

### Revision C (11/2013)

Updated Figure 1 and Table 1; Updated Section 2, Feature Description; Updated Section 4, Functional Description; Updated Section 6, Interface Description; Updated Figure 7-1 and 7-2; Updated Section 8, Development Support; Other minor corrections.

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- Technical Support

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**Technical support is available through the web site at: <http://microchip.com/support>**

# MGC3130

## PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

<u>PART NO.</u>	<u>[X]<sup>(1)</sup></u>	-	<u>X</u>	<u>/XX</u>	<u>XXX</u>
Device	Tape and Reel Option		Temperature Range	Package	Pattern
<b>Device:</b>	MGC3130				
<b>Tape and Reel Option:</b>	Blank = Standard packaging (tube or tray) T = Tape and Reel <sup>(1)</sup>				
<b>Temperature Range:</b>	I = -40°C to +85°C (Industrial)				
<b>Package:<sup>(2)</sup></b>	MQ = QFN				
<b>Pattern:</b>	QTP, SQTP, Code or Special Requirements (blank otherwise)				

**Examples:**

a) MGC3130 - I/MQ  
Industrial temperature,  
QFN package

**Note 1:** Tape and Reel identifier only appears in the catalog part number description. This identifier is used for ordering purposes and is not printed on the device package. Check with your Microchip Sales Office for package availability with the Tape and Reel option.

**2:** For other small form-factor package availability and marking information, please visit [www.microchip.com/packaging](http://www.microchip.com/packaging) or contact your local sales office.

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- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
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