MTCH9010 Data Sheet

MTCH9010

Product Page Links

Description

The Microchip MTCH9010 Liquid Detector with digital and raw data output provides a simple yet flexible way to detect liquid presence on different sensors. When coupled with the appropriate sensor, the system can run the capacitive or the conductive liquid presence detection method.

Features

- Capacitive and Conductive Operation Mode
- Adjustable Liquid Detection Threshold
- Configurable Sleep Period
- Liquid Detection Indication by OUT Pin Level
- Sensor Raw Data Value Output on UART with three output formats
- Heartbeat Signal
- Support for a Wide Range of Sensor Shapes and Sizes
- Easy Configuration Mode Via Configuration Input Pins
- Enhanced Configuration Mode Via UART
- Operating Voltage Range:
  - 1.8-5.5V
- Operating Temperature:
  - -40°C to +85°C
  - -40°C to +125°C
- Low-Power Sleep Operation:
  - <1 µA @5V/25°C during Sleep mode

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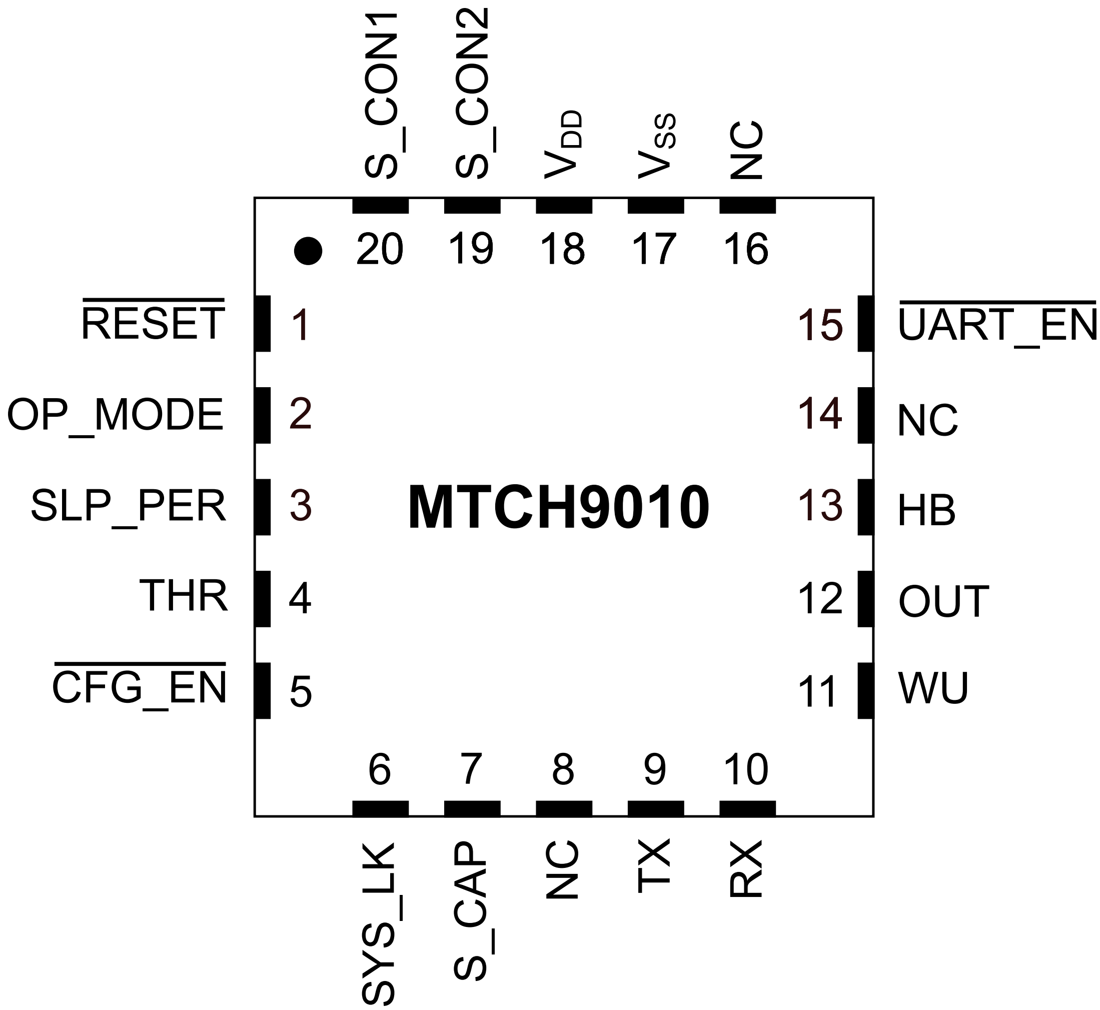
1. Pin Diagram

Figure 1-1. 20-Pin VQFN



Note: Connecting the exposed bottom pad to V_{SS} is recommended. However, it must not be the only V_{SS} connection to the device.

2. Pin Configuration

Pin Number	Name	Type	Function
1	$\overline{\text{RESET}}$	-	Device reset
2	OP_MODE	Input	Capacitive or Conductive mode selection
3	SLP_PER	Input	Sleep period or wake-up request selection
4	THR	Input	Liquid detection threshold
5	$\overline{\text{CFG\_EN}}$	Input	Enhanced configuration mode enable
6	SYS_LK	Input	System lock enable
7	S_CAP	Input	Capacitive electrode input
8	NC	-	Not connected
9	TX	Output	Serial data transmission
10	RX	Input	Serial data receive
11	WU	Input	Wake-up request
12	OUT	Output	Liquid detection alarm
13	HB	Output	Heartbeat signal
14	NC	-	Not connected
15	$\overline{\text{UART\_EN}}$	Input	Extended output enable
16	NC	-	Not connected
17	V_{SS}	-	Power supply GND
18	V_{DD}	-	Power supply (+)
19	S_CON2	Input	Conductive electrode input 2
20	S_CON1	Input	Conductive electrode input 1

3. Configuration

The MTCH9010 liquid detection sensor features several configuration input pins, and each pin controls one of the following configuration parameters:

- Operation Mode Selection (Capacitive or Conductive)
- Sleep Period Selection
- Liquid Detection Threshold
- Extended Output Enable
- Enhanced Configuration Mode Enable
- System Lock Enable

The Sleep Period and Liquid Detection Threshold inputs are set by applying a voltage level to the respective configuration pin. The Appendix provides information on how to generate these input voltages.

The Operation Mode, Extended Output, Enhanced Configuration Mode, and System Lock inputs are set by connecting the pin to V_{DD} or GND.

If the System Lock is not enabled, MTCH9010 reads the I/O configuration input pins at power-up. Otherwise, the saved parameters will be used instead.

3.1. Operation Mode

The MTCH9010 liquid detector offers flexibility in liquid detection by offering both capacitive and conductive detection methods.

MTCH9010 can be configured to operate with capacitive or conductive detection methods. The operation mode can be set through the digital input OP_MODE or the Enhanced Configuration.

The MODE pin must have a 0V or V_{DD} voltage level. The following table shows the correspondence between the pin voltage and the operation mode for the device:

Table 3-1. Operation Mode Settings

Voltage on MODE Pin	Operation Mode Selection
0V	Conductive
V_{DD}	Capacitive

3.2. Sleep Period

The MTCH9010 liquid detector has a configurable Sleep period, which can be done either through the analog input pin SLP_PER or the Enhanced Configuration using UART. There are nine predefined Sleep periods, ranging from 1 to 256 seconds. Additionally, the MTCH9010 provides on-demand wake-up via the WU pin. The WU pin detects falling edge signals, interrupts the Sleep state, checks for liquid presence, and returns the device to the Sleep state until the following wake-up request.

Note: Between wake-up requests, implement a wait time of at least 150 ms.

The SLP_PER pin must be in the range of 0V and V_{DD}. The following table shows the corresponding voltage for the wake-up request and each of the predefined Sleep periods:

Table 3-2. Sleep Period Settings on SLP_PER Pin

Voltage Value for Sleep Period Setting			Sleep Period [s]	Option
Interval Lower Limit [V]	Interval Upper Limit [V]	Ideal Value [V]		
GND	1 × V_{DD} / 18	GND	-	Wake-up on Request

Table 3-2. Sleep Period Settings on SLP_PER Pin (continued)

Voltage Value for Sleep Period Setting			Sleep Period [s]	Option
Interval Lower Limit [V]	Interval Upper Limit [V]	Ideal Value [V]		
$1 \times V_{DD} / 18$	$3 \times V_{DD} / 18$	$1 \times V_{DD} / 9$	1	Sleep period of 1 second
$3 \times V_{DD} / 18$	$5 \times V_{DD} / 18$	$2 \times V_{DD} / 9$	2	Sleep period of 2 seconds
$5 \times V_{DD} / 18$	$7 \times V_{DD} / 18$	$3 \times V_{DD} / 9$	4	Sleep period of 4 seconds
$7 \times V_{DD} / 18$	$9 \times V_{DD} / 18$	$4 \times V_{DD} / 9$	8	Sleep period of 8 seconds
$9 \times V_{DD} / 18$	$11 \times V_{DD} / 18$	$5 \times V_{DD} / 9$	16	Sleep period of 16 seconds
$11 \times V_{DD} / 18$	$13 \times V_{DD} / 18$	$6 \times V_{DD} / 9$	32	Sleep period of 32 seconds
$13 \times V_{DD} / 18$	$15 \times V_{DD} / 18$	$7 \times V_{DD} / 9$	64	Sleep period of 64 seconds
$15 \times V_{DD} / 18$	$17 \times V_{DD} / 18$	$8 \times V_{DD} / 9$	128	Sleep period of 128 seconds
$17 \times V_{DD} / 18$	V_{DD}	V_{DD}	256	Sleep period of 256 seconds

3.3. Liquid Detection Threshold

A configurable threshold mechanism for liquid detection is implemented in the MTCH9010 liquid detector. This configurable parameter can be provided through a voltage signal connected to the analog input pin THR or by using the Enhanced Configuration.

Several factors influence the measurements and create the need for a configurable threshold for liquid detection:

- Sensor design and dimensions
- Liquid properties
- Sensitivity requirements for the application
- Environmental temperature and humidity

The threshold value is computed according to the following equations by configuring the liquid detection threshold through the THR analog input pin:

- If the operation mode is configured as a Capacitive detection method, the following equation is used for the threshold:

$$\text{threshold} = \frac{\text{referenceValue} \times \text{adcStandardMeas}}{65535} \times \frac{20}{100}$$

- If the operation mode is configured as a Conductive detection method, the following equation is used for the threshold:

$$\text{threshold} = \text{referenceValue} + \frac{\text{adcStandardMeas} \times (65535 - \text{referenceValue})}{65535}$$

Note: The reference value is represented by an average of measurements using the sensor in a dry state.

The voltage signal used as input for the THR pin must be within the range of 0V and V_{DD}. The following table shows the correlation between the THR voltage and the liquid detection threshold level:

Table 3-3. Liquid Detection Threshold Settings

Input Range	Liquid Detection Threshold	
	Capacitive Operation Mode	Conductive Operation Mode
0V to V_{DD}	• Lowest at 0V • Increases with voltage on the THR pin • Highest at V_{DD} (20% of the reference value)	• Reference value at 0V • Increases with voltage on the THR pin • Highest at V_{DD}

3.4. Extended Output Mode

The MTCH9010 liquid detector supports an Extended Output mode that complements the Digital Output Mode by offering more information about the detection parameters.

Note:
Enable the Extended Output Mode using the $\overline{\text{UART\_EN}}$ digital input pin or the Enhanced Configuration Mode. Refer to theExtended Output chapter.

3.5. Enhanced Configuration Mode Enable

Besides the configuration pins, the MTCH9010 supports the Enhanced Configuration mode via serial communication. The serial communication parameters are as follows:

- Baud rate of 38400 bits/second
- Eight data bits
- No parity bit
- One stop bit

The configuration provided by the user through this configuration mode is stored in the Nonvolatile Memory (NVM), making it invulnerable to Power-on Reset (POR).

The $\overline{\text{CFG\_EN}}$ digital input pin controls the usage of the Enhanced Configuration mode. The following table shows the correspondence between the $\overline{\text{CFG\_EN}}$ pin voltage and Enhanced Configuration options:

Table 3-4. Enhanced Configuration Settings

Voltage on CFG_EN Pin	Enhanced Configration Selection
0V	Enabled
V_{DD}	Disabled

When it comes to setting parameters using a serial communication interface, this configuration mode provides flexibility. The parameters are sent sequentially by transmitting the required data series through the serial communication channel. After each parameter is sent individually, a validation key (ENTER key) is required.

Important: The validation key (ENTER) is represented by the carriage return (`\r`) with the ASCII code equal to `0x0D` in the hexadecimal system or `13` in the decimal system.

After receiving a parameter, the device sends back an ACK or a NACK character, depending on the outcome of the parameter validation process.

The ACK signal is a byte sent on the same serial communication with a value equal to `0x06` in the hexadecimal system or `6` in the decimal system. The NACK signal is a byte long with a value equal to `0x15` in the hexadecimal system or `21` in the decimal system.

The table below shows the accepted reference value and threshold value.

Table 3-5. Enhanced Configuration Parameters Values Range

Parameter	Range	
	Lower Limit	Upper Limit
Reference Value	0	65535
Threshold	0	65535

Notes:

1. According to the sensor characteristics, the reference value and the threshold parameters must be carefully chosen. It is advisable to conduct an initial testing phase and measure the sensor's Reference Value in the actual operating environment to ensure optimal functionality.
2. Selecting a threshold value of zero will be accepted by MTCH9010, but a liquid detection alert will only happen if the delta is greater than 1.
3. Setting a low threshold value can result in false triggers. It is recommended to tune the threshold level according to the application requirements and environment characteristics.

The following table describes the available options when it comes to configuring application parameters through the Enhanced Configuration mode:

Table 3-6. Enhanced Configuration Parameters

Parameter	Value	Configuration
Operation Mode	0	Capacitive
	1	Conductive
Sleep Time	0	Wake-up on request
	1	1 second
	2	2 seconds
	3	4 seconds
	4	8 seconds
	5	16 seconds
	6	32 seconds
	7	64 seconds
	8	128 seconds
	9	256 seconds
Extended Output Mode	0	Disabled
	1	Enabled
Extended Output Format(1)	0	Delta measurement
	1	Standard measurement
	2	Both standard and delta measurements
	3	MPLAB® Data Visualizer Data Stream protocol format(2)
Capacitive/Conductive Reference Value	0	Set the standard measurement as Reference Value
	1	Repeat the capacitive/conductive measurement(3)
	2	Set custom Reference Value(4)
Capacitive/Conductive Detection Threshold	0	Set custom Detection Threshold

Notes:

1. These options are only available in the Enhanced Configuration mode if the Extended Output mode is enabled.
2. Refer to the *MPLAB Data Visualizer User's Guide*.
3. Selecting this option triggers a new standard measurement.
4. Selecting this option must be followed by a user input of the Reference Value.

Important: If any other value than the ones presented in the table above is input to the Enhanced Configuration process, it will be considered invalid and the user will be prompted to input the value again.

Send the configuration parameters to the MTCH9010 following the procedure shown in the example below. Use the `ENTER Key` after each parameter. The example showcases a configuration for using the Capacitive mode, with four seconds of sleep time, Extended Output mode enabled for standard measurement only, and with custom reference value and threshold:

- `0 + ENTER key` - selecting Capacitive Mode
- `3 + ENTER key` - selecting four second period for Sleep
- `1 + ENTER key` - Extended Output Mode is enabled
- `1 + ENTER key` - the Extended Output Mode is configured to output standard measurement only
- `2 + ENTER key` - selecting a custom reference value usage
- `REFERENCE VALUE + ENTER key` - setting a custom reference value
- `THRESHOLD VALUE + ENTER key` - setting a custom detection threshold

Note: For examples of enhanced configuration, refer to Enhanced Configuration with Manual Input of Parameters Example and Enhanced Configuration Script Example in the Appendix chapter.

3.6. System Lock

The MTCH9010 liquid detector provides a System Lock mechanism that saves the parameters configured through the Enhanced Configuration mode in the Nonvolatile Memory (NVM) and restores the settings at every start-up. Enable this feature at the next start-up after the Enhanced Configuration and calibration process.

The parameters configured using the Enhanced Configuration mode are stored in the NVM at two memory locations for redundancy purposes. The application will load the parameters from the first memory location and use the second memory location only if the loading fails.

Important: If the saved configuration is compromised in both memory locations (due to incomplete configuration or data corruption), the device will enter an error state, as indicated by the OUT and HB pins. Refer to the Error State chapter.

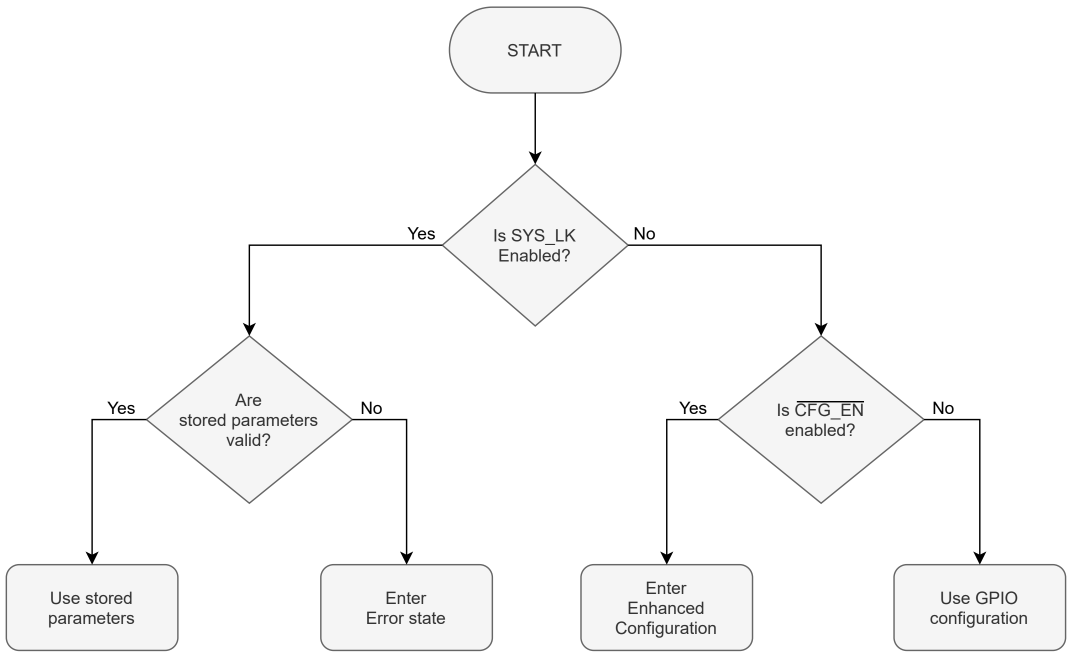
The SYS_LK digital input pin controls the usage of the System Lock mode. The following table shows the correspondence between the SYS_LK pin voltage and System Lock settings:

Table 3-7. System Lock Settings

Voltage on SYS_LK Pin	System Lock
0V	Enabled
V_{DD}	Disabled

Note: If the parameters validation process detects data corruption in the saved parameters, the device enters the Error state. Refer to the Error State chapter.

Figure 3-1. System Lock Flow Diagram



4. Liquid Detection Sensor

The MTCH9010 supports capacitive and conductive sensor designs for liquid detection.

4.1. Capacitive Detection Method

The capacitive method for liquid detection relies on the principle that the presence of a liquid changes the dielectric constant of the medium between two conductive plates, which in turn affects the system capacitance. The capacitance of the sensor electrode attached to the S_CAP pin is measured periodically. The period can be provided through the SLP_PER pin or through the Enhanced Configuration. The increased dielectric constant results in a higher capacitance value when the liquid is present. Conversely, when the liquid is absent, the capacitance value is lower.

The capacitive sensor input pin is connected to the sensor electrode via a series resistor to reduce the Electromagnetic Interference (EMI) and increase Electromagnetic Compatibility (EMC). The series resistor can be from 1 kΩ to 100 kΩ, depending on the sensor capacitance and desired level of EMC performance. For further details, refer to Microchip Application Note (AN2934) - Capacitive Touch Sensor Design.

4.2. Conductive Detection Method

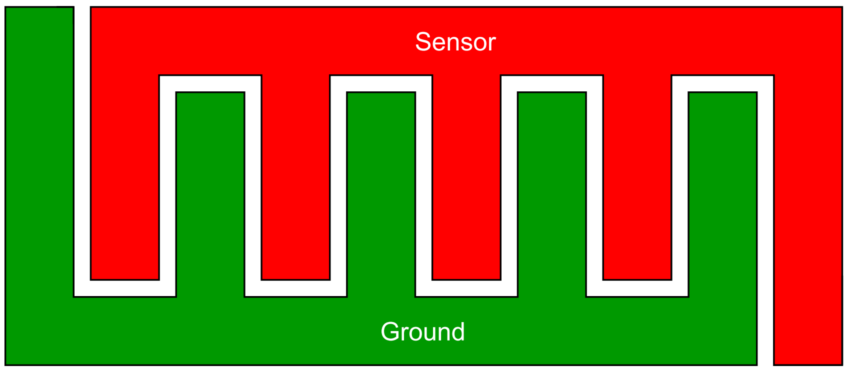
Detecting liquid using the conductive method involves measuring the electrical conductivity of the liquid. This method is based on the principle that liquids, especially those containing ions (such as water with dissolved salts), can conduct electricity. Two electrodes, typically made of conductive materials like stainless steel or copper, are placed where liquid presence needs to be detected. When the liquid comes into contact with the electrodes, it completes the electrical circuit, allowing current to flow between them. The presence of ions in the liquid facilitates this flow of current.

5. Sensor Design

5.1. Capacitive Sensor Design

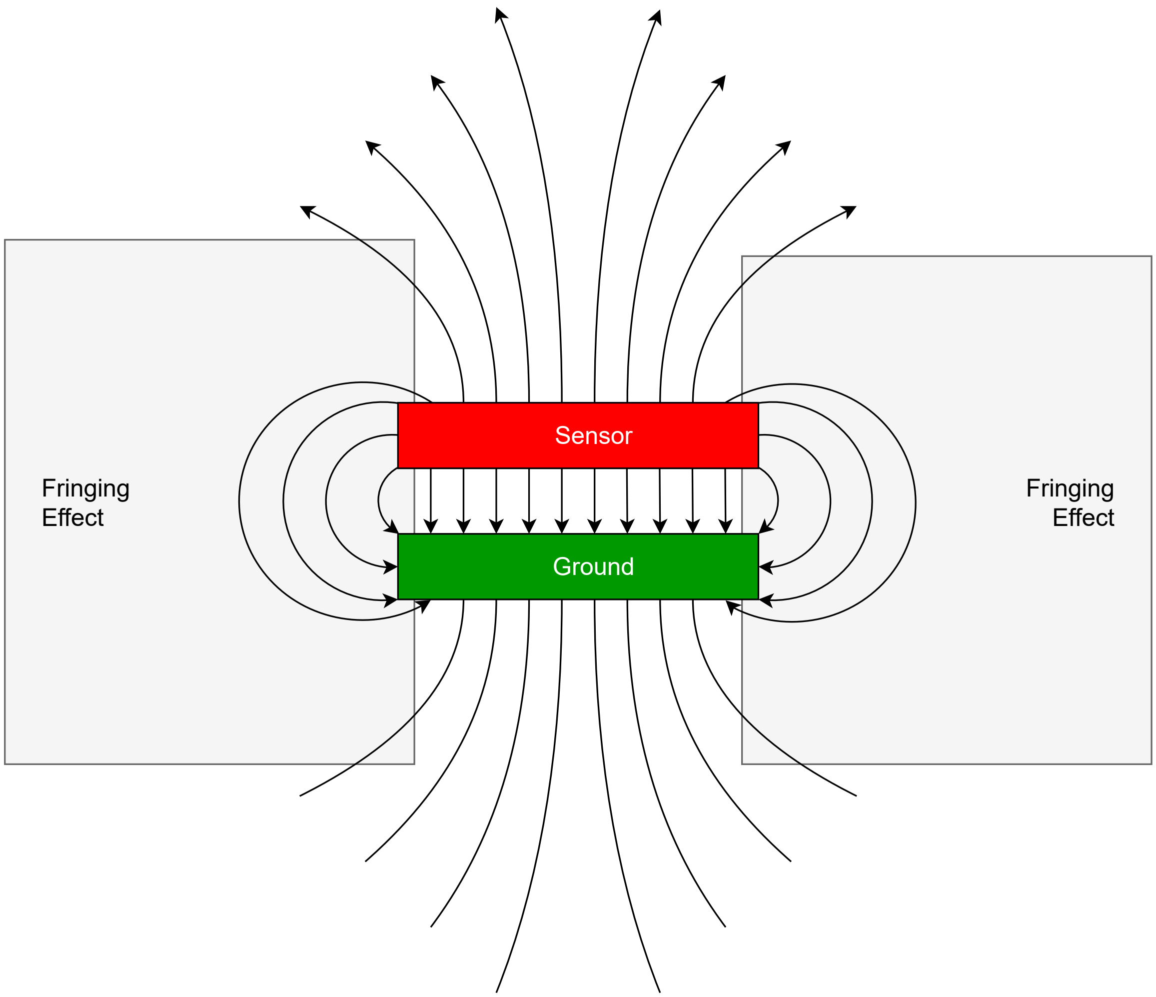
Due to their sensitivity and reliability, interleaved electrode capacitive sensors are used frequently in liquid detection applications. The sensor consists of two electrodes arranged in a comb-like structure where the fingers of one electrode are placed between the fingers of the other electrode. The electrodes are typically made of conductive materials such as copper and are usually printed or etched onto a nonconductive substrate, such as a Printed Circuit Board (PCB).

Figure 5-1. Interleaved Capacitive Design Example



Fringing capacitance is the key principle in the operation of interleaved capacitive sensors. In a typical parallel plate capacitor, the electric field lines are mostly confined between the plates. However, in capacitive sensors with interleaved electrodes, the electric field lines extend outward from the edges of the electrodes, creating a fringing effect. The total capacitance is a combination of the direct capacitance between the electrodes and the fringing capacitance.

Figure 5-2. Fringing Effect



When the sensor is exposed to water, the dielectric constant of the medium between the electrodes changes significantly. Water has a high dielectric constant (around 80) compared to air (approximately 1) or other common materials. This change in the dielectric constant leads to a measurable change in the capacitance of the sensor.

The geometry of the interleaved electrodes, including the width, spacing, and length of the fingers, affects the fringing capacitance. The fringing capacitance becomes more significant when the electrodes are closely spaced and have a large surface area. The interleaved design increases the number of edges from which the fringing fields emanate, which enhances the sensor's sensitivity.

Figure 5-3. Electric Fields of a Parallel Plate Capacitor

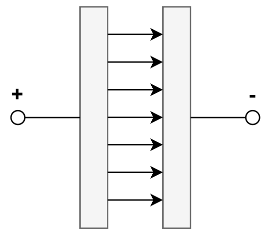
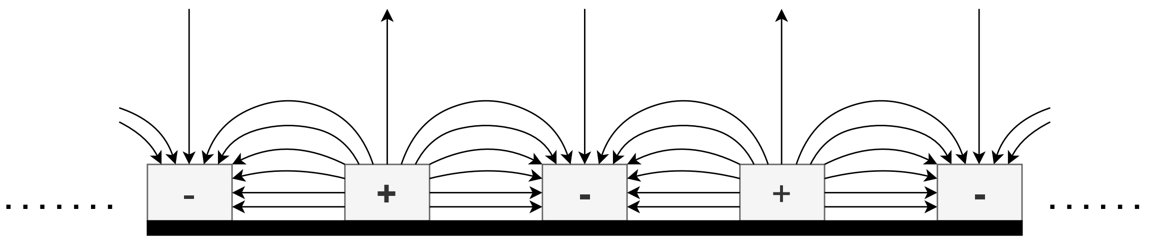


Figure 5-4. Electric Fields of an Interleaved Electrode Sensor



Fringing capacitance is generally harder to analyze and calculate than the capacitance of a parallel plate capacitor. If simulation programs are unavailable, prototyping can be a practical and effective approach to designing an interleaved electrode capacitive sensor.

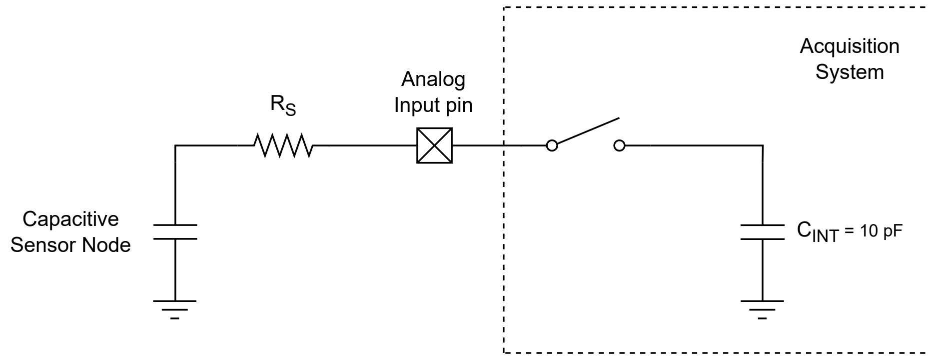
When designing an interleaved capacitive liquid detection sensor, it is important to ensure that the sensor capacitance is within the range that allows accurate measurements. Ideally, the sensor's capacitance may be in the same order of magnitude as the internal capacitance of the acquisition system. This aspect helps to achieve a good signal-to-noise ratio and ensures that the acquisition system can accurately measure changes in capacitance. In the case of MTCH9010, the internal capacitance of the system is 10 pF.

In capacitive sensing applications, series resistors can help improve the measurement accuracy by filtering out high-frequency noise and providing a more stable signal, which can be especially important when detecting small changes in capacitance due to the presence of liquids.

The combination of the series resistor and the capacitance of the electrodes form an RC circuit, which has a specific time constant. This time constant can affect the sensor response time. Selecting the appropriate resistor value is crucial to ensure the sensor responds promptly while delivering stable and accurate measurements.

To determine the appropriate series resistor value for a 20 pF capacitive sensor, given that the acquisition system has an internal capacitance of 10 pF and a minimum acquisition time of 5 µs, the combined capacitance needs to be considered and ensure that the RC time constant allows the internal capacitor to charge sufficiently within the acquisition time. The total capacitance seen by the system will be the sum between the sensor capacitance and the system's internal capacitance.

Figure 5-5. Capacitive Acquisition System



For the system to acquire a stable voltage, the internal capacitor might charge a significant portion of its final value within the acquisition time. A common rule of thumb is to allow the capacitor to charge for at least 3 to 5-time constants to reach over 95% of its final value.

Given the minimum acquisition time of 5 µs, the time constant can be a fraction of this time. Choosing 1 µs as a reasonable time constant allows for multiple time constants within the acquisition time.

There are advantages and disadvantages of using a sensor with either a greater or lesser capacitance value, given the same series resistor and figure dimensions (length and width).

As the sensor capacitance is directly influenced by its geometry, a higher capacitance sensor is achieved by increasing the number of fingers in the comb-like structure, which, in turn increases the strength of the fringing electric field and results in greater sensitivity to changes in the dielectric constant at the surface of the sensor, improving the detection accuracy. Higher capacitance can also lead to a stronger signal and may improve the signal-to-noise ratio and make the system more robust against electrical noise. As a downside, higher capacitance increases the RC time constant, which means the sensor will take longer to charge and discharge, and the acquisition system may not be able to acquire the signal within its minimum acquisition time, leading to inaccurate readings.

A sensor with fewer fingers will have a decreased capacitance, resulting in a shorter RC time constant, allowing the sensor to charge and discharge more quickly. Such a sensor may be more compatible with the system's acquisition time, ensuring a more accurate reading. As a downside, the sensor may be less sensitive to changes in the dielectric constant as the fringing electric field is weaker. The acquired signal may also be weaker which can reduce the signal-to-noise ratio, making the system more susceptible to electrical noise.

5.2. Conductive Sensor Design

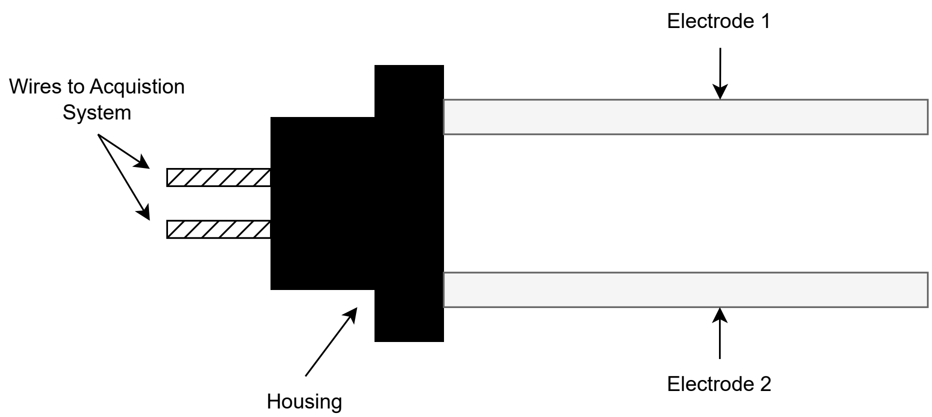
Conductive liquid detection sensors operate based on the principle that conductive liquids can complete an electrical circuit. The sensor typically consists of two or more electrodes placed where liquid detection is required. The electrodes are typically made of conductive materials such as steel, copper, or other corrosion-resistant metals.

When no conductive liquid is present, the resistance between the electrodes is very high because air or any non-conductive medium between the electrodes provides no path for electrical current to flow. When a conductive liquid (such as water with dissolved salts or other conductive substances) comes into contact with the electrodes, it creates a conductive path between them, significantly lowering the resistance between the electrodes. Then the system will measure this electrical conductivity change. Connect two pull-up resistors to the electrodes, with one resistor for each. The resistors help create a clear distinction between the presence and absence of liquid by ensuring a significant voltage drop when liquid is detected. They also help reduce the noise and interference that might affect the detection circuit.

Conductive liquid detection sensors can come in various shapes and forms, each designed to suit specific applications and requirements. The design can range from simple configurations like two conductive wires to more complex structures like interleaved electrodes.

The simplest form of a conductive liquid sensor consists of two parallel wires or rods placed at the desired detection point. This type of sensor is frequently used to monitor conductive liquid levels in tanks. The advantages of such sensors include simplicity, cost-effectiveness, and versatility.

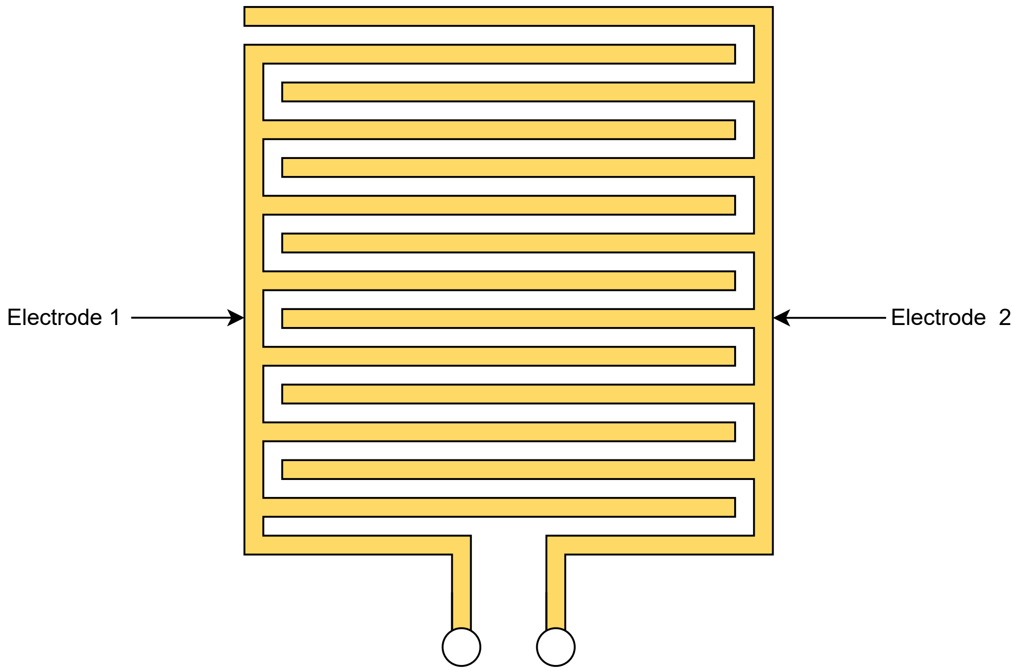
Figure 5-6. Conductivity Sensor



The conductive electrodes can also be arranged in an interleaved pattern. Due to its sensitivity and reliability, typically, this sensor type is used to detect liquid leaks in different applications across different industries. Such sensors can also be designed on a printed circuit board. The exposed copper traces will act as electrodes and can be shaped in various patterns.

The PCB geometry and the dimensions of the electrodes play a crucial role in the performance of the interleaved sensor. The overall size and shape of the electrodes determine the coverage area. When widespread detection is required, a larger sensor will have an increased detection surface area, making it suitable for applications. The spacing between the electrodes and their width influences the sensor sensitivity. Closer electrode spacing and reduced electrode width can provide higher resolution, allowing the sensor to detect smaller amounts of liquid. However, if the electrodes are too narrow, they may become fragile and more prone to damage, and if the spacing is too small, it might lead to short-circuiting or bridging by contaminants.

Figure 5-7. Conductive Sensor Design



A disadvantage of the conductive liquid detection method is that the sensor's effectiveness depends on the conductivity of the liquid. Nonconductive liquids such as oils cannot be detected using this method. Another drawback is the potential corrosion of the sensor's electrodes as they come in direct contact with the liquid. The electrodes can also become fouled or coated with residues from the liquid, which can affect their performance and require regular cleaning.

To reduce the overall corrosion rate, the MTCH9010 implements electrode polarity reversal when operating in Conductive mode. In one acquisition cycle, the system is configured so that the current flows from Electrode 1 to Electrode 2. In the next acquisition cycle, the system reverses the current flow. Periodically reversing the current flow helps ensure that both electrodes experience similar wear and tear, extending the lifespan of the sensor.

6. Output

The MTCH9010 provides multiple output channels that offer information about the liquid leakage detection measurements and the device state. The output channels are the following:

- Digital Output
- Extended Output
- Heartbeat

6.1. Digital Output

The Digital Output option provides a digital signal on the OUT pin that indicates the liquid presence on the connected sensor circuit. This Output mode is enabled by default and operates in Conductive and Capacitive operation modes.

The presence of liquid on the connected sensor circuit in this Output mode is relative to the liquid detection threshold. The delta measurement is obtained by subtracting the reference value from the standard measurement.

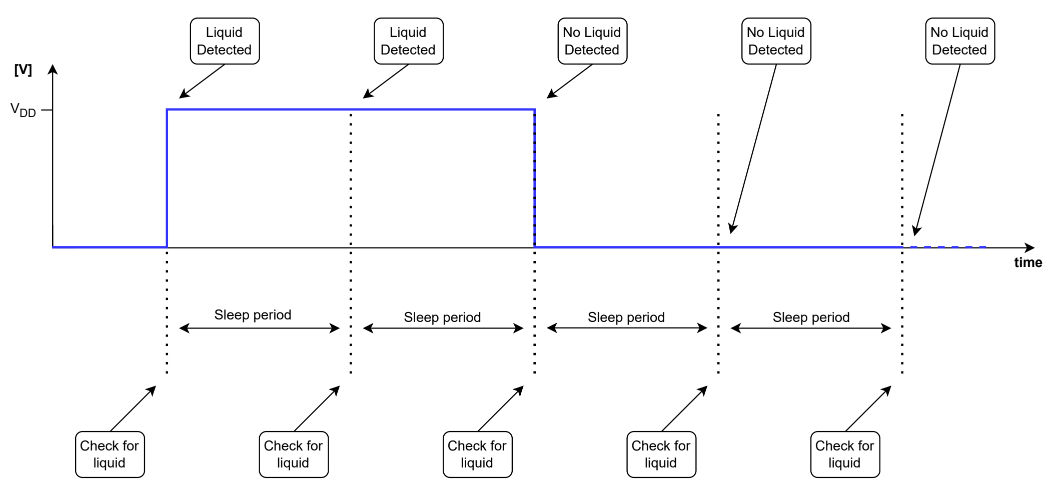
The correlation between the voltage level on the OUT pin and the delta measurement is explained in the table below:

Table 6-1. Digital Output

OUT Pin State	Liquid Detection Option	Interpretation
LOW	Not detected	Delta measurement is smaller than the liquid detection threshold
HIGH	Detected	Delta measurement is greater than the liquid detection threshold

If any liquid is detected, the OUT signal will remain in a high state until the Sleep period expires and a new measurement is made. If the next measurement determines that liquid is present, the OUT signal will remain High. Otherwise it will go Low. Below is an example of five consecutive measurements, out of which the first two show liquid was detected. The measurements are separated by the Sleep period.

Figure 6-1. MTCH9010 OUT Pin Signal Example



The OUT pin has an alternate function used when the device enters an Error state. Refer to Error State.

6.2. Extended Output

MTCH9010 supports Universal Asynchronous Receiver and Transmitter (UART) output. There are four output formats available:

- Both standard measurement (raw data) and delta
- Only standard measurement (raw data)
- Only delta
- MPLAB® Data Visualizer Data Stream protocol format

By default, both the raw measurement and delta parameters are provided. The three other output formats can be selected by configuring the output format through the Enhanced Configuration.

The Extended Output mode of MTCH9010 provides information on the liquid detection parameters through serial communication. This mode is disabled by default but can be enabled through the UART_EN pin or by using the Enhanced Configuration mode.

The parameters displayed by the Extended Output mode are presented below:

1. The first information offered by the Extended Output mode is the firmware version:
   `Firmware vX.Y.Z`
   - `X` - the major version of the firmware.
   - `Y` - the minor version of the firmware.
   - `Z` - the patch version of the firmware.
2. The reference value and the liquid detection threshold represent the following series of parameters:
   `<reference_value> <liquid_detection_threshold>`
   - `<reference_value>` - the value measured with a completely dry sensor or an initial desired sensor state.
   - `<liquid_detection_threshold>` - the value of the liquid detection threshold configured by the user.
3. The next parameters are the standard and delta measurements that are displayed after each new measurement:
   `<standard_measurement> <delta_measurement>`
   - `<standard_measurement>` - the standard value measured on the sensor.
   - `<delta_measurement>` - the value obtained by subtracting the reference value from the standard measurement value.

   Note: In the Enhanced Configuration mode, besides the option where both standard and delta measurements are displayed, there is also the option to display the standard or delta measurement only.

Important: The firmware version, the reference value, and the liquid detection threshold are displayed only once at the start of the operation.

The Extended Output mode can be accessed using the UART_EN pin according to the table below:

Table 6-2. Extended Output

Voltage on UART_EN Pin	Extended Output Selection
0V	Enabled

Table 6-2. Extended Output (continued)

Voltage on UART_EN Pin	Extended Output Selection
V_{DD}	Disabled

Note: If the Extended Output mode is enabled using the $\overline{\text{UART\_EN}}$ pin, the output format is both standard and delta measurement. Selecting another option for the Extended Output format must be done through the Enhanced Configuration mode.

After configuring the operation mode and the Sleep period in the Enhanced Configuration mode, the following two settings are the ones that configure the Extended Output mode:

Table 6-3. Extended Output Options in the Enhanced Configuration Mode

Enhanced Configuration Selection	Command	Option
Extended Output mode	0	Disabled
	1	Enabled
Extended Output Format(1)	0	Delta measurement
	1	Standard measurement
	2	Both standard and delta measurements
	3	MPLAB® Data Visualizer Data Stream protocol format(2)

Notes:

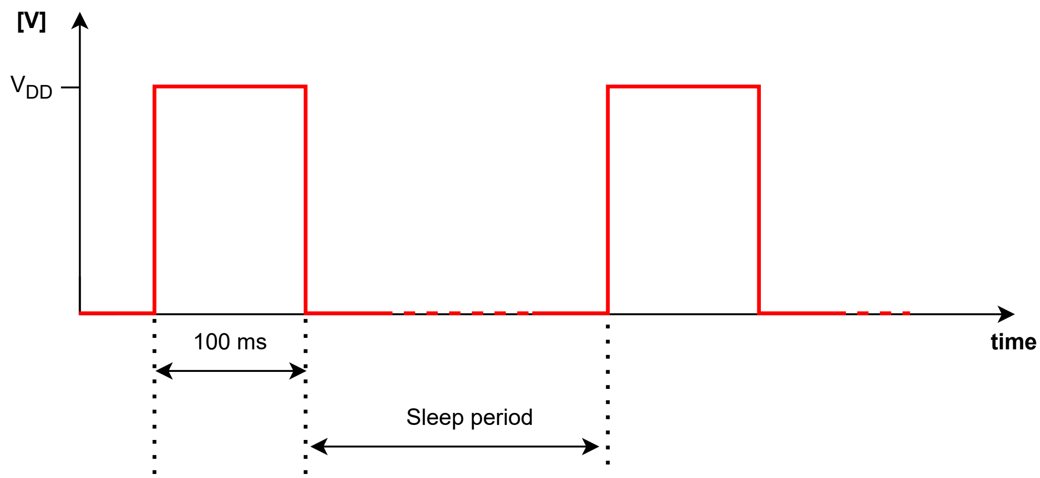
1. Only if the Extended Output mode is enabled these options are available in the Enhanced Configuration mode.
2. Refer to the *MPLAB Data Visualizer User's Guide*.

6.3. Heartbeat

The MTCH9010 liquid detector provides a Heartbeat feature that signals that the device is fully operational. The heartbeat signal depends on the configured Sleep period, the output level toggling every time the device enters Sleep state.

On the HB pin, in case of proper operation, the device will output a 100 ms long pulse while it wakes up, acquires data, and outputs it before going back to Sleep state.

Figure 6-2. MTCH9010 Heartbeat Signal



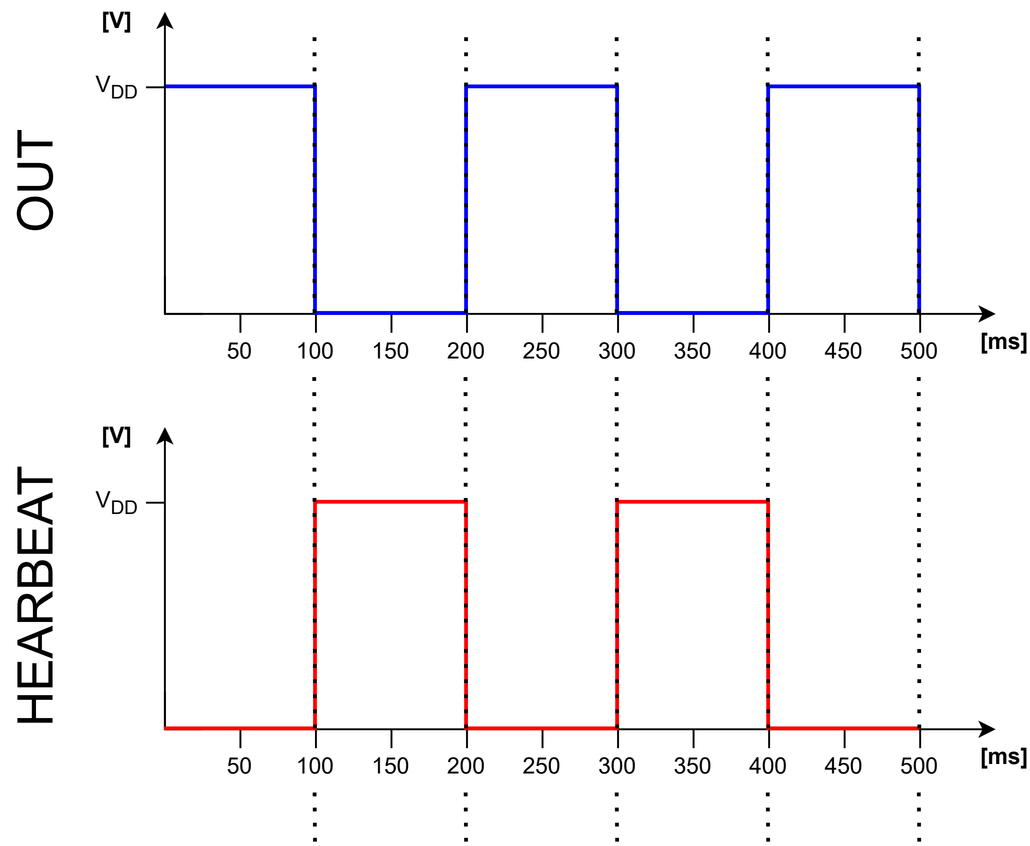
The HB pin has an alternate function used when the device enters an Error state. Refer to Error State.

7. Error State

MTCH9010 implements a saved parameters validation feature using a CRC-16-CCITT algorithm when the System Lock option is enabled.

If the CRC-16-CCITT algorithm detects data corruption in the saved parameters, the device enters the Error state. In this state, the OUT and HB pins output a square signal with a period of 200 ms and a 50% duty cycle. These two signals are complementary to each other.

Figure 7-1. MTCH9010 Error OUT and HB Pins Signals

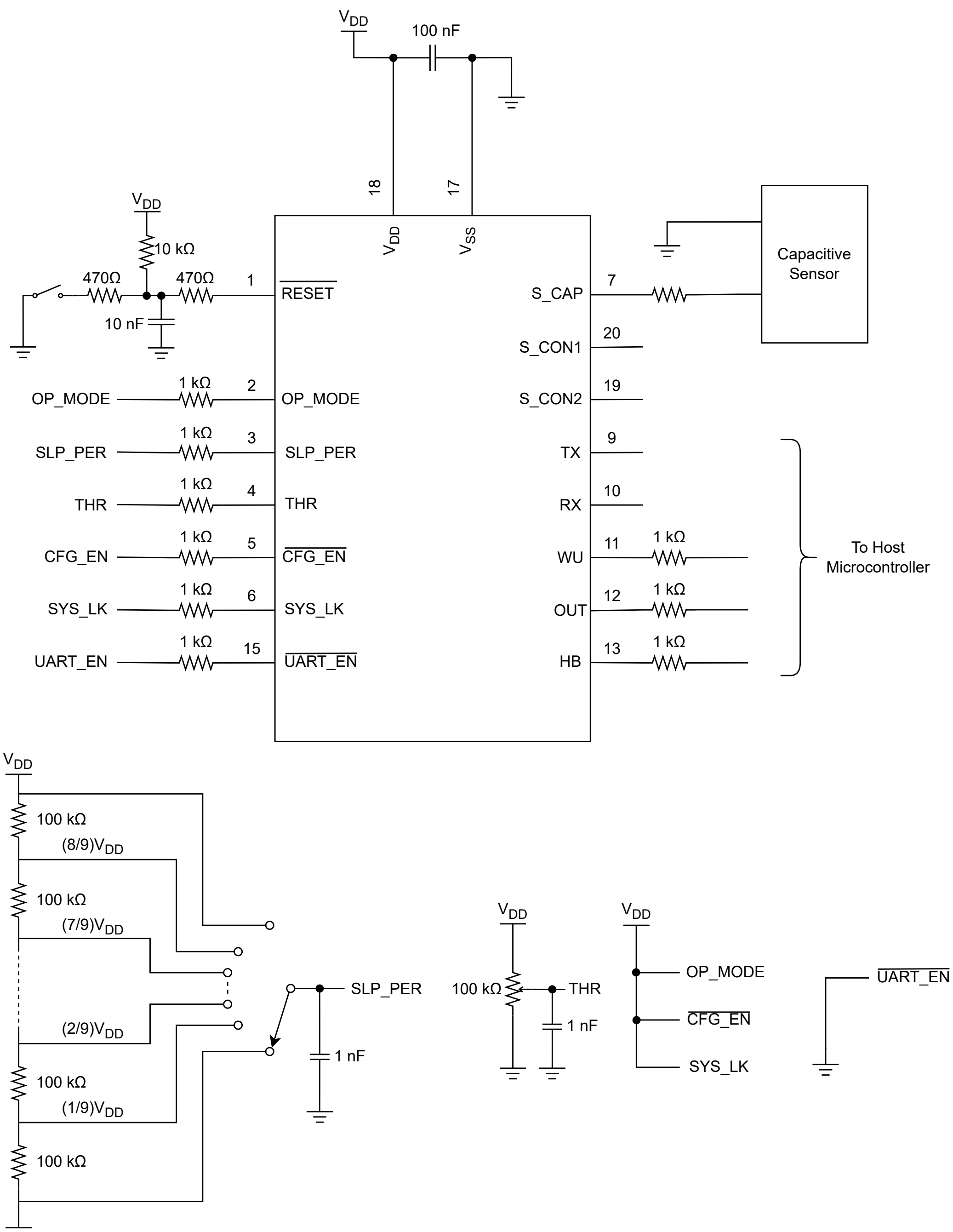


Important: If the device enters the Error state, it is recommended to redo the configuration using the Enhanced Configuration mode or disable System Lock and use the configuration pins for operation parameters settings.

8. Example Circuit

8.1. Example Circuit - Capacitive

Figure 8-1. MTCH9010 Example Circuit - Capacitive Operation Mode

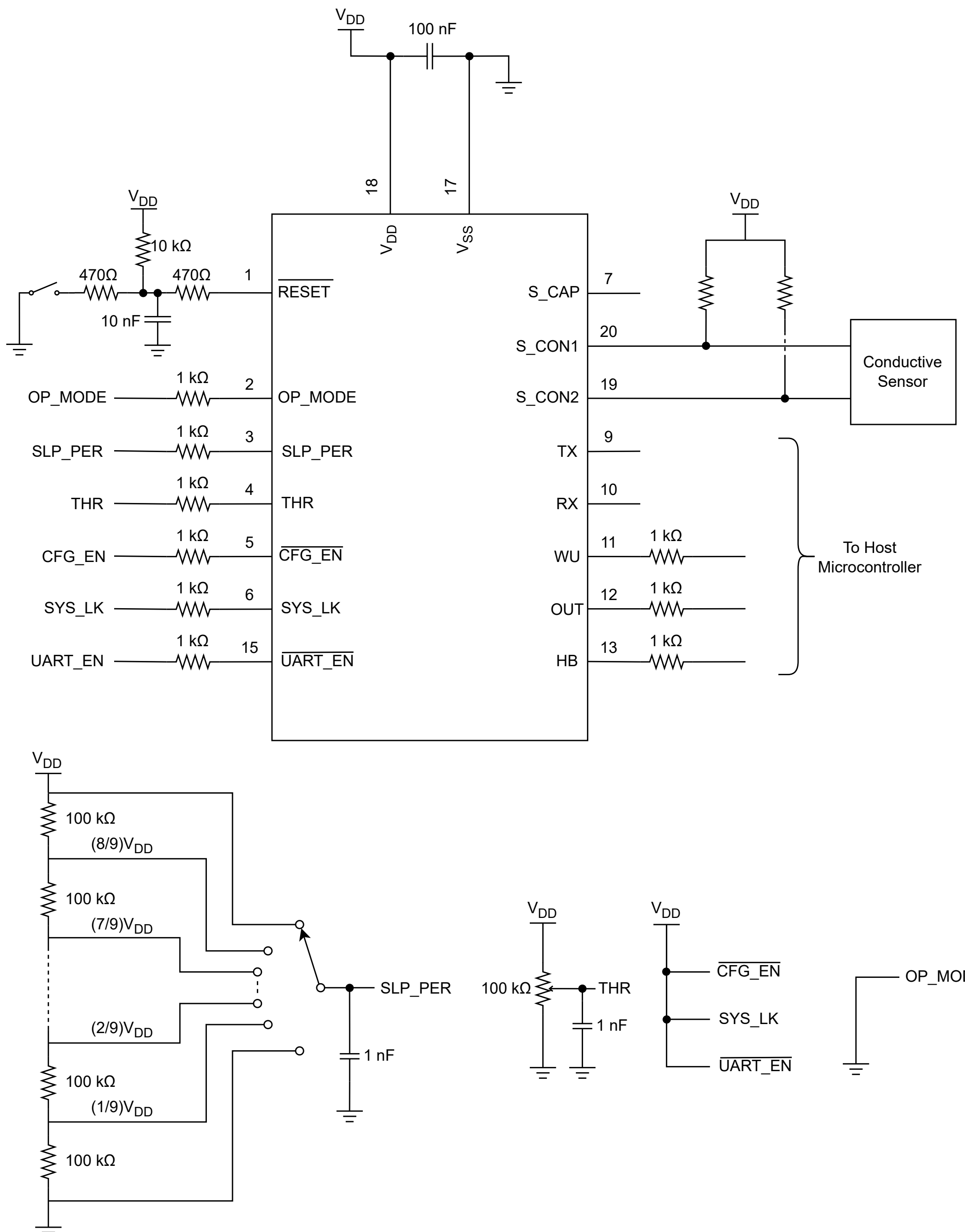


The schematic above presents an example circuit for the following scenario: Capacitive Operation mode, Sleep configured for Wake-up on request, System Lock disabled, Extended Output mode enabled.

- OP_MODE pin is connected to V_{DD}, configuring the operation mode to Capacitive
- SLP_PER pin is connected to GND on a ten-level voltage divider, enabling the Wake-up on request feature. The host must use a signal on the WU pin to trigger acquisitions.
- The THR pin is connected to a potentiometer, where the Liquid Detection threshold is configured
- The $\overline{\text{CFG\_EN}}$ pin is connected to V_{DD}, which disables the Enhanced Configuration mode
- The SYS_LK pin is connected to V_{DD}, which disables the System Lock feature
- The $\overline{\text{UART\_EN}}$ pin is connected to GND, enabling the Extended Output mode

8.2. Example Circuit - Conductive

Figure 8-2. MTCH9010 Example Circuit - Conductive Operation Mode



The schematic above presents an example circuit for the following scenario: Conductive Operation mode, Sleep configured for 256 seconds, System Lock disabled, and Extended Output mode disabled.

- The OP_MODE pin is connected to GND, configuring the operation mode to Conductive
- The SLP_PER pin is connected to V_{DD} on a ten-level voltage divider, configuring the Sleep period to 256 seconds
- The THR pin is connected to a potentiometer, where the Liquid Detection threshold is configured
- The $\overline{\text{CFG\_EN}}$ pin is connected to V_{DD}, which disables the Enhanced Configuration mode.
- The SYS_LK pin is connected to V_{DD}, which disables the System Lock feature.
- The $\overline{\text{UART\_EN}}$ pin is connected to V_{DD}, which disables the Extended Output mode.

9. Power Consumption

The power consumption depends on the device configuration. The following tables show the power consumption of the MTCH9010 liquid detector operating at 5V. For the measurements, the device was configured to use the stored parameters (System Lock enabled), and two scenarios were subject to measurements - Extended Output disabled and Extended Output enabled.

Table 9-1. Power Consumption Measurements

Sleep Period (s)	Average Current over a Sleep Period [µA]		Peak Current in a Sleep Period [mA]		Minimum Sleep Current [µA]	
	Extended Output Disabled	Extended Output Enabled	Extended Output Disabled	Extended Output Enabled	Extended Output Disabled	Extended Output Enabled
1	28.9	37.6				
2	14.5	19.4				
4	8.07	9.86				
8	4.63	6.27				
16	2.59	3.24	1.64	1.71	0.8	0.8
32	<1	1.72				
64	<1	1.59				
128	<1	1.1				
256	<1	<1				

Note: If Sleep is configured in the Wake-up on-request option, the Sleep period is controlled by the user, and the average current depends on the device's wake-up frequency.

10. Electrical Characteristics

10.1. Disclaimer

Unless otherwise specified, typical values are measured at T = 25°C and V_{DD} = 3.0V, and all minimum and maximum values are valid across the operating temperature and voltage.

10.2. Electrical Specification

Stresses beyond those listed in this chapter may cause permanent damage to the device. This is a stress rating only, and functional operation of the device at these or other conditions beyond those indicated in the operational chapters of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Table 10-1. Absolute Maximum Ratings

Symbol	Description	Min.	Max.	Unit
—	Ambient temperature under bias	-40	+85/+125	°C
$T_{Storage}$	Storage temperature	-65	+150	°C
V_{Pin}	Pin voltage to GND	-0.3	V_{DD} + 0.3	V
I_{Pin}	I/O pin sink/source current	—	±25	mA

10.3. General Operating Ratings

The device must operate within the ratings listed in this chapter for all other electrical characteristics and typical characteristics of the device to be valid.

Table 10-2. General Operating Conditions

Symbol	Description	Condition	Min.	Max.	Unit
V_{DD}	Operation supply voltage	—	2	5.5	V
—	Supply ripple noise	—	—	20	mV p-p
S_{VDD}	V_{DD} rise rate	—	0.05	—	V/ms
T	Operating temperature range(1)	Standard temperature range	-40	85	°C
		Extended temperature range	-40	125	°C

Note: 1. Refer to the device ordering codes for the device temperature range.

10.4. I/O Pin Characteristics

Table 10-3. I/O Pin Characteristics (T_A = 25°C, V_{DD} = 3.0V, Unless Otherwise Stated)

Symbol	Description	Condition	Min.	Typ.	Max.	Unit
V_{OL}	I/O pin drive strength	I_{OL} = 10 mA, V_{DD} = 3.0V	—	—	0.6	V
V_{OH}	I/O pin drive strength	I_{OH} = 6 mA, V_{DD} = 3.0V	V_{DD}-0.7	—	—	V
V_{IL}	With Schmitt Trigger Buffer	1.8V ≤ V_{DD} ≤ 5.5V	—	—	0.2 V_{DD}	V
	$\overline{\text{RESET}}$	—	—	—	0.2 V_{DD}	V
V_{IH}	With Schmitt Trigger Buffer	1.8V ≤ V_{DD} ≤ 5.5V	0.8 V_{DD}	—	—	V
	$\overline{\text{RESET}}$	—	0.8 V_{DD}	—	—	V
I_{IL}	I/O Ports	V_{SS} ≤ V_{PIN} ≤ V_{DD}, Pin at high-impedance, 85°C V_{SS} ≤ V_{PIN} ≤ V_{DD}, Pin at high-impedance, 125°C	—	±5 ±5	±125 ±1000	V
	$\overline{\text{RESET}}$	V_{SS} ≤ V_{PIN} ≤ V_{DD}, Pin at high-impedance, 85°C	—	±50	±200	V

Table 10-4. Sensor Capacitance

Symbol	Description	Condition	Min.	Typ.	Max.	Unit
C_X	Sensor electrode capacitance	—	1	—	20	pF

11. Ordering Information

Available ordering options:

- Click the following product page link:
  - MTCH9010 Product Page
- Contact your local sales representative
- Search by product name at www.microchipdirect.com

11.1. Product Information

Ordering Code	Supply Voltage	Package Type	Package Media	Temperature Range
MTCH9010-I/REB	1.8-5.5V	VQFN	Tray	-40°C to + 85°C
MTCH9010T-I/REB	1.8-5.5V	VQFN	Tape and Reel	-40°C to + 85°C
MTCH9010-E/REB	1.8-5.5V	VQFN	Tray	-40°C to + 125°C
MTCH9010T-E/REB	1.8-5.5V	VQFN	Tape and Reel	-40°C to + 125°C

12. Package Marking

12.1. 20-Pin VQFN

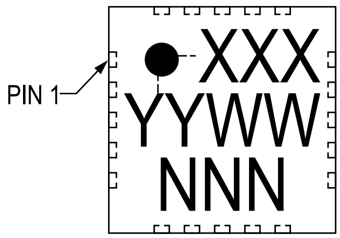


Figure 12-1. General

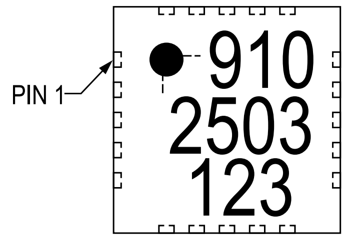


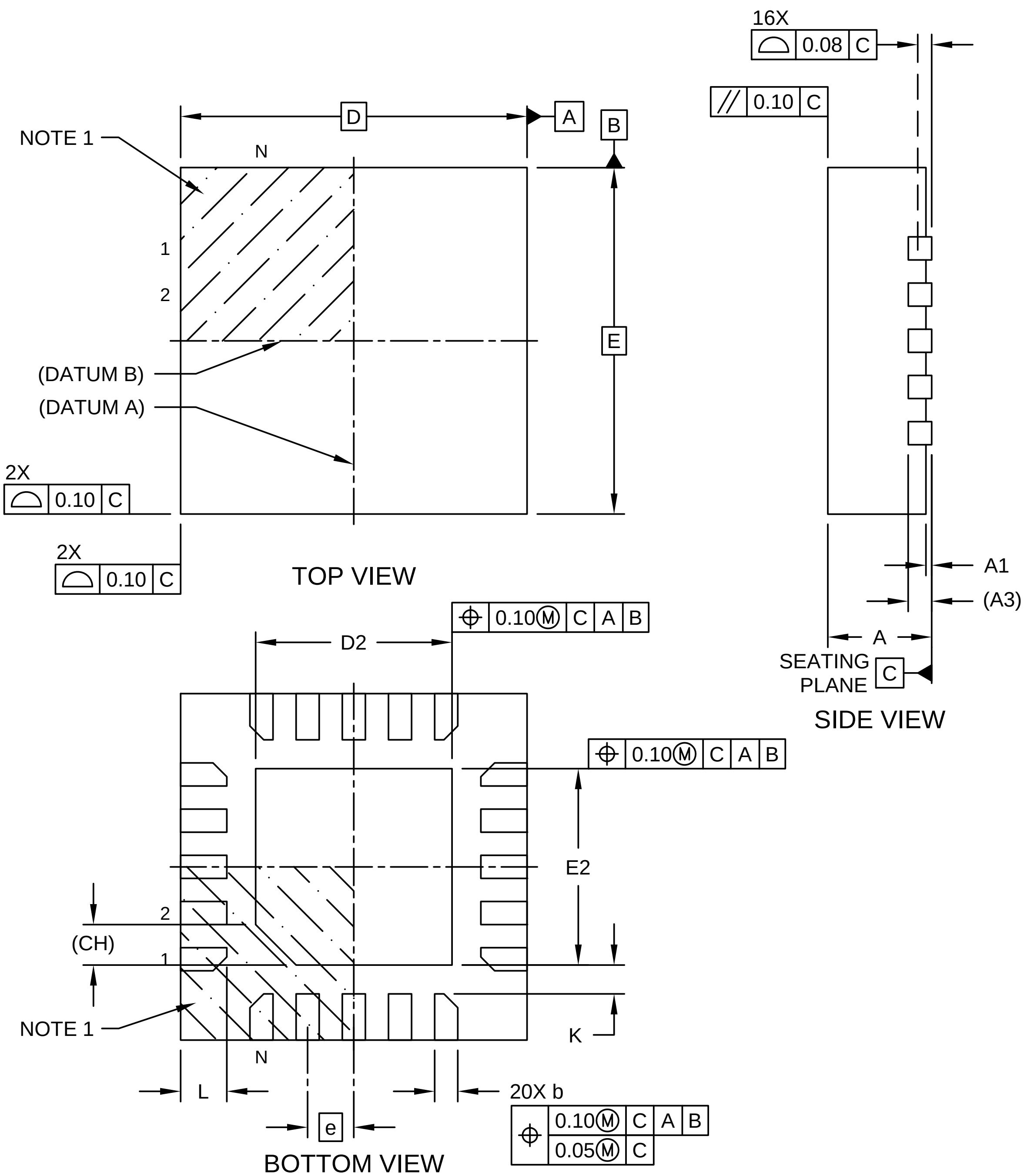
Figure 12-2. Example

13. Package Drawing

13.1. 20-Pin VQFN

20-Lead Very Thin Plastic Quad Flat, No Lead Package (REB) - 3x3 mm Body [VQFN] With 1.7 mm Exposed Pad; Atmel Legacy Global Package Code ZCL

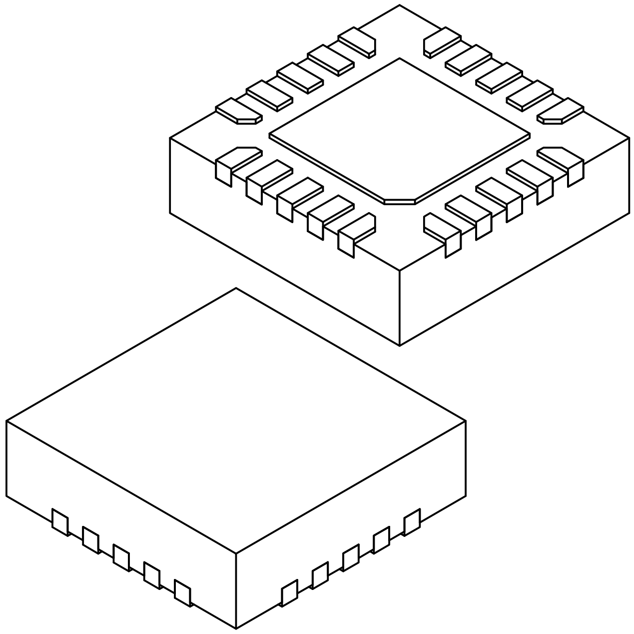
Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Microchip Technology Drawing C04-21380 Rev A Sheet 1 of 2

20-Lead Very Thin Plastic Quad Flat, No Lead Package (REB) - 3x3 mm Body [VQFN] With 1.7 mm Exposed Pad; Atmel Legacy Global Package Code ZCL

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



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Terminals	N		20	
Pitch	e		0.40 BSC	
Overall Height	A	0.80	0.85	0.90
Standoff	A1	0.00	0.035	0.05
Terminal Thickness	A3		0.203 REF	
Overall Length	D		3.00 BSC	
Exposed Pad Length	D2	1.60	1.70	1.80
Overall Width	E		3.00 BSC	
Exposed Pad Width	E2	1.60	1.70	1.80
Terminal Width	b	0.15	0.20	0.25
Terminal Length	L	0.35	0.40	0.45
Terminal-to-Exposed-Pad	K	0.20	-	-
Pin 1 Index Chamfer	CH		0.35 REF	

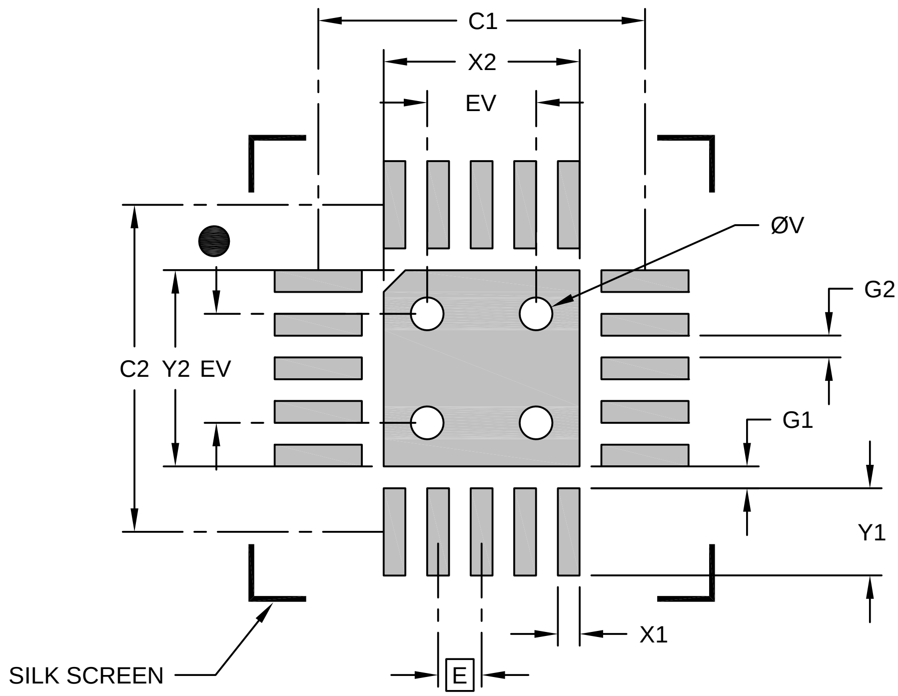
Notes:

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 C04-21380 Rev A Sheet 2 of 2

20-Lead Very Thin Plastic Quad Flat, No Lead Package (REB) - 3x3 mm Body [VQFN] With 1.7 mm Exposed Pad; Atmel Legacy Global Package Code ZCL

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



RECOMMENDED LAND PATTERN

	Units	MILLIMETERS		
	Dimension Limits	MIN	NOM	MAX
Contact Pitch	E		0.40 BSC	
Optional Center Pad Width	X2			1.80
Optional Center Pad Length	Y2			1.80
Contact Pad Spacing	C1		3.00	
Contact Pad Spacing	C2		3.00	
Contact Pad Width (X20)	X1			0.20
Contact Pad Length (X20)	Y1			0.80
Contact Pad to Center Pad (X20)	G1	0.20		
Contact Pad to Contact Pad (X16)	G2	0.20		
Thermal Via Diameter	V		0.30	
Thermal Via Pitch	EV		1.00	

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.
2. For best soldering results, thermal vias, if used, should be filled or tented to avoid solder loss during reflow process

Microchip Technology Drawing C04-23380 Rev A

14. Appendix

14.1. Static Input Voltage

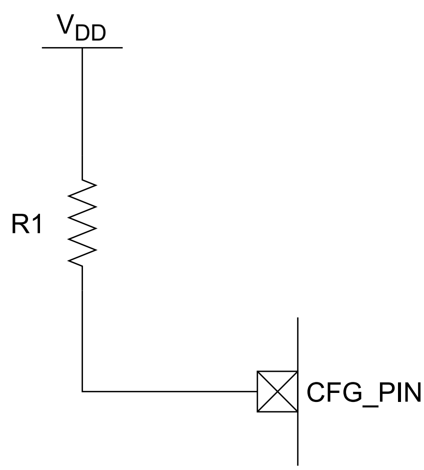
These methods will configure the MTCH9010 liquid detector to provide a fixed behavior at power-up and run time.

14.1.1. Direct Connection

For digital input configuration pins, the available settings are to connect it either to V_{DD} or GND.

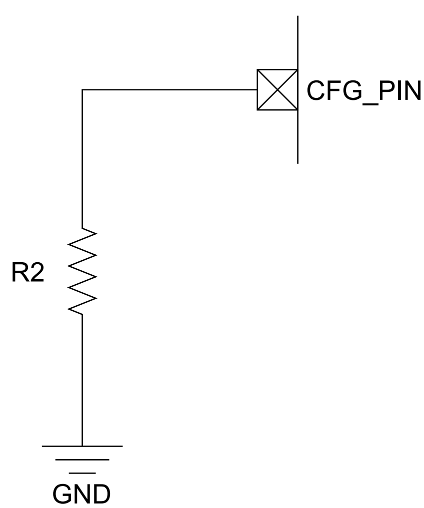
The following configuration shows an example of how to connect a configuration pin to V_{DD}:

Figure 14-1. Direct Connection to V_{DD}



The following configuration presents an example of how to connect a configuration pin to GND:

Figure 14-2. Direct Connection to GND

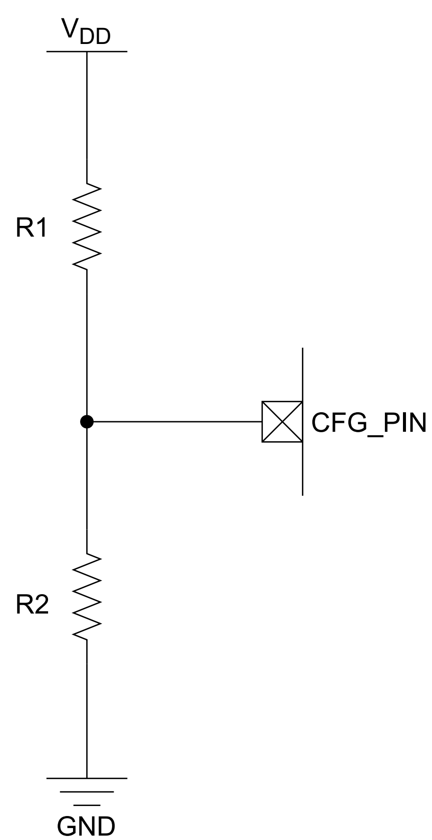


Important: The pull-up and pull-down resistors are a precautionary recommendation, as the MTCH9010 liquid detector device will not pull the CFG_PIN to either V_{DD} or GND during operation. In this case, the typical value used for the pull-up and pull-down resistors is 1 kΩ.

14.1.2. Resistor Ladder

This configuration represents a solution for the scenario where multiple fixed values of analog voltages are required to set a given configuration option. An example of this case is selecting the Sleep period.

Figure 14-3. Resistor Ladder



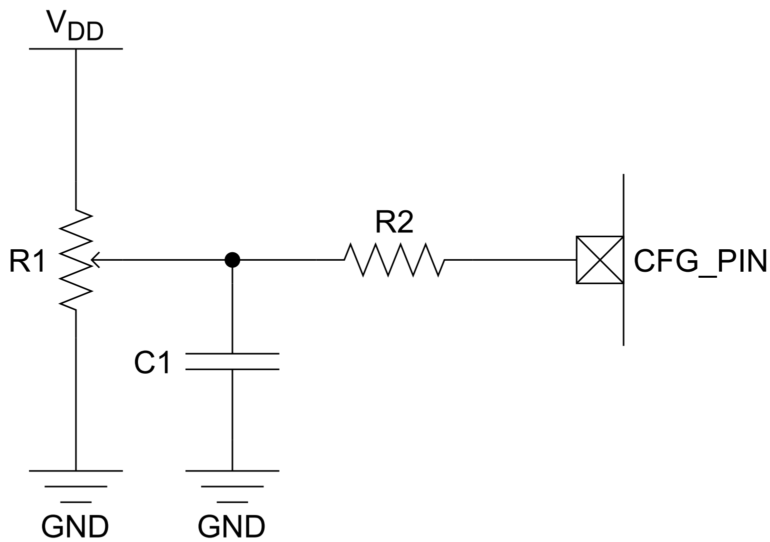
Important: It is recommended to select values for the R1 and R2 resistors that exceed 100 kΩ to reduce power consumption.

14.2. Dynamic Input Voltage

14.2.1. Potentiometer

This configuration provides a convenient method of changing an analog voltage level.

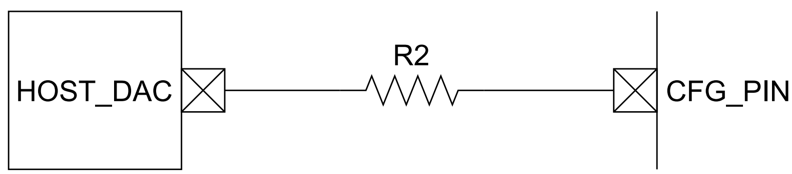
Figure 14-4. Potentiometer



14.2.2. DAC Controlled by Host

This is a suitable solution for the scenario where a setting must be changed dynamically during device run time.

Figure 14-5. DAC Controlled by Host

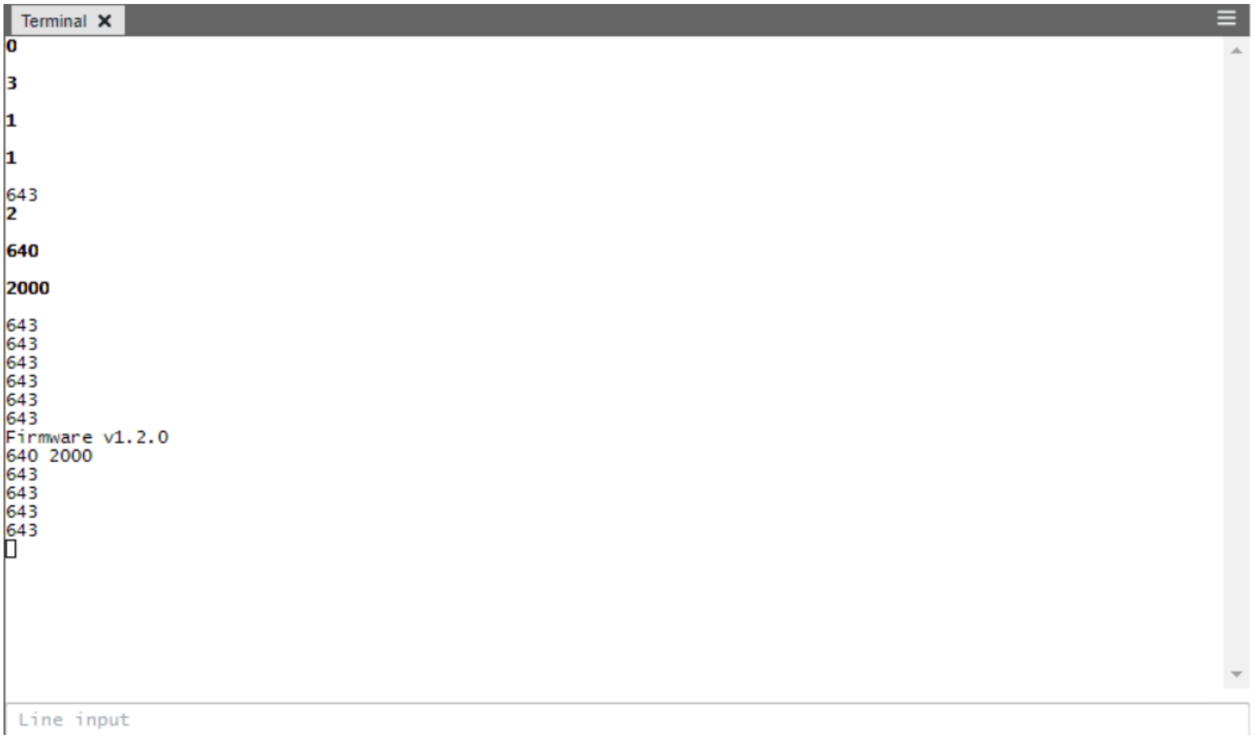


14.3. Enhanced Configuration with Manual Input of Parameters Example

Below is an enhanced configuration example using the MPLAB Data Visualizer terminal. In this example, the parameters are configured in the following way:

- Operation Mode: Capacitive (option `0`)
- Sleep time: Four seconds (option `3`)
- Extended output mode: Serial data enabled (option `1`)
- Extended output format: Standard measurement only (option `1`)
- Confirm the reference value provided (option `0`)
- Provide the threshold value: `2000`

Figure 14-6. Enhanced Configuration with Manual Input of Parameters Example



14.4. Enhanced Configuration Script Example

Below is a PowerShell®-compatible script example for an Enhanced Configuration. The following parameters are set in this example:

- COM30 port used
- Operation Mode: Capacitive (option `0`)
- Sleep time: Two seconds (option `2`)
- Extended output mode: Serial data enabled (option `1`)
- Extended output format: Standard measurement and delta (option `2`)
- Confirm the reference value provided (option `0`)
- Provide the threshold value: `500`

```
$port = New-Object System.IO.Ports.SerialPort COM30, 38400, None, 8, 1
$port.Open()
function Send-SerialData($data){
    $port.WriteLine($data)
    $port.WriteLine("`r")
    Write-Host "$data`r"
    Start-Sleep -Milliseconds 500
}
Write-Host "Waiting for reset. Please apply a reset!"
do {
    $data = $port.ReadLine().Trim()
}while ($data -ne "Firmware v1.2.1")

Write-Host "Reset received."
Write-Host "$data"
Write-Host "Sending configuration"
Write-Host "Operation Mode:"
Send-SerialData 0
Write-Host "Sleep Time: "
Send-SerialData 2
Write-Host "Extended Output Mode: "
```

```
Send-SerialData 1
Write-Host "Extended Output Format: "
Send-SerialData 2
Write-Host "Confirm Reference Value: "
Send-SerialData 0
Write-Host "Detection Threshold: "
Send-SerialData 500
Write-Host "Configuration done"

$port.Close()
```

15. Revision History

Revision	Date	Description
A	04/2025	Initial document release

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