

# MN5010HS

## Design Guidelines

### 1. Introduction

This document contains important technical information, design notes and helpful hints to assist the designer in achieving first time success in bringing up a design using the MN5010HS GPS Receiver module. It contains design examples and suggestions on a wide variety of topics, including power supply connections and bypassing, RF interface design, shielding and filtering requirements, antenna considerations and other important subjects.

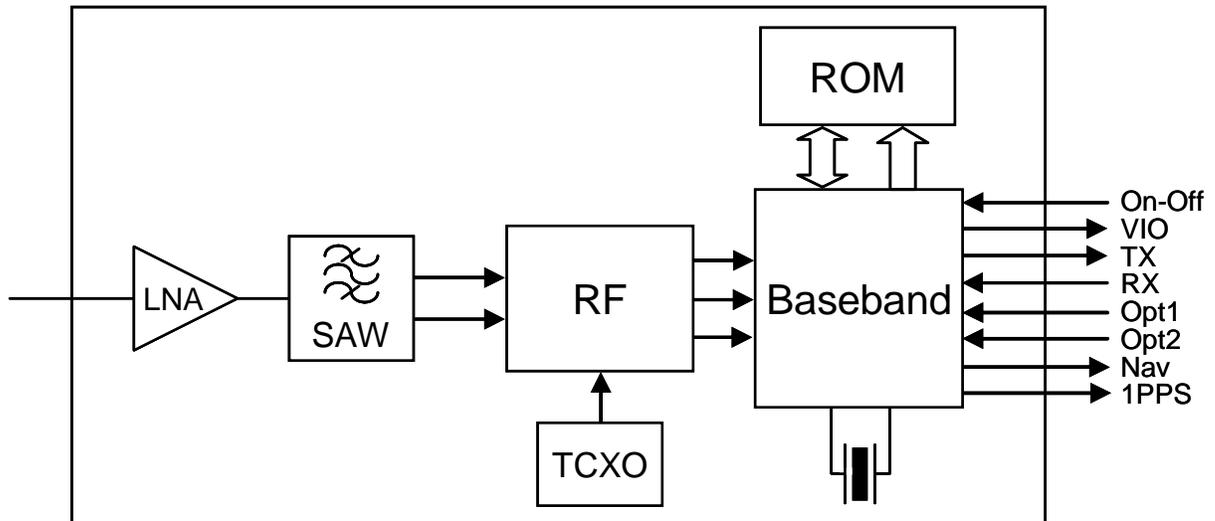


Figure 1 - MN5010HS Block Diagram

### 2. Power Supply & Reset

The MN5010HS GPS Receiver Module is designed to operate directly from a battery with a supply range of 3.25 volts DC minimum to 5.5 volts DC maximum, such as a standard Lithium Ion battery pack or a three-pack of Nickel Metal Hydride batteries. The battery voltage should always be present in order to keep the internal RTC clock and SRAM alive, even when the receiver is in hibernate mode.

#### 2.1. On-Off Control

Power is controlled via Pin 22, the ON-OFF signal pin of the MN5010HS. The On-Off control signal is a 1.8 volt I/O signal. If this line is left floating or tied to ground, the receiver will power up whenever battery voltage is applied and run continuously. Although the battery line can be switched off to power down the receiver, data stored in the receiver will be lost, with the following results:

- Internal TCXO calibration data is lost, lengthening the time for a cold start.
- Current ephemeris data is lost, requiring download of the latest ephemeris data.
- The current time is lost, eliminating the possibility of a hot start or warm start.
- The current location is lost, eliminating the possibility of a warm start.
- Any user commanded configuration options (such as port speed and protocol) are lost and the receiver will default to the configuration as defined by the OPT1 and OPT2 pins.
- Current almanac data is lost and the receiver will revert to the factory almanac..
- Patch RAM contents (if used) are lost and will require a new download.

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To place the receiver into hibernate state (all internal power supplies other than RTC/SRAM off) from the full power operate state, pulse the On-Off control high for a minimum of 1 millisecond. To return the receiver to full power operate state from the hibernate state, pulse the On-Off control high for a minimum of 1 millisecond. The Power On-Off pulse must not occur more than once per second.

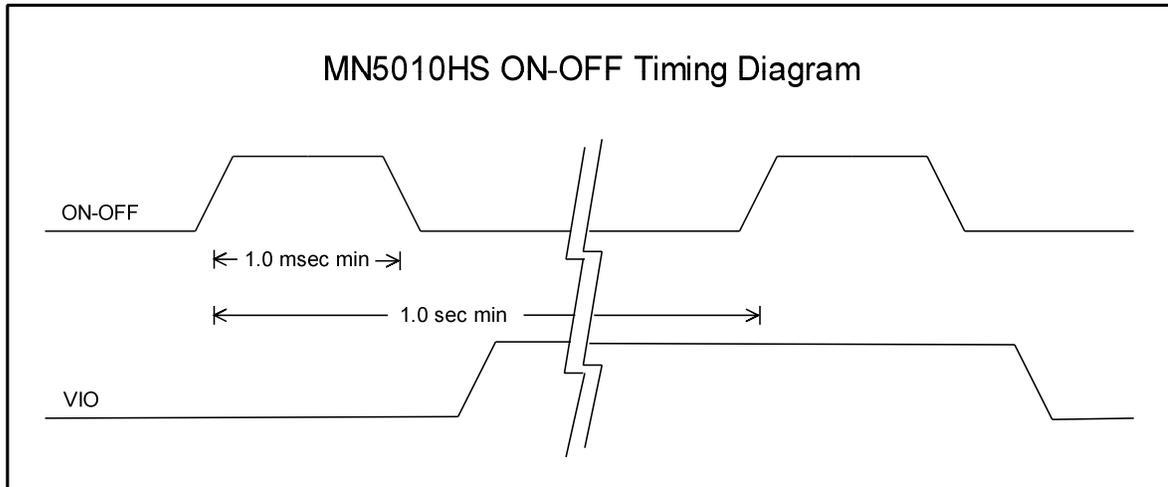


Figure 2 - ON-OFF Signal Timing

If the receiver is operating in one of the power management modes (adaptive trickle power mode or push-to-fix mode), use the software commands to return the receiver to full power operating mode before sending the On-Off pulse. Sending an On-Off pulse during ATP or PTF power modes could result in an undetermined power state.

The current powered state of the receiver can be determined by the state of the VIO pin.

Do not apply an On-Off pulse to the MN5010HS if the main battery supply is not present.

The internal ON-OFF signal is a 1.2 volt logic level. A series resistor of 2.7K and a shunt resistor to ground of 4.7K to the internal ON-OFF node reduces the 1.8 volt external logic level to this 1.2 volt internal logic level. This network must be taken into account if designing a resistive divider network to interface the 1.8 volt logic level ON-OFF signal to a 3 volt I/O controller, for example.

### 2.2. VIO Pin

VIO is the output of the internal 1.8 volt I/O regulator. If VIO is approximately 1.8 volts, then the MN5010HS is in an active power state. If VIO is approximately 0 volts, then the MN5010HS is in hibernate state.

VIO can be used to provide power to an external buffer which would drive the MN5010HS RX line. Select a buffer that powers down with high impedance inputs and outputs thereby eliminating the possibility of back-driving the MN5010HS through the TX line.

VIO can supply no more than 5mA.

Under no circumstances should this line be driven by any source.

### 2.3. Reset Circuit Requirements – nMR Pin

The MN5010HS does not require any reset circuit for proper operation. If an external reset is desired, the nMR signal at pin 23 may be pulled low through either an open collector or open drain transistor or integrated circuit. Do not connect this line to either a pull-up resistor or a device that can

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drive the nMR line high. The nMR line is a connection into an open collector bus with 1.2 volt logic levels. Driving this line high, or pulling it high to a voltage greater than 1.2 volts can permanently damage the device. The nMR line must be held low a minimum of 30msec for the reset to be properly recognized.

Holding the nMR line low does not place the receiver into a low power state and should not be used for this purpose.

Pulling the nMR line low and releasing it will restart the receiver, and take it out of hibernation unless the OPT1 and OPT2 signals specify configuration 1,0 (which starts in the hibernate state).

### 3. Default Configuration

The MN5010HS OPT1 and OPT2 input pins change the default behavior of the receiver upon startup (either power-on or reset). Note that these signals do not have internal pull-up or pull-down resistors. It is important to either pull up the input to 1.8 volts or pull it down to ground and not leave the lines floating.

OPT1	OPT2	Description
0	0	<ul style="list-style-type: none"><li>• NMEA 4800 bps, {GGA, GSA, GSV(5 sec), RMC, VTG},</li><li>• SBAS Off, Static Filter Off, Internal DR Off,</li><li>• Extended Ephemeris is not available.</li></ul>
0	1	SiRF Binary 57600 bps
1	0	<ul style="list-style-type: none"><li>• NMEA 57600 bps, {GGA, GSA, GSV, RMC, VTG, EE SiRF Proprietary}</li><li>• SBAS On, Static Filter On, Internal DR On (15 second timeout),</li><li>• Extended Ephemeris is available.</li></ul> Note - the receiver powers up in hibernate state for this configuration.
1	1	Reserved

Table 1 - OPT Pin Description

### 4. Serial Data Lines

#### 4.1. TX Data Line

The TX data line outputs serial data from the MN5010HS receiver to the host. This signal is a 1.8 volt CMOS I/O logic level with the idle condition being logic high.

During hibernation, the TX data line will be at 0 volts. The user is cautioned to ensure that any downstream processing of this signal can tolerate a 0 volt condition (BREAK condition) whenever the MN5010HS is in hibernate state. If necessary, the VIO line may be monitored to determine if the receiver is in hibernate state.

#### 4.2. RX Data Line

The RX data line inputs serial data and commands from the host to the MN5010HS receiver. This signal is a 1.8 volt CMOS I/O logic level with the idle condition being logic high.

During hibernation and when power to the MN5010HS is not present, take care not to drive this line high (the normal default idle state of this signal) to prevent partially powering the MN5010HS by backdriving the ESD diode protection circuitry. Use the VIO signal to determine whether or not it is safe to drive this line.

During idle condition, do not hold this line low while the receiver is active.

If command/data input is not needed, this pin can be connected to VIO through a 10 KΩ resistor.

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### 5. Navigation Indication Pin

Pin 20 of the MN5010HS is the NAV pin, and outputs a signal that pulses high for 100 milliseconds every second whenever the MN5010HS is in navigation. When the receiver drops out of navigation, the NAV signal is continuously low. This signal is a 1.8 volt CMOS I/O logic level.

### 6. 1PPS Pin

The 1PPS signal is available on pin 9, and pulses high for 1 microsecond at a 1 Hz rate. It is valid during 3D navigation. The 1PPS signal can vary by up to 200 nanoseconds and trails the UTC 1 second epoch by 450 nanoseconds.

### 7. Reserved Pin

Pin 4 of the MN5010HS is reserved for factory use. It must be grounded, preferably through a zero  $\Omega$  resistor.

### 8. RF Interface

#### 8.1. RF Input

The MN5010HS GPS Receiver Module accepts a standard L1 GPS C/A code signal (from a passive or active antenna) on the RF Input pad of the module. If a passive antenna is desired, no additional circuitry is required.

#### 8.2. Passive Antenna

A passive antenna can be directly connected to the ANT input of the MN5010HS. Assuming the antenna is well tuned for the ground plane it would sit on and any plastics that would enclose it, matching of the antenna to the MN5010HS would not be required. However, good practice suggests that footprints for a PI matching network would be prudent if space permits.

The ANT input to the MN5010HS directly feeds an LNA. If high levels of RF interference are expected in the end product, the addition of a pre-select SAW or ceramic filter may be required to provide good performance.

The rejection characteristics of the pre-select filter can be determined by measuring the out of band signal levels and using the values from the jamming curve of the MN5010HS as shown in the data sheet.

#### 8.3. Active Antenna

If an active antenna is required, then suitable means for powering the active antenna must be provided external to the MN5010HS GPS Receiver Module. The RF input is isolated from DC levels to a maximum of  $\pm 15$  V. In addition, depending upon the amplifier gain of the active antenna (not to be confused with antenna gain) and cable loss, an RF attenuator may need to be inserted in front of the MN5010HS to attenuate the output of the active antenna. Generally, an excess gain greater than 14 dB will need to be attenuated to bring the total gain in front of the MN5010HS down to 14 dB. Operating with higher gain is possible, but may result in somewhat degraded performance in interference rejection.

If tolerance to high levels of RF interference is required in the end product, the active antenna can be selected to have both a pre-select and post-select filter to attenuate the unwanted interference.

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### 8.4. LO Leakage

The MN5010HS has an internal LO at 1571.424MHz that can appear at the ANT pad of the device. While this level is quite low (approximately -80 dBm), it is high enough that it could interfere with another GPS receiver in the vicinity. This is not a problem in normal operation, but during test and evaluation, several receivers could be operating simultaneously from a common antenna or other signal source. In this case, care must be taken to provide proper isolation between the receivers.

### 8.5. Spurious Signals

Due to the size of the MN5010HS module and the tight IC geometries used internally, the MN5010HS does generate a fair amount of digital noise. Since this is all based upon the internal reference frequency of 16.369 MHz, it is synchronous within the receiver and does not impact receiver operation. However, some signals may interfere with external circuitry. It may be necessary to shield the GPS module and related circuitry from other receivers in the end product. If spurious emission (other than LO leakage) from the GPS antenna are an issue, then either an active antenna or a pre-select SAW filter between the ANT pad of the MN5010HS and the passive antenna can be considered.

## 9. Shielding and Filtering Requirements

The MN5010HS is designed to use a GPS signal that can be as low as -159 dBm. Any source of interference near in frequency to the GPS signal could potentially jam the MN5010HS and disrupt reception of the signal.

### 9.1. Digital Emissions

For proper system design, the GPS antenna needs to be shielded from any potential jamming source. For that reason, in most designs not containing a transmitter, it makes more sense to shield the digital portion of the product rather than the RF portion. This keeps the digital noise from radiating into the antenna and/or antenna feed lines. Generally, it is not necessary to provide additional shielding around the MN5010HS and associated circuitry.

It is important to note the GPS signal level is well below any regulatory emissions requirement for EMI and EMC. Thus while a product meets FCC class B or CISPR 22, it is possible the emissions from the product will still seriously impact the MN5010HS performance.

Excessive interference into the MN5010HS via the antenna can result in low to very low reported C/Nos of the satellite signals and subsequent excessive TTFF times. Assuming an 18mm square patch antenna with good LNA, the reported C/Nos should be in the high 40s and low 50s. If the values are below this, then interference needs to be considered as a problem and resolved. This can also be checked by substituting an external active antenna and moving it closer to and away from the device and noting the change in reported C/Nos. If any improvement in signal is noted as the external antenna is moved away from the device, then additional shielding is required.

### 9.2. RF Emissions

If the product contains an RF transmitter or a second heterodyne receiver, then care must be taken to prevent overloading the front end of the MN5010HS if simultaneous operation is required. This overloading can come from several sources.

First, the input LNA of the MN5010HS does not have a preselect filter and is fairly broad band. If for example a GSM transmitter (1.8 GHz) were close by, then the GSM signal could overload the LNA. The output of the LNA is going to be proportional to its input, and if the GSM signal so dominates, the GPS signal would be attenuated and sensitivity of the receiver would be reduced. The OEM designer would need to design suitable input filtering to the MN5010HS to protect in this case.

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A second case occurs in the collocated transmitter. The power amplifier has both a gain and a noise figure. If we take an example of a power amp noise figure of 15 dB and 30 dB of gain, this would mean that the power amp radiates broadband noise approximately 45 dB above thermal noise. This means the power amp alone could present a noise source in the GPS band of -129 dBm. While this would easily meet any regulatory emissions requirements, it would render the GPS receiver inoperative. In this case, a suitable filter must be placed on the output of the power amplifier of the collocated transmitter, not the GPS receiver, to avoid this case.

### 10. GPS Antenna Selection

Currently, there are several types of GPS antennas available for the user to choose from. Each type of antenna has both advantages and disadvantages which need to be carefully weighed in making a selection. In addition, most antenna types are available in both an active version (which includes a built in LNA) and passive version.

When selecting the antenna it is important both to consider the characteristics of the GPS signal itself and the characteristics of the antenna. The GPS signal is broadcast at 1.57542GHz and comes from each of the visible GPS satellites. The receiver needs a minimum of four signals to compute a 3D position. Ideally, the antenna should have an unrestricted view of the sky. Certain locations may limit the visibility of the sky such as being close to a building, etc, so it is important that the product in which the antenna is installed does not further reduce satellite visibility.

The GPS signal is also right hand circularly polarized (RHCP) so best results are achieved under most conditions with a right hand circularly polarized antenna. Under severe obscuration where multipath signal reflections are present, a linearly polarized antenna may give better results under the assumption that a reflected signal is better than no signal.

Antennas are specified by antenna type, antenna gain, antenna pattern, polarization and axial ratio. Antenna gain is the ratio of the signal level received by the antenna under consideration at zenith as compared to a theoretical isotropic radiator (equal signal level in all directions). The gain is measured in dBi (for a linearly polarized antenna) or dBic (for a circularly polarized antenna). The gain of an antenna will vary depending upon elevation and azimuth of the signal source with respect to the antenna. Graphically plotting this variation results in an antenna pattern. The axial ratio of an antenna is a measure of the quality of its polarization. An axial ratio of 1 is perfect circular polarization, an infinite axial ratio in perfectly linear polarization.

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### 10.1. Patch Antennas

Patch antennas are typically square or round ceramic elements with metallic plating on both sides, the top being the antenna element and the bottom being the ground plane.

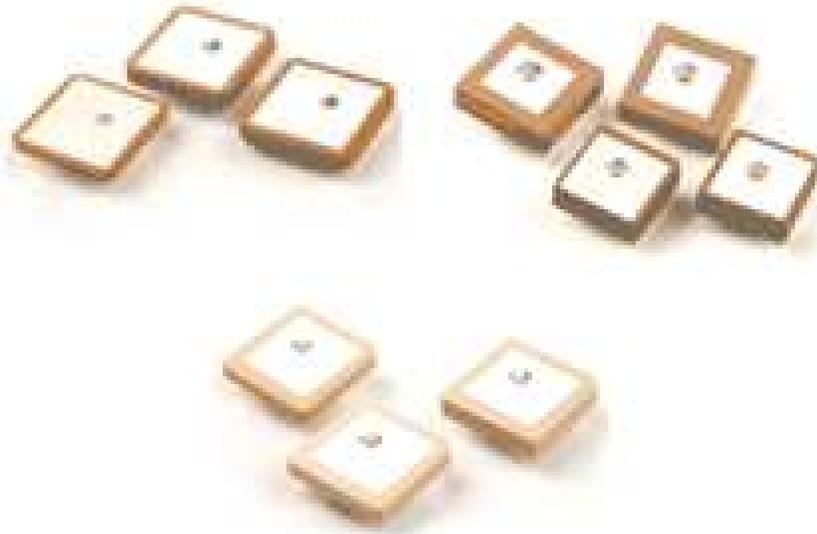


Figure 3 – Typical patch antennas

If a patch antenna is selected, it is important that it be oriented such that the top surface of the antenna is horizontal with respect to the surface of the earth. Tilting the antenna away from the horizontal will result in an artificial obscuration of potentially visible satellites.

While patch antennas are low cost and can provide good gain, it is important that they be used with a proper ground plane. The antenna vendor can provide assistance in this area. In addition, a patch antenna is detuned by the presence of anything within its near field, such as a plastic cover. The antenna vendor can tune the antenna to compensate for this detuning.

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### 10.2. Helix Antennas

Helix antennas are usually spirally wound onto a tubular ceramic piece (see Figure 4). For best performance, the helix antenna needs to be vertical with respect to the surface of the earth. Helix antennas do not require a ground plane, but may work better with one.



Figure 4 – Sarantel helix antenna (cover removed)

### 10.3. Chip Antennas

Chip antennas are the smallest type available for GPS and are quite popular in small handhelds. However, chip antennas are linearly polarized making them more receptive to multipath signals which would degrade the accuracy of the computed position in some cases. Chip antennas also have very specific ground plane requirements. The antenna vendor can provide assistance in this area and can possibly tune the chip for a specific application.

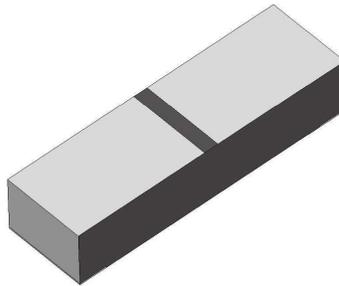


Figure 5 – Chip Antenna

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### 11. Notices

All reference and informational documents (including marketing information, specifications, reference designs, etc.) are provided for information only and are subject to change without notice. Reasonable efforts have been made in the preparation of these documents to assure their accuracy, however Micro Modular Technologies Pte. Ltd. assumes no liability resulting from errors or omissions in this, or any document, or from the use of the information contained herein. Micro Modular Technologies Pte. Ltd. reserves the right to make changes in the product design and specifications as needed and without notification to its users. Please check our website for the most current documentation. All information contained herein is the property of Micro Modular Technologies Pte Ltd. and may not be copied or reproduced, other than for your information, without prior written consent.

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