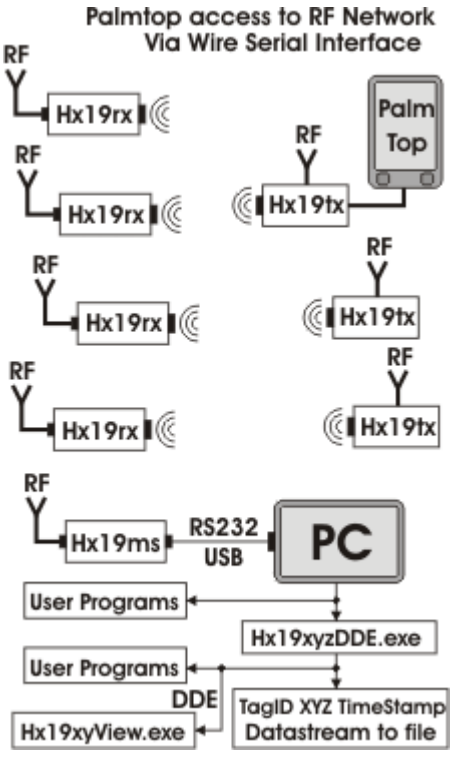
FEATURES

- Device to device range up to 14 meters (monotone only)
- Absolute accuracy better than 9mm
- Wireless networking for thousands of SQM coverage
- USID (Ultrasonic Id) up to 1023 unique identities
- RFID (Radio Frequency Id) no limit on unique identities
- Combination mode USID and RFID
- Receiver and transmitters both battery operated
- USB and Serial Interface for PC or readout programming
- Every possible ultrasonic positioning contingency with only three types of components
- Useful for high-speed small applications to high-speed coverage of very wide area

Wireless HX19 Introduction

The HX19 is designed to operate using wireless network. Both ultrasonic receivers and transmitters are linked to the controlling computer through a 2.4Ghz 250Kbaud wireless network. This system is a combines USID (ultrasonic ID) and RFID (radio frequency ID). A radio frequency signal is used to synchronize the whole network to within a microsecond. Immediately following reception of the synchronization signal the transmitter emits either a monotone sonic signal or ultrasonic ID depending on user configuration. The receivers report the time elapsed from synchronization until reception of the monotone or USID (ultrasonic ID). Hence absolute distance can be computed from the transmitter to every receiver detecting the sonic signal. The HX19 is useful for both absolute and TDOA (time difference of arrival) positioning.



Users have access to the hx19 network through a port pin on the ultrasonic positioning tag as well as through a USB interface on a computer. I.e. the coordinates of the tag can be computed externally (using a PC), and transmitted back via RF to the moving object to which the tag may be attached. The same is true for potential control codes for the moving object from the external PC.

The Hx19 system can operate asynchronously as well. RFID and USID can be harnessed by the programmer in combination for very reliable fail-safe positioning of people and objects. Here the RFID can be used for omni-directional non-line of sight localization through walls, while the USID stays within the walls giving the specific location of the signal as it bounces around inside the confine.

HX19TXHWE
Access to the RF network through the brown wire

HX19TX
Ultrasonic RF battery tag

HX19RX
Ultrasonic RF receiver

HX19MS USB monitor Synchronizer

The Hx19tx USID RFID tag

Powered by a readily available long life lithium battery, the hx19tx once a battery is inserted into the battery holder will enter its idle mode. In idle mode the Hx19tx by default emits USID (ultrasonic ID) and RFID (radio frequency ID) at the rate of once every 4 seconds. Every time the unit transmits its identification USID/RFID, it by default flashes a blue LED visible via the translucent blue box (this LED can be shut down using RF link). During this activity cycle, it also monitors for radio frequency communication. If no such communication is detected the device goes to sleep to reserve battery power. During idle mode this continuous activity cycle is asynchronous, or essentially random. If a synchronization RF signal is detected during the activity cycle, the device does not go back to sleep. Here the activity cycle is executed in synchronization with the external radio signal. Latency of the synchronous activity is around a microsecond. When synchronized the activation cycle is initiated 20 times per second, and the LED if enabled will be blinking rapidly. A Hx19ms monitor and synchronizer (see below) connected to a USB port on a computer device, can be used to synchronize and monitor the hx19 network. It is also used to send control parameters to the hx19tx.

HX19TX SIZE: 35 x 35 x 15 mm

During the synchronized activity cycle, the user can modify the control parameters of the hx19tx using the hx19ms connected to a USB port at a rate of 250k baud up to 25 meters. Hx19 devices scan for the mode and parameter control characters in the serial stream. Small alphabetic letters are considered commands, and are sometimes followed by a numeric control value. The alphabetic letters t and g are interpreted as addressing codes, i.e. t means attention all tags and g means attention all devices (including tags). Following is a simple string transmitted from a hx19ms (monitor synchronizer) within 25 meters of a hx19tx.

Control Parameters:

Parameters including the mode byte can be modified while the hx19tx is in synchronous mode. These parameters remain unchanged until either re-modified, or the battery is removed from the holder for more than 5 seconds. To ensure the parameters remain unchanged when the battery is removed these must be stored on the hx19tx EEPROM.

Tag Commands Summery

These following commands dictate the behavior of the hx19tx ultrasonic RF tags. The # means decimal numeric characters need to follow the command.

t:	Addresses all tags
g:	Addresses all devices, including tags
T#&:	Addresses a specific tag where # is the tags specific ID.
m#:	Mode # is a decimal value setting and clearing the mode bits
d#:	Downtime # is a decimal value controlling the sleep duration
e:	The device stores current parameters on EEPROM
h:	The device essentially shuts of extending battery life for years
i#:	Period of the monotone ultrasonic burst
n#:	Number of periods or length of the burst
q#:	Sequence designation, used to avoid overruns during intense positioning
o#:	Sequence designation group size
s:	Single shot, ultrasonic signal is emitted immediately following this character
p#:	RF transmission power, used to control the range bubble
c#:	Used to select one of 127 bi-directional RF channels
w:	Forces the hx19tx to transmit content of its work parameters
=:	Prepares the hx19tx to receive control commands

Addressing sequence is t= or g= string following these addressing commands are interpreted as configuration commands. See further details below.

Mode bits:

Bit.0 Set:	The LED is on during the activity cycle
Bit.1 Set:	USID or ultrasonic ID is emitted during the activity cycle
Bit.2 Set:	RFID or radio frequency ID is emitted during the activity cycle
Bit.3 Set:	Ultrasonic monotone enabled

The following shows some useful syntax examples:

Syntax example:

t=m2 d1 e

In this case all tags within range of the hx19m will stop flashing the blue LED during emission. They will stop emitting RFID, and they will stay asleep for only 0.25 seconds. Finally the configuration is permanently stored on EEPROM.

Another example: g=e

All devices receivers and repeaters will store current control parameters on EEPROM.

Given that the identification written on the back of the tag is 13 then the command string emitted from a hx19ms:

T13&=m2 d1 e

This is how a string can be sent to a selected unit, only device with the numeric 13 written on the back will be configured. Once the data has been processed the tag will broadcast an acknowledgement via radio [T13#CR] CR is carriage return ASCII code (13).

Mode control:

The mode control is bit manipulated, the user must set the bits of the control byte high or low to control the features or operational mode of the hx19tx. Following is a description of what the bits do.

Bit.0 Set: The LED is on during the activity cycle
Bit.1 Set: USID or ultrasonic ID is emitted during the activity cycle
Bit.2 Set: RFID or radio frequency ID is emitted during the activity cycle
Bit.3 Set: Ultrasonic monotone enabled

Downtime [d#] (# default 6)

If the hx19tx tag finds the command d in the configuration string from the hx19ms (see below), then it will use the first numeric value it finds to set the downtime. This parameter controls how long the device stays at sleep. The following table shows the time durations available. If the [h] command is used to shut down the hx19tx, downtime is multiplied by eight; until re-synchronization

Value # following d	1	2	3	4	5	6
Sleep duration (Seconds)	0.25	0.5	1	2	4	8

T13&=d4 this string sets the down time for tag 13 to 2 seconds. Note that the hx19tx at random cuts the sleep time in half to avoid overruns, hence if sleep duration is set at 8 seconds then the device randomly executes 4 or 8 second sleep time.

EEPROM save [e]

If the hx19tx finds the command e in the setup string, the current parameters under which the device is operating are stored on EEPROM; and will be restored in case the tag looses power.

Shutdown [h]

When the command h is found in the setup string, the hx19tx tag immediately shuts down. The tag will wake up and go through the activity cycle; if no radio communication is detected it will go back to sleep.

t=m0 h This string addresses tags, it will shut off the LED, USID, RFID and eightfold the sleep time of all tags.

Period [i#] (# default 49)

The value that follows the command i, sets the period of the monotone ultrasonic signal burst **(bit.3 of the mode value must be set high).** Application of the monotone can increase the ultrasonic distance measurement range for the tag significantly. Angular detection is also increased. But the ability to identify the signaling device is lost. Other means of identification such as time sequencing using commands q and o, can be applied in case long range is required.

Number of Periods [n#] (# default 30)

This command controls the duration of the ultrasonic signal burst, and the value that follows n is the total number of periods that are emitted.

T13=m14 i49 n100

The string above will set the monotone bit, shut off the LED, and since the i-value is 49 the hx19tx will transmit 100 periods at 40khz (25µS each) to the ultrasonic sensor. The duration of the burst is therefore 2.5mS.

Frequency = 4Mhz / [2 x (i-value +1)]

Sequencer [q#] (# default 1)

The sequencer q works in conjunction with group size control o. Given that the device emits 20 times per second, or at 50mS intervals, then q7 o9 means that the device has the designation 7 of 9. The cycle is repeated every 450mS, and the device emits during the 7th cycle, i.e. 350mS from the start sync, (see command character s). If the sequence is q1 o1 then the cycle is 50mS and the device emits during every cycle.

Sequencer group size [o#] (# default 1)

See explanation above

Single Shot command [s]

This command clears the sequencer and should be used as the start signal to all tags using the command string t=s once the sequencing has been set for each device. I.e. each tag can be given it's designation through private addressing e.g. [T4&=q3 followed by t=o4 s]. The s command can also be used to initiate a single shot, in this case set the sequencer out of the group like. t=q0 o1, or t=q10 o5, then use t=s to single shoot.

Radio Power Level [p#] (# default 2)

The numeric value following the command p, dictates the power used to transmit the RFID, and therefore the range of the RF bubble. Power levels are shown in the following table.

Value # following p	0	1	2	3
Radio transmission power	-20dBm	-10dBm	-5dBm	0dBm

Radio Channel [c#] (# default 2)

The hx19tx can transmit and receive using up to 127 RF channels around 2.4Ghz; any channel from 1 through 127 can be selected using the c command as follows.

Example: t=p3 c101 e

The string above will set all transmitters to receive and transmit at maximum power using bi-directional channel 101. This setup will be stored on EEPROM and reloaded in case the tag loses power.

Work parameters [w]

The configuration data used for the current operation is transmitted through the serial port pin. I.e. the parameters that have just been configured or the device is using are made available.

Serial I/O

A port pin can be used to receive broadcast, this makes the hx19tx useful for control or communications with a free moving object. The baud rate of the communication is 250kbaud. If the **equal sign is omitted** from the strings as shown above, the information becomes available on the port pin. The port pin is always in the state of high-Z or high impedance when not transmitting.

Example:

Connect the hx19tx device 13 port pin to a serial-usb adaptor, or RS232 port pin that is connected to a free moving laptop USB. And type “T13& This is a test”. A terminal program is shipped with the units and the program if running on the laptop will display “ This is a test”. Similarly, what ever is typed on that laptop can be addressed to another hx19tx connected to a different laptop. By typing “t this is a test” every hx19tx receiving the broadcast, will send this string through its hard-wired serial pin. Low power battery tags can be used to relay data from laptop to laptop via the hx19 RF network at 250kbaud so long as there is a [t] prefix.

The Hx19rx the receiver

The hx19rx receiver can operate in two basic modes, continuous mode and low power battery mode.

Continuous mode (bit.1 set)

In continuous active mode the hx19rx is always alert, any tag within radio frequency range is processed. Current consumption in this mode, is under 4mA at full synchronous sampling rate of 20 samples per second.

Battery mode (bit.1 clear)

In this mode, the hx19rx goes to sleep to preserve battery if no synchronizing RF activity is detected. It wakes up periodically to look for RF activity. If a synchronizing RF signal is found it enters active mode, and remains there until the RF sync is no longer detected.

HX19RX SIZE: 40 x 80 x 20 mm

The Hx19rx output string.

In active mode the Hx19rx, waits for the reception of either RFID or a special RF synchronization signal. Upon arrival of the RF signal it clears its timer and initiates a stopwatch. It logs the time of arrival of the first ultrasonic wave front, and prefixes time of flight with the character A. Then it proceeds to take a closer look at the incoming signal. If it detects an ultrasonic identity start sequence it puts the prefix B to the time of flight, and continues to stage C. In stage C the identity of the Ultrasonic Signal is extracted and stored, and the prefix C is attached to the time of flight value.

The full output format broadcasted by the Hx19rx

[RFID] [Receiver ID] [Time of sonic flight] [USID] / [checksum]

Output String Syntax: R6 T5 C68050 X5 /746

Conditions: Mode bit.2 is set

Meaning of the string shown above:

T5 is the RFID of the tag marked 5 as received by receiver R6. The USID arrived 68050 / 4 or 17012.5 microseconds after the reception of the RFID T5. In the case where mode bit.2 is set the timer of the stopwatch is always cleared and started upon the arrival of the RFID. If the mode bit is cleared then the stopwatch is cleared and started at the reception of a RF sync signal. In the above output string example mode bit.2 is set, had it been clear during the reception, T5 would not be a part of the string.

The code X5 indicates that a full USID was received, or USID confirmation was received from tag labeled 5.

The prefix C in front of 68050, means full timing process was accomplished. If an A leads the time of flight value, this means that only the first edge of arriving ultrasonic signal was detected. This could mean that the tag is out of range for USID, or the tag is in a monotone mode. In this case no [USID] X5 will be found in the string. The A label is the least reliable prefix; the signal can be any spike in the 40khz range if the environment is noisy. Prefix B is a reliable indicator that a true ultrasonic timing signal was received. The USID will not be available unless the prefix is C, but that is an absolute indicator of a tag in the range of the receiver.

Please refer to the output string example above; if the timing value has the prefix B and is accompanied by T5 (RFID 5). Then it is reasonable to assume the ultrasonic signal belonged to tag 5. Prefixes give the programmer some flexibility in case the USID isn't picked up.

T5 R6 B68065 /610

It is highly probable that the B68050 timing signal arrived from Ultrasonic tag labeled 5 although there is no X5 confirmation.

Receiver Output String example: **T5 R5 /CKSUM**

Indicates only RFID and no ultrasonic signal was received.

The function of the hx19rx can be modified using radio connection at 250baud and 2.4Ghz. This can be accomplished using the USB port of most computers; other options exist like direct serial communication using RS232 or RS485/422. Hexamite can provide a bridge between any interface types to the hx19. Most commonly, USB interface is used for the programmer's wireless control of the hx19 system.

Parameters:

Parameters can be modified while the hx19rx is in synchronous mode. Parameters remain unchanged until either re-modified or the unit looses power. To remain unchanged in the event of a power loss at start up, parameters must be stored on the hx19rx EEPROM.

Lower case alphabetic characters are recognized as commands by the hx19 system, the command may or may not have a control value referred to as #. A control value is always the first unbroken numeric characters following the command. The syntax of the control string is shown below.

Receiver Commands Summery

These following commands dictate the behavior of the hx19rx ultrasonic RF receiver, the # means decimal numeric characters need to follow the command.

r:	addresses all receivers
g:	addresses all devices, including receivers
R#&:	addresses a specific tag where # is the receiver specific ID.
m#:	mode # is a decimal value setting and clearing the mode bits
e:	the device stores current parameters on EEPROM
i#:	RF input channel.
o#:	RF output channel
p#:	RF transmission power used to control the range bubble
w:	forces the hx19rx to transmit content of its work parameters
=:	prepares the hx19rx to receive control commands

Addressing sequence is r= or g= string following these addressing commands are interpreted as configuration commands. See further details below.

Mode control:

The mode control is bit manipulated, the user must set the bits of the control byte high or low to control the features or operational mode of the hx19rx receiver. Following is a description of what the bits do.

Bit.0 Set: Disable USID scanning
Bit.1 Set: Power Savings (Low power battery mode)
Bit.2 Set: RFID scanning enabled
Bit.3 Set: First detected wave front only

Radio Power Level [p] (default 2)

The numeric value following the command p, dictates the power used to RF transmit the receiver output string. Power levels are shown in the following table. The power levels dictate the range of the receiver RF range bubble from 3 to 25 meters

Value following p	0	1	2	3
Radio transmission power	-20dBm	-10dBm	-5dBm	0dBm

Radio Channel in [i] (default 2)

This command allows the user to change the channel through which it receives broadcasts.

Example: r=i111 e

The string above will set all receivers to receive through channel 111. This setup will be stored on EEPROM and reloaded in case the receiver looses power.

Radio Channel out [o] (default 2)

This command allows the user to change the channel through which it broadcasts its result.

Example

R12345&=p0 o121 r122

The string above will set receiver 12345 to broadcast on channel 121 using minimum power, and receive through channel r122.

EEPROM save [e]

If the hx19rx finds the command e in the setup string, the current parameters under which the device is operating is stored on EEPROM, and will be restored after the device looses power.

The HX19MS monitor / synchronizer

This device is the bridge between the computer (programmer) and the hx19 positioning system. Manipulating this device is somewhat similar to the hx19rx and hx19tx. It will take commands directly from the PC through hardwired serial I/O, and apply it to itself or broadcast to the hx19 network. The hx19ms is the master synchronizer for the whole network. It monitors the broadcast from all other hx19 devices both receivers and tags, and makes it available to the programmer through the USB port.

Above on the left is a hx19ms-RS232 version. The RF communication is controlled using a RS232 or a TTL input. The version on the left connects directly to a RS232 port and is useful in case the readout or control device does not have a USB interface. Hexamite provides a visual basic program with source code to help the programmer understand the communication procedure. The hx19ms understands a few direct commands, its private address is M and following are the command codes

Synchronize command [$]

When the hx19ms receives this command character it broadcasts synchronization signals over the network. Every device enters activity cycle upon receiving the sync signal, the latency is within a microsecond.

Command codes can be broadcast through this device to the hx19 network, and the configuration of network devices can be altered on the fly.

Asynchronous command [%]

In this mode whatever other devices broadcast is repeated on the serial lines (through the serial port). Here the hx19ms acts as a passive RF receiver only.

Radio Power Level [p] (default 2)

The numeric value following the command p, controls the power used by the hx19ms to transmit to other devices on the RF network. Power levels are shown in the following table, and these indicate the radius of the RF range bubble.

Value following p	0	1	2	3
Radio transmission power	-20dBm	-10dBm	-5dBm	0dBm

Radio Channel in [i] (default 2)

This command allows the user to change the channel through which the hx19ms receives broadcasts.

Example: *M=i111 e*

The string above will set the monitor to receive via channel 111. This setup will be stored on EEPROM and reloaded in case the tag loses power.

Radio Channel out [o] (default 2)

This command allows the user to change the channel through which it broadcasts its result.

Example: *M=p0 o121 r122 e*

The string above will set network monitor to broadcast on channel 121 using minimum power, and receive through channel r122. This configuration will be stored on EEPROM and reloaded in case the unit loses power.

EEPROM save [e]

If the hx19ms finds the command e in the setup string, the current parameters under which the device is operating is stored on EEPROM, and will be restored after the device loses power.

ADDENDUM : Tag power consumption

*The Hx19tx is a low power USID/RFID tag. Maximum input voltage is 3.6Vdc and minimum input voltage is 2.5Vdc. At full operating speed of 20 emissions per second, the unit consumes about 3mA. During idle mode i.e. sleep it consumes approximately 20 micro amps. The power consumption depends on the duration of the sleep stage. As a rule of thumb, the emission lasts 13mS, during this time the unit consumes approximately 10mA. Given that there are about 50mS between samples at 20 samples/second ideally the overall current consumption is I = 13mS * 10mA / 50mS. The current consumption will be close to the calculated value.*

Using a 300mAh cell the unit should run for approx. 100 hours at full speed 20s/s. At lower sampling rates a coin cell battery will run for years. If the user remembers to shut the device off with the command character [h] while not using it, the battery will last for some additional years. When the battery is installed, a blue LED inside the box will start flashing about once every 4 seconds. Faint clicks should be heard while the LED flashes if the sensor is brought close to an ear, this means the sensor is emitting a sonic signal.

HX19TX-bat

Hx19tx-bat is a battery version, it can accept variety of 3 v coin cell lithium batteries. These are BR2320, BR2325, BR2330, BR2032, CR2320, CR2325, CR2330, and CR2032. A Philips screwdriver can be used to remove the bottom plate from the main box, the assembly must be moved out of the box to slide the battery in.

Size 35 x 35 x 15mm