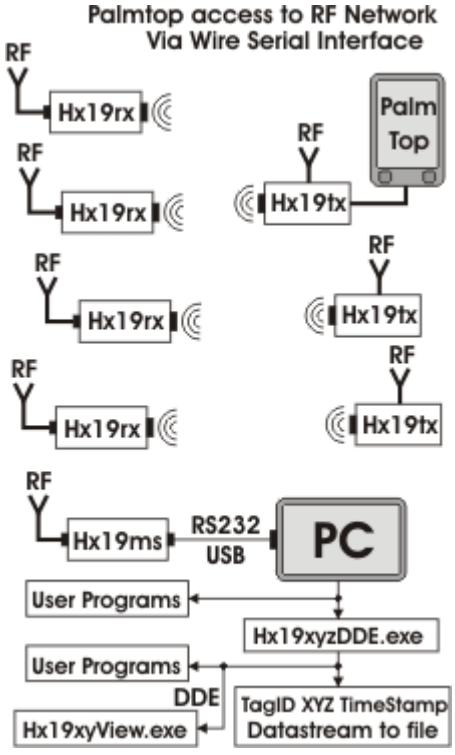
FEATURES

- Device to device range up to 14 meters (monotone only)
- Absolute accuracy better than 9mm
- Low RF power Point to Point relay networking
- USID (Ultrasonic Id) up to 1023 unique identities
- RFID (Radio Frequency Id) no limit on unique identities
- Combination mode USID and RFID
- Battery capable operation for the entire system
- USB and standard RS232C Serial Interface for PC
- Only three components and every possible positioning contingency
- Applications cover both tracking and guidance

Wireless HX19 Introduction



The HX19 is designed to satisfy every possible local positioning contingency, using ultrasound with uncertainty around the 9mm wavelength. Both ultrasonic receivers and transmitters, are linked to the controlling computer through a globally license free 2.4Ghz 250Kbaud RF network. This system combines USID (ultrasonic ID), RFID (radio frequency ID) and RF wireless network communication. Radio is used as a start signal, for synchronization latency within a microsecond. Immediately following reception of the start signal, the transmitter emits RFID and USID or a monotone sonic signal depending on user configuration. The receivers report via serial port the time elapsed from RF synchronization start, until the arrival of the monotone or USID (ultrasonic ID). Hence absolute distance can be computed from the transmitter to every receiver detecting the sonic signal. This information can be relayed back to the same transmitter the hx19ms. The HX19 is useful for both absolute, and TDOA (time difference of arrival) multilateration posi-

Users can access the RF com network using either a hx19tx transmitter/tag port pin, or a USB interface. E.g. the coordinates of the ultrasonic tag can be computed (using a PC), and the result transmitted back via RF to the moving object to which the tag may be attached.

The Hx19 is not only a synchronized system, it can operate asynchronously as well. RFID and USID can be harnessed by the programmer in combination for a 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 inside boundaries for a specific location of the signal as it echoes within the confine.

HX19TXHWE
Access the RF network through the brown wire

HX19TX
Ultrasonic RF battery Transmitter Tag

HX19RX
Ultrasonic RF Receiver

HX19MS USB Monitor Synchronizer

HX19 communications

HX19 components utilize a powerful command structure, using both direct commands and nested message features. All the commands are read by an HX19 from the first character to the last, executing each command on first come first serve basis. Note that commands requiring synchronized actions take place after the command sequence has been serviced. Characters that are not valid commands are ignored and therefore free to use. Dots, commas, space and etc between commands bear no consequence. Carriage return is sometimes a delimiter and shouldn't be used. Numeric values where required must follow the command immediately, and the value must remain unbroken. Spaces or other characters will break up the numeric value.

Addressing sequences tolerate no numeric breakup, T1234& is transmitter 1234 T& addresses all transmitters. A trend for the HX19 protocol is to have the first alphanumeric character represent a type of a device.

The character / is used by the hx19 communication protocol to separate data from checksum. And CR or carriage return is also used by the protocol as a delimiter.

HX19 communications

To properly explain the Hexamite Self Dissipating Relay Protocol, it is necessary to understand the instruction syntax.

Example: Command string syntax: T21& = m14 i49 n90 q7 o9 e

T21& is the address portion of the command string, determines who gets the string. The first character of the string must be either ! (ATTENTION) or a valid type (T for tags, R for receivers and etc). For private device addressing, the type letter must be followed by unbroken numeric characters terminated with &. Both spaces and = sign are ignored, these can be used to make the instruction more readable. Characters m, i, n, q, o, e are all commands recognized by the HX19TX. m: controls operating mode, i: controls the timing period of a signal, n: controls the number of periods emitted, q: controls a group designation for the omitted signal, o: controls the size of the group and e: stores the operating parameters on EEPROM (See Tag Command Summery for further information)

Mode command m14 equals hexadecimal 0xE. The string above will cause HX19TX device number 21 to turn off the LED, set (monotone mode) and emit both RFID and ultrasound. Command i49 sets the monotone (ping) period to 49 or approx. 40 khz. Command n90 makes the HX19TX emit 90 periods. The emission sequence relative to synchronization start is 7 of 9 and the operating parameters are stored on EEPROM. The same string could have been written like this:

T21&m14i49n90q7o9e
or
T& m14,i49,n90,q7,o9,e

In the latter case the string is addressed to all HX19TX type transmitters, i.e. they will all be set up as the T21.

! p0 e: this command sequence will force all devices, tags, receivers, monitor and etc to set RF transmitter at lowest power, and store their current operating parameters on EEPROM. Note that ! (exclamation) addresses all devices. Think of it as ATTENTION ALL DEVICES.

The Hx19tx USID RFID tag

HX19TX is powered by a readily available long life lithium battery. Once a battery is inserted into the battery holder the tag will enter its idle mode. In idle mode the Hx19tx by default flashes a blue LED emits USID (ultrasonic ID) and RFID (radio frequency ID). The randomized emission rate average is once every six seconds. A flashing LED is visible via the translucent blue box for every emission. This is referred to as the activity cycle. The LED can be shut down using RF link. During the activity cycle, the tag also scans for incoming radio frequency synchronization signal. If no such signal is detected the device goes to sleep to reserve battery power. In case a synchronization RF signal is detected the activity cycle becomes synchronized or driven by the synchronization signal. Latency of the synchronous activity is around a microsecond. When synchronized the activation cycle is initiated 16 times per second, and the LED if enabled will be flashing rapidly. A Hx19ms (see below) connected to a computer serial I/O or a USB port, can be used to synchronize and monitor the hx19 network. It is also used to send control and configuration parameters to the hx19 devices.

HX19TX SIZE: 35 x 35 x 15 mm

Only during the synchronized activity cycle, can the user modify the control parameters of the hx19tx. The hx19ms connected to serial or a USB port at a rate of 250k baud, can broadcast commands to a range of 30 meters. Hx19 devices scan for pertinent control characters in the broadcasted serial stream. Large letter signify addresses. Small alphabetic letters are considered commands, and are sometimes followed by a numeric control value. The alphabetic letters T and ! are interpreted as pertinent addressing codes, i.e. T means attention all tags and ! means attention all devices (including tags).

Syntax examples:

The first character in a control string must signify the device type. Tags understand two types ! or T. T is the first character of a private address it must be followed with a number terminated with &. Only numeric characters can exist between T and &, e.g. “T1234&”. If numeric characters are omitted “T&” the tag assumes the message is pertinent. Strings following addresses are interpreted as configuration commands. Following is a simple string broadcasted from a hx19ms (monitor synchronizer) within 30 meters of a hx19tx.

T& m2 d1 e

In this case **all** tags within range of the hx19ms 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: ! = e or simply !e

Characters not listed for control are ignored, the dummy = is ignored. All devices receiving this command including receivers and repeaters will store the **current** control parameters on EEPROM.

Given that the tag is labeled 13 this constitutes the private address of the transmitter. Then consider the following string broadcasted from a hx19ms:

T13& m7 d6 e (This is just as valid: T13&m7d6e)

Only device labeled 13 will respond to the broadcasted string above. Tag 13 will commence RFID and USID and will flash the LED every time the signals are emitted. It will set downtime to maximum 6 seconds average and store these parameters on EEPROM. However there is no way for the issuer of the command to know if it has been carried through.

T13& m7 d6 e [T13 got the message]

After the hx19tx labeled 13 has serviced the control parameters m7d6e, it will broadcast T13 got the message.

Tag Commands Summery

These following short commands dictate the behavior of the hx19tx ultrasonic RF tags. Here the # indicates decimal numeric characters need to follow the command. Note that the # is also used as acknowledge during data interchange.

!	Attention all devices. Global call to all devices, including tags respond
T&	Public transmitter call, all tags respond to this call
T#&	Addresses a specific tag privately where # is the tags specific numeric ID.
e	The device stores current parameters on EEPROM
p#	RF transmission power, used to control the range bubble
c#	Used to select one of 127 bi-directional RF channels
[	The device RF transmits the contents of its Receive Buffers via RF excluding opening and closing brackets
x	Port switch able to drive up to 100mA
m#	Mode # is a decimal value setting and clearing the mode bits
< >	Received data between the first and the last bracket is placed on the com pin. Brackets excluded.
d#	Downtime # is a decimal value controlling the sleep duration
h	The device essentially shuts off, 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	Clears Sequencer or single shot, ultrasonic signal is emitted immediately following this character
b	Transmits the rough battery status via RF only
z#	Action Timeout (one count per 4096uS) or T = # * 4096uS (default # = 15)

The mode control byte 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.

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	
Bit.4 xxx:	Reserved do not set.	
Bit.5 Set:	Enable Direct Network Access	(see Serial I/O com pin section)
Bit.6 Set:	Disable serial com pin	(see Serial I/O com pin section)
Bit.7 Set:	Disable emergency button	

Note that if USID, RFID and Monotone are disabled, then the activity cycle becomes short and the LED flashing becomes dim. But this reduces power consumption considerably.

Downtime [d#] (# default 6)

If the hx19tx tag finds the command d in the configuration string from the hx19ms. 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

T17&=d4 this string sets the down time for tag 17 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.

Shutdown [h]

When the command h is found in the setup string, the hx19tx tag immediately shuts down, the sleep time is eight folded. The tag will wake up and go through the activity cycle; if no radio communication is detected it will go back to sleep. There are two ways of waking the tag from deep sleep. Broadcasting sync signal using the hx19ms or pressing the emergency button if the unit is equipped with one. If the emergency button is held down while in deep sleep, the unit will wakeup immediately and transmit the emergency call at high rates.

T& m0 h This sequence addresses all tags. It will shut off the LED, USID, RFID and eightfold their sleep time. Be aware there is no feedback to indicate any action, one cannot know if all the units got the message. In deep sleep the hx19tx comes up once every 64 seconds to look for a sync, if not found it goes back to sleep for another 64 seconds. The sync will have to strobe continuously for more than 64 seconds to re-establish state of alertness. After 64 seconds of sync strobing, alertness is re-established. Sync duration for 70 seconds wakes the tags with certainty.

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.

Battery Status [b]

Counters are cleared when the unit looses power, i.e. the battery is removed for replacement. The counters are incremented for every chirp the unit emits. This provides a rough way of monitoring the battery status. Note that the device must be addressed privately for battery feedback. E.g. T4& b When tag 4 receives command b, it will broadcasting the battery status counters.

Period [i#] (# default 49): implemented on next sync

The value that follows the command i, sets the period of the monotone ultrasonic burst **(bit.3 of the mode byte must be set high).** Application of the monotone (ping) can increase the distance measurement range for the tag significantly. Angular detection is also increased. But the ability to identify the tag emission by ultrasound is lost. Other means of identification such as time sequencing using commands q and o, can be applied in case long range is required. The ping can be preceded by RFID, these signals occur with 4 ms separation.

Number of Periods [n#] (# default 30): implemented on next sync

This command controls the duration of the ultrasonic burst, and the value that follows n is the total number of periods that are emitted. Note that a monotone is not an identifiable ultrasonic signal. Clearing the monotone bit selects ultrasonic identity signal.

T13&=m14 i49 n100

The string above will shut of the LED, select monotone and emit RFID + sonic ping. 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.

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

Sequencer [q#] (# default 1): implemented on next sync

The sequencer q works in conjunction with group size control command o. Given that the device emits 16 times per second, or at 62.5mS intervals. Then T1& q7 o9 means that tag 1 has the designation 7 of 9. The cycle is repeated every 562.5mS, and the device emits during the 7th cycle, i.e. 437.5mS from the start sync, (see command character s). If the sequence is q1 o1 then the cycle is 62.5mS and the device emits during every cycle.

Sequencer group size [o#] (# default 1): implemented on next sync

See explanation above. Try T& = m14 i49 n90 q7 o9

Single Shot command [s]: implemented on next sync

This command clears the sequencer. When the proper sequence has been selected (q and o) then the s command should be used to start the process. It is good to broadcast T&s occasionally just in case sync is lost for some reason. 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. Do not send T&s through tag's serial pin while the device is in RF sync. While in sync only RF can trigger a single shot.

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.

Switch mode [x??]

The HX19TX contains contact pads that can be wired for switching. There are two pads on ports c and d, these can drive up to 100mA each. To set port c high on device T66, the following command is needed
T66&xch sets port c high T66&xcl sets port c low
T66&xdh sets port d high T66&xdl sets port d low

Action Timeout [z#] (*User should not have to deal with this parameter***)**

Activity cycle times out at # * 4096mS, this timeout is crucial for battery saving. After activity has ceased, the tag sleeps until action timeout. This timeout needs to be close but always lower than the sync rate. The tag uses high energy while waiting for sync, so it is good that sleep times out just before sync.

Serial I/O Com Pin Bidirectional

A port pin (com pin) can be used to receive or transmit broadcast (simplex), this makes the hx19tx able to relay information from the RF network to the object it is attached to. When the com pin is transmitting, it is configured as output. Otherwise the com pin is configured as a high impedance input (hi-z). The communication baud rate is 250kbaud. Both RX and TX utilize a single wire, and the signal needs to be inverted for RS232 port.

If bit five of the mode byte (see above) is set "direct access to RF network" is enabled. All that is received via the hx19tx com pin is broadcast over the network, and all that is received from the network is dumped serially through the com pin. Be aware that the unit being used to tap into the network, is also sensitive to the pertinent commands arriving through both RF and own com pin.

Note: Commands directed privately to the unit through own com pin are not broadcasted.

Example: T6& m7 <that which goes around comes around> c123

If this string is signaled through a com pin on a transmitter other than tag 6, it is immediately broadcasted. If received over the RF network by T6. Then T6 will turn on it's LED, and enable both RFID and USID. ONLY the string between the brackets "that which goes around comes around" will be transmitted out the T6 com pin if enabled. And then T6 will set its RF channel at 123.

On the other hand if the T6 "Direct RF network access bit" is enabled. Then the entire received string plus the string in the brackets is dumped through an enabled T6 com pin.

If ***T6& p0 [broadcast this] d1/888*** is signaled through the T6 com pin then the string

T6& p0 [broadcast this] d1/888|T6# is echoed back.

T6# is appended by T6 to acknowledge receipt of the string. The symbol | is there only for the purpose of representing the carriage return following the hexadecimal checksum 888. This is the sum of all the ASCII values from the first character to the / forwards slash. Once the correct checksum is received with the CR delimiter, the Hx19 will process the command and when finished issue an acknowledge this will be T6#. The string will be echoed back like this

If your addressing is not private or e.g. like this T&[testing]/430 then the following is echoed back.

T&[testing]/430|#

Here the private acknowledge is missing, but the # indicates the command was processed.

Installing the Battery

After a new battery is placed in the holder the transmitter LED blinks 3 times, this indicates all is well. If this doesn't happen then it may be necessary to shunt the battery with a metal object, or simply remove the battery and insert it again. If the com pin is enabled the character D will be signaled through the pin when the battery is installed. In this case the transmitter has been started with its default parameters. If parameters are at some point stored on EEPROM, the pin will signal E when a new battery is installed. This means parameters stored are reentered into the system. If there is an error in these parameters, the user may be in trouble.

Fixing Erroneous EEPROM

Remove the batteries completely for min. 10 sec. If the transmitter has an emergency button, then hold it down while the tag boots up. When the transmitter LED has blinked 3 times release the button. It is also possible to shunt the battery while pressing the emergency button. If you continue holding the button the unit will issue emergency broadcast at high rate (no harm done). The com pin will signal D instead of E, this means the default parameters have been loaded. After default parameters are loaded either these or correct parameters must be loaded in to the EEPROM using the e command. **It is not necessary to monitor the com pin while resetting to original parameters.** If there is trouble and there is no emergency button contact Hexamite.

Com Pin Startup Signals

After either D or E is signaled, indicating what parameters were loaded. Then the enabled com pin will signal < as main action cycle is executed. Just before the unit goes to sleep the com pin signals > the closing bracket. Between the brackets the device is active and listening for a sync signal. In idle mode the unit will wake up at the average interval of 6 seconds, if no sync is detected, it goes back to sleep.

Control Parameters:

All parameters including the mode byte can be modified while the hx19tx is in synchronous mode and on the fly. This can be done using either RF or I/O com pin on the tag. The parameters remain unchanged until either re-modified, or the battery is removed from the holder for more than approx. ten seconds, (it varies depending on operating state). To ensure the parameters remain unchanged when the battery is removed, these must have been stored on the hx19tx EEPROM prior to battery removal.

The Hx19rx the receiver

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

Continuous mode (bit.2 clear)

In continuous active mode the hx19rx is always alert, any tag within radio frequency range is processed. Current consumption in this mode, is approx. 30mA.

Battery mode (bit.2 set)

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. When a synchronizing RF signal is found it enters active mode, and remains there until the RF sync is no longer detected. Current consumption in this mode, is under 4mA at full synchronous sampling rate of 16 samples per second.

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 first ultrasonic wave front's time of arrival, 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

[Receiver ID] [RFID] [(prefix)-Time of sonic flight] [USID] / [checksum]

RF Output String Syntax: R6 X5 C68050 U5 /747 (carriage return)
Wire Output String Syntax: R6 X5 C68050 U5 (carriage return)

Conditions: Mode bit.1 is set

Output String Analysis

Please refer to the string shown above. X5 is the RFID of the tag marked 5 as received by receiver R6. The U5 USID arrived 68050 / 4 or 17012.5 microseconds after the reception of the RFID T5. In the case where mode bit.1 is set the timer of the receiver stopwatch is always cleared and started upon the arrival of the RFID from the tag. If the mode bit.1 is cleared then the receiver stopwatch is cleared and started at the reception of a RF sync signal from the hx19ms. In the above output string example mode bit.1 is set, had it been clear during the reception, X5 RFID 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 indicates that only the first edge of arriving ultrasonic signal was detected. Therefore it is likely that the tag is out of USID range, or the tag is in a monotone mode. In this case no USID U5 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, but the timing is not precise. 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.

X5 R6 B68065 /610

Please refer to the output string example above; if the timing value has the prefix B and is accompanied by X5 (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 available.

In case there is no ultrasound present in any form, the string will contain the RFID and the receiver ID followed by the checksum.

Absence of Ultrasound, receiver output string example: X**5 R5 /CKSUM**

The function of the hx19rx can be modified using the 2.4Ghz radio connection at 250baud. 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 including the Ethernet. Commonly, USB interface through Hx19ms is used for the programmer's wireless control of the hx19 system.

Parameters:

If the hx19rx is set for battery savings mode, then parameters can be modified only while the unit is in synchronization with the hx19ms.

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 numeric value referred to as #. A control value is interpreted as the first unbroken numeric characters following the command identifier. 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.

!	Attention all devices. Global call to all devices, receivers included
R&	Public transmitter call, all tags respond to this call
R#&	Addresses a specific receiver privately, # is the specific numeric ID.
e	The device stores current operating parameters on EEPROM
p#	Select RF transmission power, used to control the range bubble
r#:	Select RF input channel.
t#:	Select RF output channel
[	Everything between the first opening "[" and the last "]" closing bracket is RF broadcasted
x	Port switch able to drive up to 1A @ 16V
m#	Mode # is a decimal value setting and clearing the mode bits
< >	Received data between the first and the last bracket is placed on the serial wire I/O Brackets are excluded. Note that some receivers don't have a serial I/O port.
b	Receiver looks for ^# between broadcast brackets and replaces with # characters from memory (See self dissipating point to point protocol)
f#:	Optional: Time of flight allowance
s#:	Optional: Time to serially transmit results
d#:	Optional: Time remaining for synchronization

EEPROM save [e]

If the hx19rx finds the command e in the setup string, the current parameters under which the device is operating get transferred to EEPROM. These parameters will installed during startup.

Radio Power Level [p#] (default 2)

The numeric value following the command p, dictates the RF power used to 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 5 to 40 meters

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

Radio Channel out [t#] (default 2)

This command allows the user to change the RF channel through which the hx19rx broadcasts its result.

Example: R12345&=p0 t121 r122

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

Radio Channel in [r#] (default 2)

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

Example: R& r111 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.

Switch mode [x??]

The HX19RX contains contact pads that can be wired for switching. There are two pads one for ports a and another for port b. These port pins can drive up to 1500mA each, (special versions can be provided that switch up to 7A @ 16V). To set the port pins high on e.g. device R366, the following command is needed

R366&xah sets port a high
R366&xal sets port a low
R366&xbh sets port b high
R366&xbl sets port b low

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: First detected wave front only
Bit.1 Set: RFID scanning enabled
Bit.2 Set: Power Savings (Low power battery mode)
Bit.3 Set: Disable sonic timing and USID scanning
Bit.4 Reserved: Don't set this bit
Bit.5 Set: Reduce sensitivity
Bit.6 Set: Shut of op amp good for saving energy
Bit.7 Set: Disable streaming data. Put results into a storage ring buffer

Bit.0.set Just the first wave front returning will be timed. Highest timing classification displayed is A. This bit should be set if a long distance positioning is required in a sonically quiet surrounding. Positioning range and angle is significantly increased.

Bit.1.set The hx19rx will not scan for USID in the absence of accompanying RFID. Hx19rx output string will contain at least the receiver ID and RFID if USID is not found. Otherwise all three are included receiver ID, RFID and USID. If this bit is clear no RFID is found in the output string.

Bit.2.set If set the hx19rx enters sleep mode or battery saving mode. It can take roughly a minute to wake it up. Once it wakes up to synchronized action it consumes roughly 4mA at 16 samples/second (full action).

Bit.3.set If set the unit does not scan for ultrasonic activity.

Bit.4.RESERVED. keep this bit clear.

Bit.5.set Reduces signal sensitivity of the receiver, may help where ambient noise is high.

Bit.6.set Turns of the analog input system. If the device is using battery and ultrasound is not needed, then save energy by setting this bit high.

Bit.7.set This will disable streaming data through RF, and accumulate incoming data into a ring buffer 128 characters long. Oldest data is overwritten by incoming data.

The following is preliminary and tricky, the whole component system HX19RX, HX19MS and HX19TX must all be tuned together. The USER can experiment with values but shouldn't burn anything into EEPROM until the operation has been verified.

ADVANCED INFORMATION

Synchronization and Sampling

Energy saving of the HX19 is optimized at default 16 samples/second. The sampling rate can be increased or decreased, but it is not a straight forward process. There are 62.5mS between syncs and the receiver must be ready to receive next sync when it arrives. I.e. it must be finished with its work and standing by for a new sync. Default settings for the HX19RX make it come out of sleep just in time 1/16 (sec) to receive a new sync. The less time it spends actively waiting for a sync the more energy is required. While receiving RFID the HX19RX requires 20mA current. Clearly if the unit is operating from a power supply this is not a concern, and the timing parameters are not so critical.

The following optional parameters help reduce power consumption when sync rate is changed. While the system waits for the sync emitted ultrasonic signal to arrive, it goes to sleep to reserve power. The device waits as long for the signal to arrive as specified by the Time of Flight Allowance. Then it moves to the next step where it transmits the result from the distance timing.

Time of Flight Allowance [f#] (default 189)

This value determines how long the receiver waits for an ultrasonic signal to arrive before it times out. When it times out the device goes into sleep mode, and doesn't wake up until it is ready to transmit ultrasonic timing results, this period is determined by Time to Transmit Result below. The timer increments once every 256 microseconds, hence the optimization for 1/16 sync is 189 * 0.256 = 48 milliseconds

Time to Transmit Result [s#] (default 26)

Receivers that must share RF channel when transmitting ultrasonic timing results, cannot be allowed to transmit results simultaneously. The baud rate is 250Kbaud and the length of the result is less than 30 characters. The interval is therefore (30characters * 10bits / 250000baud) or 12 milliseconds. Each receiver must be given its unique 12milliseconds slot. After transmitting the results the device goes to sleep for the time specified by the "Time to Next Sync" parameter

Time to Next Sync [d#] (default 14)

The relationship between sync interval and the receiver timeouts is as follows:

Sync Interval = (189 + 26 + 14) * 0.256 = 59 milliseconds
Sync Interval for 16 samples per second is 1/16 = 63 milliseconds.

Make sure the receiver sync is always a few milliseconds shorter than the synchronization interwval

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 broadcasts from all other hx19 devices, receivers, tags and other HX19MS units. The RF network is accessible via USB, Ethernet and etc. 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. HX19MS-USB on the right enable access to the HX19 RF network via USB port. Hexamite provides a visual basic programs with source code to help the programmer understand the communication procedure. The hx19ms understands a few direct commands, its general address type is M.

Monitor Synchronizer Command Summery

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

!	Attention all devices. Global call to all devices, monitors included
M&	Public monitor synchronizer call, every HX19MS responds to this call
M#&	Addresses a specific a HX19MS privately, # is the specific numeric device ID.
e	The device stores current operating parameters on EEPROM
p#	Select RF transmission power, used to control the range bubble
r#:	Select RF input channel.
t#:	Select RF output channel
[	The device RF transmits the contents of its Receive Buffers via RF excluding first opening and closing brackets
x	Port switch able to drive up to 1.5A @ 16V
m#	Mode # is a decimal value setting and clearing the mode bits
< >	Received data between the first and the last bracket is placed on the serial wire I/O Brackets are excluded. Note that some receivers don't have a serial I/O port.
$	Turn synchronization ON
%	Turn synchronization OFF
f#	synchronization rate control (one count per 1024uS) T = # * 1024uS
g	Get contents of round buffer (polling)

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.

Radio Channel in [r] (default 2)

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

Example: *M& r111 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 [t] (default 2)

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

Example: *M& p0 t121 r122 e*

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

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 timing 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. Note that the HX19TX must be strobe synchronized with a HX19MS to receive commands from any networked device.

Asynchronous command [%]

Synchronization strobe is turned off. In this mode what other devices broadcast is repeated on the serial lines (through the serial port). Here the hx19ms acts as a passive RF monitor 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 indicative of range are shown in the following table.

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

Get round buffer [g]

The hx19ms stores all incoming data from RF on a round buffer size 384 bytes. When the device receives the g command it dumps the available stored RF data through it's serial wire. If a silent running mode is selected (mode.bit.0 set) then networks of hx19ms can be polled.

M1& g When this command is received over wire network, monitor M1 will dump data

Synchronization Rate [f#] (default 62.5) [For advanced user only]

The value that follows f determines the interval between syncs in terms of approx. millisecond, or precisely 1.024mS. Minimum value accepted is 20 and maximum 255. See also **Synchronization Value [z#]** for the HX19TX

Mode Byte [m#] (default 0)

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

Bit.0 Set: Silent running. No RF data dumping via wire (USB/RS232/RS485/Ethernet)
Bit.1 Set: Repeater enabled. All incoming RF data is broadcasted as it comes.
Bit.2 Set: Disable broadcast of incoming Wire data
Bit.3 Set: Enable dedicated RF command mode

Bit.0 Set: Silent running, no data comes out the serial port unless it is between command brackets < >. I.e. the device does not transmit anything through wires unless specifically told to do so through the command structure.

Bit.1 Set: The hx19ms can be used as a repeater to extend the broadcasting range.

Bit.2.Set The device does not repeat or broadcast incoming RF data on the wire port (USB/ RS232/RS485/Ethernet)

Bit.3 Set: If the communication is intense. Spending time on repeating the all RF data on the wire port, or storing in buffer may be an unacceptable overhead. Setting this bit high will make the HX19MS more alert to RF interchange.

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 16 emissions per second, the unit consumes about 5mA. During sleep it consumes approximately 10 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 20mA. Given that there are about 62.5mS between samples at 16 samples/second, ideally the overall current consumption is I = 13mS * 20mA / 63mS. The current consumption will be close to the calculated value.*

Using a 300mAh cell the unit should run for approx. 60 hours at full speed 16s/s. At lower sampling rates a coin cell battery can run for years. If the user remembers to shut the device off with the command character [h] while not using it, the battery life will be extended significantly. When the battery is installed, a blue LED inside the box will start flash ***twice****. Then it will immediately activate and emit by default USID, RFID and flash the LED for the* ***third*** *time. After startup the tag will emit and flash the LED at random 8 or 4 second intervals. Faint clicks should be heard while the LED flashes if the sensor is brought close to an ear. This indicates the sensor is emitting a sonic signal.*

HX19TX-bat

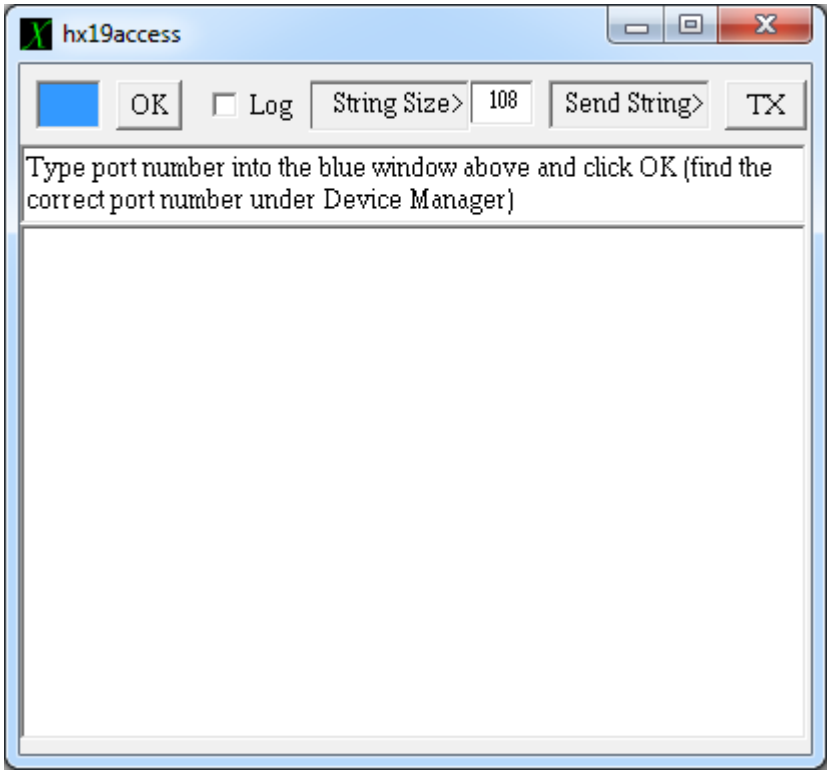
Hx19tx-bat is a battery version, it can accept variety of 3 v coin cell lithium batteries. These are BR2320, BR2325, BR2330, BR2032, CR2320, CR2325 and CR2330. CR2032 will fit into the holder, but it may need to be secured. A Philips screwdriver can be used to remove the bottom plate from the main box.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

Size 35 x 35 x 15mm

HX19 ACCESS PROGRAM WITH SOURCE CODE.

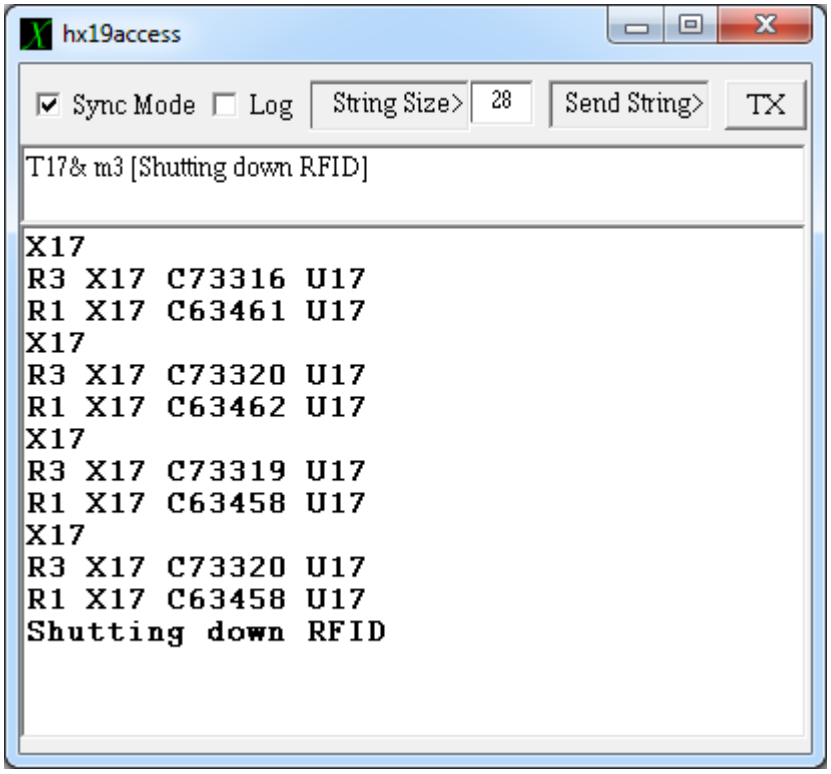
The HX19 Access

If the access program doesn't find a file called port.txt, containing reference to the serial port that connects the computer to the hx19ms. Then the window below pops up. Go to “Windows Control Panel” and find “Device Manager”. Under Ports (COM & LPT) the port number to which the Hx19 is linked can be found. Note that “Visual Basic” may not find ports over 16. In case all ports are occupied, it still may be possible to share one of the already allocated ports under 16. After typing the serial port number into the blue window then click Ok. If a tag within range is RF activated RFID should scroll down the main white window.



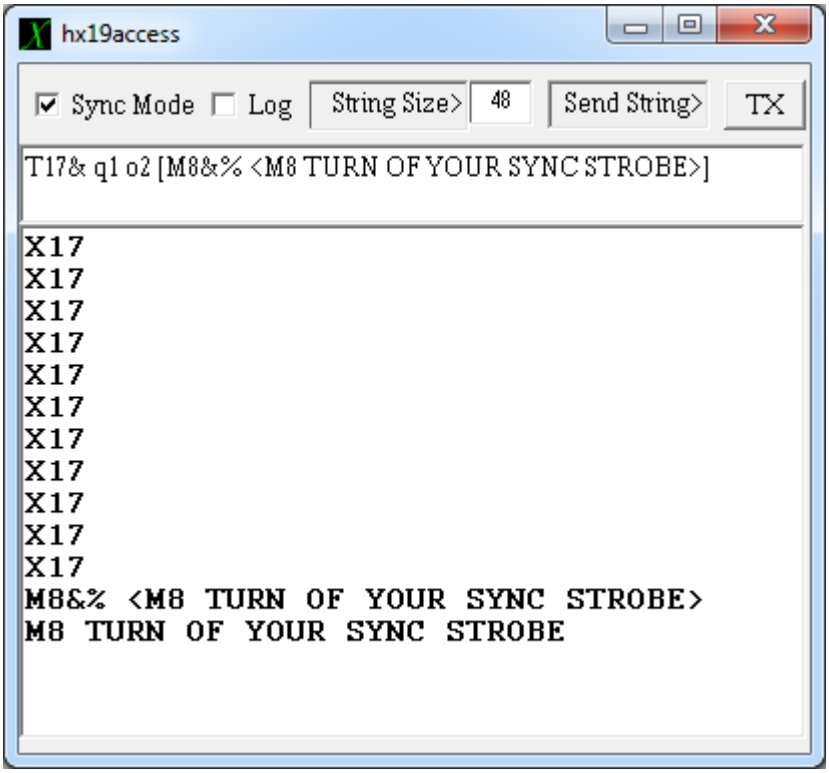
The hx19access program uses Hx19ms to read and write to the Hx19 wireless network. In the following example a single tag number 17 is placed on a table facing a ceiling. Receivers 3 and 1 are on a table also facing the ceiling. In this case are not facing the tag, rather picking up the T17 echo from the ceiling. The USID was triggered by the synchronization pulse in this case (see below). It took the USID U17 (63460/4000000) seconds to arrive at the HX19R R1 and (73320/40000000) seconds to reach HX19R-R3.

The string T17& m3 [Shutting down RFID] was broadcasted through the HX19MS, this forced the tag T17 to stop emitting RFID. It is still sending USID, but the receivers are in mode m2 where only bit.1 is set. Nothing will be reported unless it follows a proper RFID.

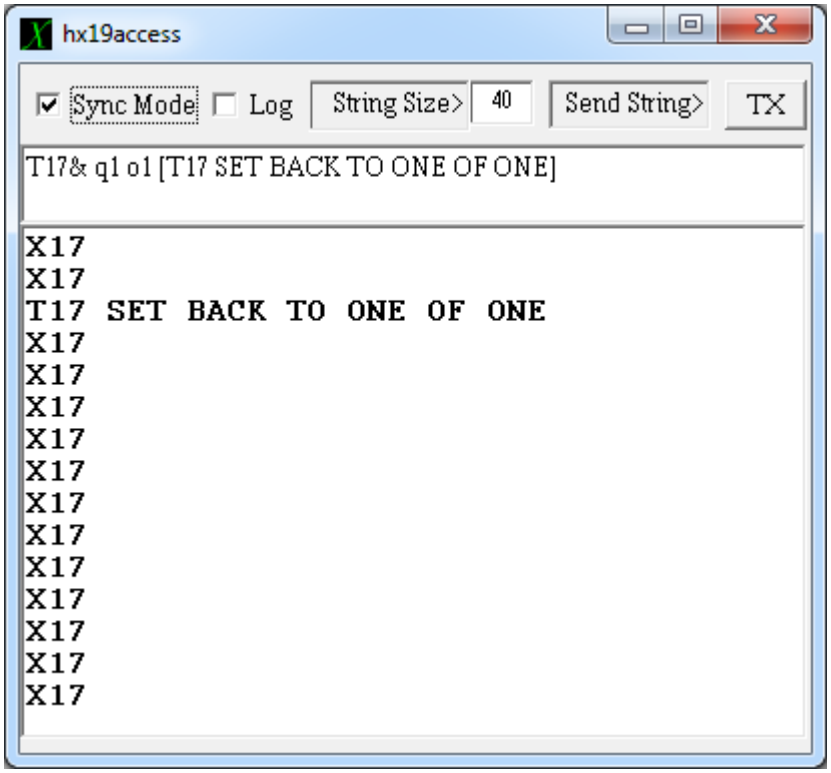


In the following example, the receiver have been set to transmit results on RF channel 6. But the HX19MS is still receiving on default channel 2. Command M8&r6 will force the HX19MS to receive on channel 6.

Given that the mode byte of T17 is m7, the following command sets T17 into a mode where RFID/USID and LED are emitted every other sync strobe. Immediately following the radification of the sequencing commands, the T17 broadcasts an order for M8 to stop its sync strobe and display "M8 TURN OF YOUR SYNC STROBE" through the USB/serial port. But since the mode byte of the HX19MS M8 is set at m0, the unit will repeat all that is received on the RF network. Therefore the whole string emitted by T17 plus the string within the < > brackets.



In the previous example the T17 was set to emit once every other cycle. In the following the X17 lines will be scrolling slowly initially. When the T17 receives the strobe command below, it will set emission 1 of 1 and broadcast “T17 SET BACK TO ONE OF ONE”. After the broadcast the X17 will scroll at double rate down the screen.



```
Dim linebuffer(100)
Dim nn%, engage As Boolean

Private Sub Check1_Click()
If Check1.Value = 1 Then checkOut "M&$" Else checkOut "M&%"
End Sub

Private Sub Check2_Click()
 If Check2.Value = 1 Then
   Open "hx19.log" For Output As 1
  Else
   Close 1
 End If
End Sub

Private Sub Command1_Click()
engage = True
End Sub

Private Sub Command3_Click()
checkOut Text6
End Sub

Private Sub tScroll(nline)       'scrolls 16 lines of text through textwindow
Dim jj%

linebuffer(nn) = nline
nn = (nn + 1) And 15
jj = nn + 1
Text3 = ""
Do
 Text3 = Text3 + linebuffer(jj)
 jj = (jj + 1) And 15
Loop Until jj = nn

End Sub

Private Sub checkOut(temst$)
 xsum = 0
 For i = 1 To Len(temst)          'compute the checksum of the string
  xx = Mid(temst, i, 1)
  xsum = xsum + Asc(xx)           'accumulate ASCII codes
 Next
 temst = temst + "/" + Hex(xsum)    'append the checksum in hexadecimal format
 Form1.MSComm1.Output = temst + Chr(13)

End Sub
```

```
Private Sub Form_Activate()
Text4.Visible = False
Command1.Visible = False
Check1.Visible = True

On Error GoTo fixit
  Open "port.txt" For Input As 1
   Input #1, Port
  Close 1
GoTo allOK
fixit:
Check1.Visible = False
Text4.Visible = True
Command1.Visible = True

Text6 = "Type port number into the blue window above and click OK (find the correct port number under De-
vice Manager)"
Do: DoEvents: Loop Until engage = True
  Open "port.txt" For Output As 1
   Print #1, Val(Text4)
  Close 1
Text4.Visible = False
Command1.Visible = False
Check1.Visible = True
Port = Val(Text4)
allOK:
Text6 = ""
    Form1.MSComm1.CommPort = Port
    Form1.MSComm1.Settings = "256000,N,8,1"
    Form1.MSComm1.InputLen = 0
    Form1.MSComm1.PortOpen = True
    Form1.MSComm1.InputLen = 1 'get serial characters one by one
    Form1.MSComm1.InBufferCount = 0
    Form1.MSComm1.OutBufferCount = 0
ticnt = 0
 Do
    Do: DoEvents: Loop While Form1.MSComm1.InBufferCount < 1
    cc = Form1.MSComm1.Input
     If cc = Chr(13) Then
       tScroll comline + vbCrLf
       If Check2.Value = 1 Then Print #1, comline
'        If InStr(1, comline, "U") > 0 Then Beep
       comline = ""
      Else
       comline = comline + cc
       Text3 = Text3 + cc
     End If
 Loop

End Sub
```

```
Private Sub Text6_Change()
Text5 = Format(Len(Text6), "#")
End Sub

Private Sub Form_Terminate()
Close
End        'TERMINATE PROGRAM
End Sub

Private Sub Form_Unload(Cancel As Integer)
Close
End        'TERMINATE PROGRAM
End Sub
```