

**InfinID Technologies, Inc.**

# **V-Tag RFID Tag Reference**

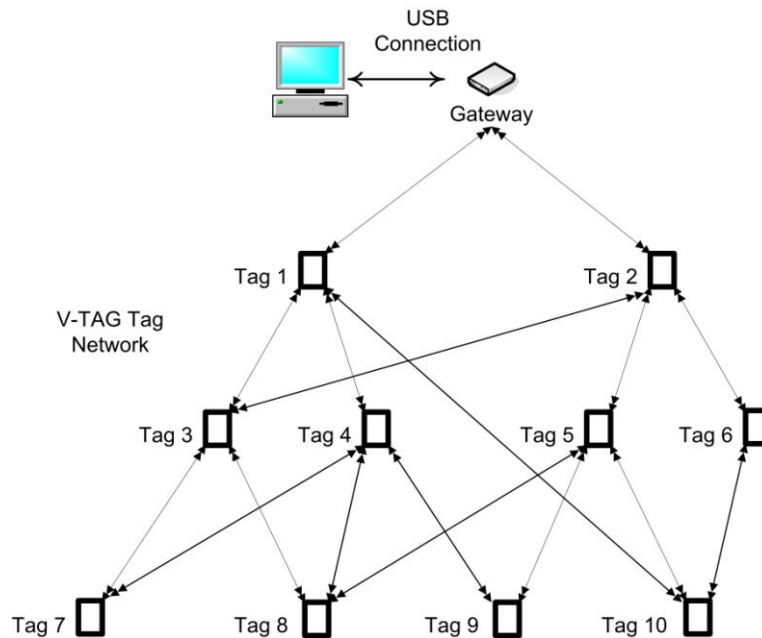
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## 1.0 System Overview

The V-Tag is a RFID tag with a set of sensors for temperature, acceleration and battery level. In contrast to other systems where each tag is polled by a central gateway, the V-Tag tag relays messages from other V-Tag tags which aids with tag read range and communications reliability. See Figure 1-1.



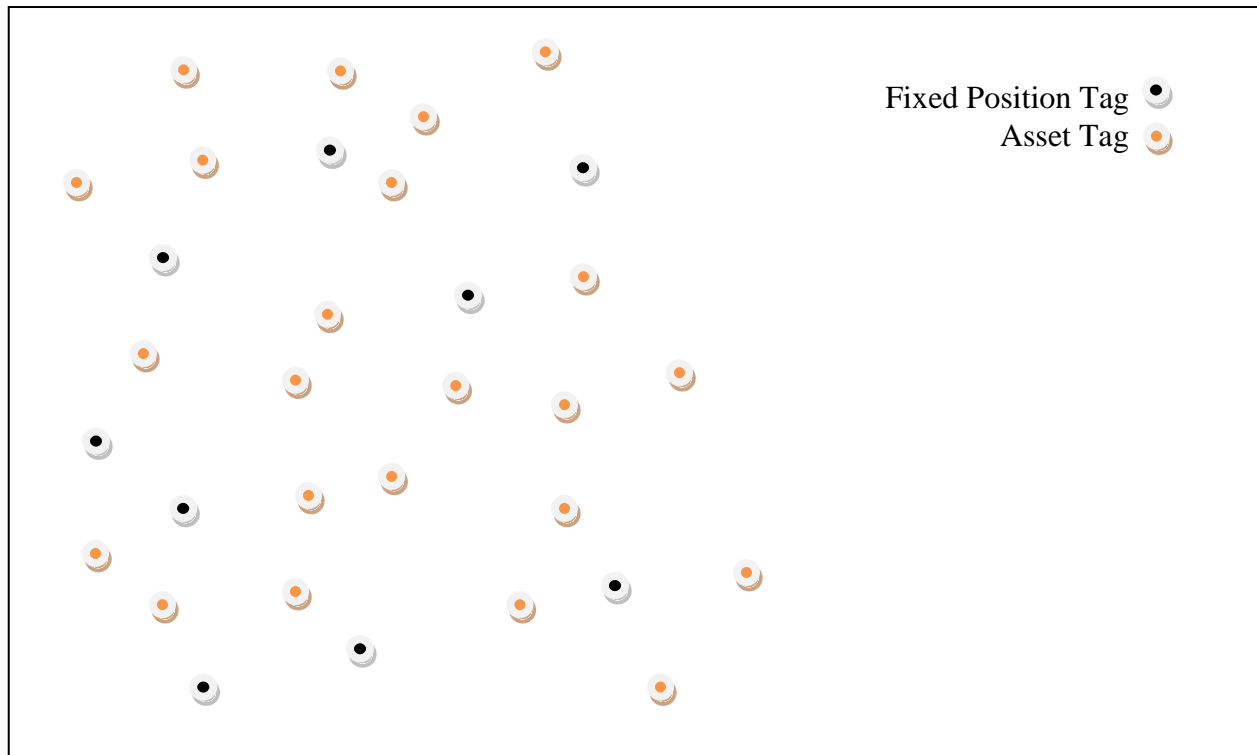
**Figure 1-1 V-Tag System Overview**

V-Tag tags provide hourly sensor reports for temperature, acceleration and battery level with immediate alarms if a sensor exceeds its threshold value.

## 2.0 V-Tag Location and Tracking System

### 2.1 Fixed Position and Asset Tags

The V-Tag tags can provide estimates of their own location. The V-Tag location tracking system consists of fixed position tags and asset tags. The fixed position tags are V-Tag tags that are not expected to move and are programmed with their fixed X, Y, and Z coordinates. The asset tags are attached to items that can move about. The asset tags calculate their own position based on received signal strength of messages from neighboring tags.



**Figure 2-1 V-Tag Location and Tracking System**

Notice that fixed position and asset tags have different labels as shown in Figure 2-2 and therefore cannot be swapped. The reason for this is that fixed position tags are programmed to relay messages from tag to tag whereas asset tags are programmed to find the nearest fixed position tag to act as a relay. This allows the battery life of the asset tags to be substantially extended.



**Figure 2-2 Labels for Asset and Fixed Position Tags**

**Fixed Position Tag Placement:** When setting up the fixed position tags in an open area, the fixed position tags should be placed at 100 to 200 feet intervals. The fixed position tags should be positioned at least 8 feet from the ground to provide good line of sight to other tags. The tags should be oriented so that the label on the tag is the right way up.

**Asset Tag Placement:** When setting up asset tags, attach each tag to the side of the object being tracked. The tag should be oriented so that the label on the tag is the right way up. The asset tag should be positioned at least 12 inches from the ground so that the signal can travel unimpeded. Avoid placing the tag within 3 inches of the ground.

See the "Tag Placement Guidelines" user manual for example photographs of tag placement.

## ***2.2 Location and Tracking System Algorithm***

Location and Tracking System algorithms are discussed in Chapter 8.0 "Location Tracking Algorithm Details." The default algorithm is "Nearest Fixed" which positions the tag to be within 3 feet of the nearest fixed position tag as determined by received signal strength.

## ***2.3 Accelerometer***

When the accelerometer detects tag movement, a series of 10 location reports is sent at one minute intervals to provide updates of tag location.

## ***2.4 Neighbor Discovery for Fixed Position Tags***

To conserve battery, the fixed position tag spends 99% of its time sleeping. This means that it cannot instantly discover new neighbors. The following steps are used for neighbor discovery for fixed position tags.

- A background scanning process is constantly running. This will do a complete survey of the neighborhood in 1 hour if the tag has two or less neighbors, or 10 hours if the tag has three or more neighbors.
- A full scan runs when needed. The full scan takes 5 minutes. The full scan runs when the tag starts for the first time, when the tag detects motion, when the tag restarts radio transmissions

following a “Resume” command, and when a tag detects its first neighbor in an otherwise empty neighbor table.

## ***2.5 Neighbor Discovery for Asset Tags***

To conserve battery, the asset tags only perform neighbor discovery after movement. They then perform a full scan to calculate their position which remains unchanged until the next time they are moved or shaken. Be sure to move or shake the nearby asset tags if you place a new fixed position tag as a reference tag in an area.

### 3.0 V-Tag Sensor Reports

Sensor reports are sent once an hour by default. The reporting period is configurable. The sensor report contains the following information:

Source Distance (Hops)	Source Distance is the number of hops to the nearest gateway for fixed position V-Tag active RFID tags. It is based on communications with tag neighbors. For example, if the tag hears reports from a set of neighbors, and the neighbor with the lowest source distance reports a distance of 4 to the nearest gateway, this tag will then report a distance of 5. Asset tags do not relay messages and do not track or report the source distance in hops.
TTL (Time to Live)	When a tag sends a sensor report to the gateway, it initializes the TTL (Time to Live) to source distance + 5 if it is a fixed position tag or 20 if it is an asset tag. Every time the packet is relayed, the TTL is decreased by one by the relaying node. If the TTL reaches zero, the packet is no longer relayed. Low values of TTL may indicate routing issues.
Minimum Temperature	Minimum Temperature is the minimum temperature observed during the past hour. Temperatures are measured every 16 seconds and reported once an hour.
Maximum Temperature	Maximum Temperature is the maximum temperature observed during the past hour. Temperatures are measured every 16 seconds and reported once an hour.
Maximum Acceleration (g)	Maximum Acceleration is the maximum acceleration observed during the past hour. It is measured in units of standard gravity <i>g</i> . Acceleration is measured 12 times every second and reported once an hour. The sensor observes acceleration along all 3 axes. The readings should range between 0 and 16 <i>g</i> in steps of 0.25 <i>g</i> .
Battery (Volts)	Battery is the maximum battery voltage observed during the past hour. The battery voltage is measured every 16 seconds and reported once an hour. With the standard lithium manganese primary battery, the voltage starts at 3.0V and decreases slowly to 2.5V as the battery is consumed.
X	Current X coordinate in meters. Tag positions are calculated once every 30 seconds based on RSSI measurements from neighbors.
Y	Current Y coordinate in meters. Tag positions are calculated once every 30 seconds based on RSSI measurements from neighbors.
Z	Current Z coordinate as a floor number (-127 to +127).

Position Type	Position Type indicates whether this tag has received a command to set its position. If so its position type will be "Fixed" otherwise it will be "Estimated".
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## 4.0 V-Tag Sensor Statistics Reports

Sensor statistics reports are sent once a day. The statistics provide information on the inner workings of the V-Tag and are intended for maintenance and diagnostics. The sensor statistics report contains the following information:

Source Distance (Hops)	Source Distance is the number of hops to the nearest gateway for fixed position V-Tag active RFID tags. It is based on communications with tag neighbors. For example, if the tag hears reports from a set of neighbors, and the neighbor with the lowest source distance reports a distance of 4 to the nearest gateway, this tag will then report a distance of 5. Asset tags do not relay messages and do not track or report the source distance in hops.
TTL (Time to Live)	When a tag sends a sensor report to the gateway, it initializes the TTL (Time to Live) to source distance + 5 if it is a fixed position tag or 20 if it is an asset tag. Every time the packet is relayed, the TTL is decreased by one by the relaying node. If the TTL reaches zero, the packet is no longer relayed. Low values of TTL may indicate routing issues.
Active Neighbors	Active Neighbors is the number of neighbors that the tag has synchronized successfully with in the last 30 second synchronization period. It has a maximum value of 12.
Total Errors	Total Exceptions is the number of internal software exceptions that the tag has observed since being powered up. It should normally be zero.
Last Error	Last Exception is the error code of the last internal software exception that the tag has observed since being powered up. Possible error codes are 1=SPI Interface error, 2=Radio buffer reset failed, 3=Radio TX underflow, 4=Client tracking error, 5=Memory corruption, 6=Radio layer management error, 7=I2C communication error, 8=Watchdog triggered, 9=Task management, 10=Task duplication, 11=Recent low voltage reset.
Best Neighbor	Best Neighbor is the V-Tag tag ID of the neighboring tag with the strongest radio signal.
Best Neighbor RSSI (dBm)	Best Neighbor RSSI is the received radio signal strength of the neighboring tag with the strongest radio signal. Values normally range from 0 (strong signal) to -100 (weak signal).
Minimum Queue	The V-Tag tag has an internal queue of packets waiting to be relayed. Minimum queue measures the minimum length of this queue over a twenty four hour period. The

	statistic is reset after being reported.
Maximum Queue	The V-Tag tag has an internal queue of packets waiting to be relayed. Maximum queue measures the maximum length of this queue over a twenty four hour period. The statistic is reset after being reported.
Average Queue	The V-Tag tag has an internal queue of packets waiting to be relayed. Average queue measures the average length of this queue over a twenty four hour period. The statistic is reset after being reported.
Packets Processed	Processed packets counts the number of packets processed by this tag over a twenty four hour period. A packet is considered processed if (i) if it queued for retransmission but the same packet is seen more than 5 times being transmitted from other tags and therefore discarded by this tag or (ii) if it is queued for retransmission and transmitted. The statistic is reset after being reported.
Alarm Count	Alarm count is the count of sensor threshold alarms reported over a twenty four hour period. The statistic is reset after being reported.
Firmware Level	Firmware version is the V-Tag tag firmware version.
Movement Triggers	Movement triggers counts the number of times that tag detection of its own movement caused a series of updated position reports to be sent to the gateway.
Dropped Packets	Dropped packets is a count of the number of packets originated by an asset tag that could not be sent because the asset tag could not find a nearby fixed position to relay the packets. The statistic is reset after being reported.
Days Since Reset	Days since reset is a count of the number of days since the tag was reset due to low battery, reset button being pressed or tag internal error.

## **5.0 Commands available on the V-Tag Map**

### ***5.1 Get Position***

This command will cause the tag to report its latest position. The map display will be updated when the response comes back.

### ***5.2 Set Position***

Set Position allows you to set the V-Tag as either a fixed position or estimated position tag. A fixed position V-Tag is typically used to help coordinate location tracking effectively. In order to set the position of a fixed position tag, while the set position command is selected, simply click anywhere on the map and a dialog will pop up. Map dragging is disabled while set position is selected.

### ***5.3 Activate***

If you have purchased the V-Tag Finder unit, you may be able to track down a tag by requesting it to issue a series of packets and then noting the received signal strength as you point the finder antenna in various directions. The Activate command is used to command the tag to send small test packets at 1 second intervals for a period of 20 minutes.

### ***5.4 Reset Tag***

This command will cause an asset tag to recalculate its location. This could be useful after setting in place some new fixed position tags which the asset tag has not yet discovered.

### ***5.5 Buzz***

If you know the position of an item to within 30 feet but there are many similar tagged items in the area, you can use the buzz command to cause an individual tag to emit a 5 second buzz. This will help with identifying an individual item. Not all tags are equipped with buzzers.

### ***5.6 Set Box***

Set a bounding box for a tag. If a tag leaves the box, then an alarm notification is immediately issued. The check is performed once every 30 seconds. After an alarm notification has been issued, the tag must re-enter the box before any new alarms are generated.

## **6.0 Network Commands**

### ***6.1 Set Security***

Tags generate beacons once every 30 seconds for clock synchronization purposes. By default, detecting tag beacons is disabled, since you may see a lot of tag activity close to a gateway and this activity is not always significant. To enable notification for tag beacons, you need to enable security mode for the gateway. Only tag beacons within 1 hop of the gateway are reported.

Security mode is one of:

- On
- Off
- Snoop

The threshold is a threshold value in dBm that allows you to ignore tag reads that are further from the gateway and have low dBm received signal strength readings. In this way, you can use the gateway as a security portal at an entrance or exit. Values normally range from 0 (strong signal) to -100 (weak signal). If you issue the snoop version of the command, you will put the gateway into “snoop” mode whereby it will report nearby tags but not send any packets into the network and therefore not make itself known for hourly data collection reports or any other tag interactions. This may be useful if you are hooking up a gateway for security purposes only and do not intend to do any data collection or tag command processing at that gateway. The gateway will act as a security monitoring point, but not as a periodic sensor data collector.

### ***6.2 Shutdown***

Some applications require that all tags in the network stop transmitting for an extended period for munitions safety or secrecy reasons. Use the shutdown command to request that all tags stop transmitting. Once the shutdown command has been issued, it propagates through the network for 5 minutes, and then all tags shutdown radio transmissions simultaneously. The gateway also ceases transmitting.

### ***6.3 Resume***

Some applications require that all tags in the network stop transmitting for an extended period for munitions safety or secrecy reasons. Use the resume command to request that all tags resume transmitting after a previous shutdown. Once the resume command has been issued, it propagates through the network and all tags resume radio transmissions within about 30 seconds.

## ***6.4 Reset Network***

The reset network command causes all asset tags in the network to recalculate their locations. This could be useful after setting in place some new fixed position tags which the current asset tags have not yet discovered.

## ***6.5 Set Reporting Interval***

Set a new reporting interval. The default reporting interval is for tags to report all of their sensor measurements once an hour. This command allows you the change the frequency of the sensor data reports. When tags are purchased for the first time, the default reporting interval is one hour. The reporting interval can be varied from fifteen minutes to twenty four hours in various steps. If the reporting interval is set to the special value of "Any," then the gateway will send no commands into the network to change the reporting interval. When gateways are purchased for the first time, the default reporting interval is "Any."

There is a tradeoff between reporting interval and maximum network size as shown in the following table.

<b>Reporting Interval</b>	<b>Maximum Network Size (Nodes)</b>
15 Minutes	250
30 Minutes	500
1 hour	1000
2 hours	2000
4 hours	4000
6 hours	6000
12 hours	12000
24 hours	24000

## 7.0 Asset Commands

### 7.1 Set Algorithm

Set the location tracking algorithm used by the tag. Location tracking algorithms are discussed in Chapter 8.0 “Location Tracking Algorithm Details.” The default algorithm is “Nearest Fixed” which positions the tag to be within 3 feet of the nearest fixed position tag as determined by received signal strength. Tuning controls the threshold for movement triggers. It is measured in g with a default value of 0.1875g and a range of 0.1g to 3.0g. The max\_floor and min\_floor parameters limit the floor levels returned by the location tracking calculation algorithm.

If the tag location tracking algorithm type is set to “None,” then tags will not carry out any location tracking calculations, and will advertize their position as “Unknown.” If the tag location tracking algorithm type is set to “MSE Minimization,” tags will carry out location tracking calculations based on observing RSSI measurements from their neighbors and using these measurements to estimate distances. If the tag location tracking algorithm type is set to “MSE\_3D,” tags will carry out the more computation intensive 3D location tracking algorithm. If the tag location tracking algorithm type is set to “Nearest Fixed,” tags will find the nearest fixed position tag and randomly select a nearby location. If the tag location tracking algorithm type is set to “Directional,” tags will find the two nearest fixed position tags and calculate a position as close to the nearest fixed but offset towards the second nearest fixed. If the tag location tracking algorithm type is set to “Line,” tags will find the two nearest fixed position tags and calculate a position on a line between the tags setting themselves closer to the tag with the strongest signal.

### 7.2 Set Threshold

A tag may be configured with thresholds for temperature, light level, acceleration, or battery level. If the threshold is exceeded, an immediate alarm is generated. The threshold level is a numerical value indicating the level of the threshold. The threshold duration is a duration in seconds, except for acceleration, when it is measured in milliseconds. When processed by the tag, the duration will be rounded to the next highest 16 second interval, except for acceleration which will be rounded to the next highest 50 millisecond interval. To disable a threshold, set the duration to 0 in the set threshold command. If a threshold value is exceeded and an alarm reported, no new alarm indication will be issued until the sensor measurement has dropped back below the threshold value for a period of 300 seconds. By default, there is a low battery threshold of 2.7V configured for each tag when it arrives from the factory. Tags generally will fail when the battery voltage drops below 2.5V. Thresholds for acceleration should range between 0 and 16g with a resolution of 0.25g. Light level readings should range between 0 Lux for a closed case and 600 Lux for an open case in bright sunlight.

### ***7.3 Get Threshold***

A tag may be configured with thresholds for temperature, light level, acceleration, or battery level. If the threshold is exceeded, an immediate alarm is generated. Use the Get Threshold command to query a tag for its current threshold settings. The results are shown on the queued commands screen.

### ***7.4 Acceleration Sensor***

The acceleration sensor is checked 12 times per second to check whether the tag is moving. By configuring the tag to ignore the acceleration sensor, you can add a month or two to the battery life. Note that the tag movement notifications are used by the location estimation algorithms, so you should not disable the acceleration sensor if you need location estimates. When a tag is set to a fixed position for location tracking purposes, the acceleration sensor is disabled by default, but may be enabled by user command. Likewise, when a tag is set to estimate its position, the acceleration sensor is enabled by default, but may be disabled by user command.

### ***7.5 Get Alarms***

A tag may be out of communications range of a gateway when an over threshold event happens. To address this situation, all tags log their last 64 alarms in flash memory for later retrieval by a gateway. These alarms may be listed using the Get Alarms command. The results are shown on the queued commands screen.

### ***7.6 Clear Alarms***

A tag may be out of communications range of a gateway when an over threshold event happens. To address this situation, all tags log their last 64 alarms in flash memory for later retrieval by a gateway. These alarms may be cleared using the Clear Alarms command.

## 8.0 Location Tracking Algorithm Details

V-Tag RFID tags support six location tracking algorithms. Use the “Set Algorithm” command to select which algorithm is used by the tag. The default algorithm is the “Nearest Fixed” algorithm. The algorithms in order from simplest to most complex are:

- None
- Nearest Fixed
- Directional
- Line
- MSE Minimization
- 3D

Position location using RSSI is challenging because if two tags are far apart, signal strength can be affected by obstacles and signal multipath interference as well as distance. So unless the tags are very close, there is a lot of uncertainty in inferring distance from RSSI. This is the reason that simpler algorithms perform better.

### 8.1 *None*

If the location tracking algorithm is set to “None” the tags will not carry out any location tracking calculations, and will advertise their position as “Unknown.” This can be useful if you want a fixed position tag to act as a relay and not influence any location calculations. Set the location tracking algorithm to None for the fixed position tag and it will only carry out packet relaying.

### 8.2 *Nearest Fixed*

If the tag location tracking algorithm type is set to “Nearest Fixed,” tags will find the nearest fixed position tag based on received signal strength and randomly select a nearby location at a 1 meter distance from the fixed position tag. On a map display, asset tags will be displayed in a circle around the nearest fixed position tag at a distance of 1 meter from the tag.

### 8.3 *Directional*

If the tag location tracking algorithm type is set to “Directional,” tags will find the two nearest fixed position tags and calculate a position at a 1 meter distance from the nearest fixed but in the direction of the second nearest fixed. On a map display, asset tags will be displayed in a circle around the nearest fixed position tag at a distance of 1 meter from the tag.

### 8.4 *Line*

If the tag location tracking algorithm type is set to “Line,” tags will find the two nearest fixed position tags and calculate a position on a line between the tags setting themselves closer to the



tag with the strongest signal. The position is calculated by doing an RSSI to distance calculation using the curve described in Section 6 of the SDK manual and then using the distances to set the location. For example if the asset tag is 3 meters from the closest fixed position tag and 6 meters from the second closest fixed position tag, the tag will estimate its own position as one third of the way along the line between the closest and the second closest.

## **8.5 MSE Minimization**

If the tag location tracking algorithm type is set to “MSE Minimization,” tags will carry out location tracking calculations based on observing RSSI measurements from their neighbors and using these measurements to estimate distances. The location tracking position estimation algorithm uses received signal strength from neighbors to estimate distance to these neighbors, and then estimates X and Y coordinates to minimize the errors in the distance estimates.

- More weight is given to signal strength reports from fixed neighbors than from asset neighbors.
- More weight is given to signal strength reports from nearby neighbors than from distant neighbors.
- More weight is given to signal strength reports from neighbors with no recent accelerometer detection of movement than neighbors with recent accelerometer detection of movement.

The Z coordinate floor number is estimated as being the average floor number of neighboring fixed position tags. The tag will spend approximately 500 ms every 30 seconds calculating its own position if the MSE Minimization location tracking algorithm is selected. Expect 3 meter accuracy using this algorithm indoors and 10 meter accuracy using this algorithm outdoors.

## **8.6 3D**

If the tag location tracking algorithm type is set to “MSE\_3D,” tags will carry out the more computation intensive 3D location tracking algorithm. This is the same as the MSE minimization except that all three coordinates X, Y, and Z are estimated. The main concern with using this algorithm is that the tag may miss beacon messages from neighboring tags if it is busy doing calculations. The tag will spend approximately 1000 ms every 30 seconds calculating its own position if the 3D location tracking algorithm is selected. Expect 3 meter accuracy using this algorithm indoors and 10 meter accuracy using this algorithm outdoors.

## **Appendix A FCC Compliance Statement**

### **FCC NOTICE**

This equipment has been tested and found to comply with the limits for a class B digital device pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- \* Reorient or relocate the receiving antenna.
- \* Increase the separation between the equipment and receiver.
- \* Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- \* Consult the dealer or an experienced radio/TV technician for help.

In order to maintain compliance with FCC regulations, shielded cables must be used with this equipment. Operation with non-approved equipment or unshielded cables is likely to result in interference to radio and TV reception. The user is cautioned that changes and modifications made to the equipment without the approval of the manufacturer could void the user's authority to operate the equipment.