

# Magellan Technology

## White Paper

### Comparison between

### 125 kHz Low Frequency (LF) & 13.56 MHz High Frequency (HF)

## Introduction

The term “Communication Protocol” is the technical term used to describe the “language” used between an RF tag and an RF reader. Protocols operate at different frequencies and have different features, functionality and characteristics.

The gaming industry has, in the past, used LF as its preferred frequency band for gaming applications. Today a new, cheaper, faster and functionally far superior technology is available in the HF frequency band.

The earlier more expensive LF technology is typified by tags which operate at 125 kHz and which use a relatively large and bulky air wound copper coil antenna for the inductive transfer of energy from a reader antenna to the RF tag antenna.

The newer more advanced HF technology operates at 13.56 MHz and uses a much less expensive, thin, flat antenna. This feature also makes the new HF technology suitable for gaming applications which use playing cards as well as gaming chips. This added utility cannot be provided by technology which uses heavy air wound copper coils.

The new technology is provided by Magellan Technology and Progressive Gaming International Corporation (PGIC) of Las Vegas.

For comparison purposes this paper will use a typical or generic reference LF tag to represent the present LF technology. PGIC's new HF StackTag ® tag provided by Magellan Technology will be used as the HF reference tag. (Please note, however, that only Magellan's HF technology provides all of the HF functionality described in this paper).

This White Paper will compare the old LF and the new HF systems by describing their respective functionality in terms of their ability to read multiple tags; their anti collision capability; their stackability; communication speed; memory size; security features; international acceptance; general utility; and cost.

The paper will conclude with a simple comparative annex.

## Respective Functionality

- Multiple Tags and Anti Collision Capability

It is desirable in managing the games of Baccarat and Roulette to read many hundreds of tags on a gaming table at the same time. All LF systems are limited by the fact that the tag and the reader can only communicate at slow speeds on a single frequency or channel. This means that the ability of all LF protocols is slow when

compared with higher speeds of all HF RF systems generally and especially so when compared with the very high speed HF RF system of Magellan.

Magellan and PGIC's HF table systems are also quite different from LF systems in that each of Magellan's tags has the capability to communicate very quickly on any one or more of 8 different reply frequencies. This means, particularly when multiple HF tags are simultaneously within the operating range of a reader, that they will all be correctly identified and their several identifying messages individually and correctly received.

(For a further description of typical problems with LF tags see the paper from ETH Zurich)

<http://www.vs.inf.ethz.ch/publ/papers/RFIDIssues.pdf>

- **Stackability**

To provide stackability, Magellan's HF tags are made intentionally with very thin un-tuned antennas. This avoids the usual problem of parasitic coupling between tuned tag antennas and also minimises the amount of copper in the field of the reader.

Magellan's HF tags also operate in two power states, a normal power state and a low power state where the tags draw only the lowest possible current. Tags move between states so that at any time the majority of the tags are in the low power state. This further eliminates the normal problems associated with parasitic coupling between the antennas of closely stacked tags and also provides the benefits of time division multiplexed operation together with frequency hopping.

Magellan's tag and system design ensures that Magellan's HF StackTag tags can be reliably read when stacked 25 high for baccarat applications and 40 tags high for roulette gaming applications.

- **Communication Speed – LF Tags**

All LF tags have a slow data rate as the RF Bandwidth available at LF is limited. In the case of the LF reference tag the command rate, meaning the communication speed between reader and tag, is only 5.2 kbits a second in the command direction and 2 or 4 kbits/sec in the reply direction during the anti collision procedure. This very slow data rate is not suited to reading multiple tags quickly.

The reference LF tag also uses a tree search algorithm which needs time to complete its anti collision process. In practice this means that the LF system will read a maximum of 20-25 tags in one second. (In the case of a previously "known" population of tags, in inventory tracking mode, this tree search algorithm can be optimized to read 100 tags in 3.2 seconds)

LF tags also reply on only one channel which makes the entire LF system vulnerable to collapse or mistaken reads when interference and noise is experienced on this single channel.

- **Communication Speed – HF Tags**

The Bandwidth available at HF is much more generous than at LF and this permits Magellan and PGIC's HF tags, which use Phase Jitter Modulation (PJM) to have a command data rate of 424 kbits per second (vs. 5.2 kbits/sec for LF) and a reply data rate of 106 kbits/sec (vs. 4 kbits/sec for LF). The speed difference is evident.

PGIC gaming table applications can therefore communicate with many hundreds of gaming tokens practically simultaneously. This also means that PGIC's tags have much more functionality and can access much more available memory.

Magellan's high data rate provides not only the functionality of reading many hundreds of tags in less than one second but also of reading thousands of tags in one or two seconds.

Magellan's HF tags reply on any one of eight channels so, where one channel is blocked for whatever reason, there are seven other channels a tag can use to reply. All replies are at 106 kbits a second but, as these replies have eight different available reply channels, the effective notional reply rate if all channels are in use is 848k bits per second.

The LF system reads at a maximum rate of 20 -25 tags a second. To read a table of 500 tags will therefore take 20-25 seconds. This period of time is unacceptably long. In stark contrast a Magellan HF system will read an entire table of 500 tags in just a couple of seconds.

- **Memory Size**

All LF tags have such a slow data rate that they can only usefully have a small memory. This is because the time required by LF tags to access a larger memory increases the time needed to read and write to the tag to unacceptable levels. It has been argued that only a small memory is required by any gaming application and that a simple ID number or a license plate is all that is needed. This is disingenuous and seeks to make a virtue out of a vice as the larger memory of the HF tag can equally well be used to hold a simple license plate or ID number.

The gaming customer should have the freedom of choice to use or not use a larger memory. Only with a larger memory can customers have the extra functionality they need.

Because of their very high data rate, Magellan's chips have a significant speed advantage and this translates directly into the ability to be able to use as much or as little of the 8K bit memory available to the user.

## **Security/Accuracy and Reliability**

All RF communication protocols use a cyclic redundancy check (CRC) to confirm the accuracy of the data conveyed. LF tags do not have a satisfactory CRC as their slow speed limits their CRC to an 8 bit check. Indeed, the reference LF tag does not use a CRC at all during its anti collision procedure and this is unacceptable in terms of reliability and robustness of the system.

Magellan has a data rate that allows the use of a full 32 bit CRC (the minimum acceptable standard for good reliability and accuracy).

Magellan's much larger memory and memory map also provide many features not available with less capable tags.

- **International Acceptance**

The HF protocol used by Magellan was published as an International Standard in August 2004 and is available from ISO. This was after five years of intense review and improvement by experts from 28 countries. This means that PGI gaming systems based on this standard are acceptable world wide. Also noteworthy is that this new standard (ISO 18000-3 Mode 2) not only provides improved functionality over all LF systems it also provides new functionality over the earlier HF technologies which still use an earlier HF communication protocol (e.g. ISO 18000-3 Mode 1)

- General Utility

Magellan's technology is not just one reader and one tag. There is an entire family of tags and readers available from multiple manufacturers. These include Gaming Table Readers for Baccarat and Roulette. Tray Readers, Tablet Readers, Vault Readers and Desk Top Readers. Also available are Tag Issuers and Panel Readers for access control if required.

PGI's gaming solutions and systems based on the new International HF technology will not only offer improved performance and new applications for existing customers but will also provide new business and new applications for new customers.

- Cost

Silicon based microchips cost essentially the same. It is therefore the requirement for air wound copper coil antennae that make the inlets for LF tags much more expensive to build than are the inlets for HF tags. The attachment of the micro chip (or of a chip already mounted in a plastic molded package) to the wire terminals of the air wound copper coil is also both difficult and slow in manufacturability and this adds markedly to the overall cost of LF tags.

It is a fact that an LF tag will therefore always cost more than an HF tag.

## **Conclusion**

It is demonstrably the case that older LF communication protocols based on a single command and reply channel and a slow data rate can never hope to provide a functionally competitive solution to that now provided by modern advanced HF systems based on the new ISO high speed communication protocol ISO 18000-3 Mode 2.

Only Mode 2 provides frequency hopping, very high speed, large memory, multiple reply channels and advanced memory features on a slim and inexpensive antenna suitable for both gaming chips and playing cards. To try and stick with an old technology, simply because that is all that is known, is analogous to sticking with black and white TV when color TV is available at a lower cost.

The laws of physics do not permit a product developed with a specific, finite and limited functionality to continue to meet the changing needs of a rapidly changing and increasingly demanding global gaming industry. New challenges and new higher order requirements drive technology providers to innovate and provide ever more capable features and functionality at a lesser and lesser price.

The succession of older technology by new technology is the natural course of events and it is quite reasonable that older technology continues where it has an installed base and a continuing usefulness. Never the less, the new does replace the old and the older technology becomes a legacy technology that is increasingly less relevant as time, the market and the customer move on.

RTF  
Sydney  
5 July 2005

## Comparison table

	Typical LF reference tag	Magellan HF StackTag
Frequency	125 KHz	13.56 MHz
Bit rate - Command	5.2 kbits/sec	424 kbits/sec
Bit rate - Reply	2 or 4 kbits sec during anti collision	106 kbits/sec
Number of reply channels	One	Eight
Memory capacity	256 bit	8128 bit
CRC	8 bit sometimes used	16 bit command 32 bit in reply
Anti Collision functionality	Not reliable (no CRC in replies during the anti collision procedure)	Fast and reliable
International standard	No	Yes ISO18000-3 Mode 2
Tag antenna type	Air wound copper coil	Slim foil
Suitability for use in gaming tokens and playing cards	Limited use in gaming tokens not possible in playing cards	Yes - Both
Silicon cost	Low	Low
Tag antenna cost	High	Low
Antenna and chip attachment cost (manufacturability)	High, especially if molded package is also used	Low
Theoretical maximum read rate in one second	Approx 20 – 25	Approx 1,200
Ability to read many hundreds of tags in <u>one</u> second	No  100 tags in 5-7 seconds 100 tags in 3.2 seconds in inventory mode (previously known population)	Yes  200 tags in under one second in real world applications
Stackability/Stack Height	5 – 15 (max)	25 - 40