GO CARD® SYSTEM

MK5 TARGET DESCRIPTION

REVISION STATUS

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1. GENERAL

The MK5 Target is one of the components of a ***GO CARD***®[1] System, and it communicates with the Tags. It is very simple to install and operate and requires only a single tuning adjustment (either before or after installation).

The Target is a one-piece device with an integrated, easy to tune, antenna. This configuration allows a single design to be tuned to operate properly in a variety of different metallic environments and different mountings. The Target can be surface or through-hole mounted without having to be redesigned nor re-certified for each new use. The Target is tuned with a tuning capacitor which is accessible from both the top and the bottom of the Target.

The Target provides baud-rate conversion, collision-resolution, and RS232 multi-drop capability. The Target provides control of it's red/yellow/green LED indicator and of the four yellow LEDs used for back-lighting. The Target operates over a wide range of supply voltages and does not require a well-regulated and filtered power supply because of the included DC to DC converter.

2. TUNING THE TARGET

The Target is an RF device which operates at a carrier frequency of 13.560 MHz. It is initially tuned, when manufactured, to allow it to be tested for operation. It MUST be properly re-tuned for almost all installations. Note: even a plastic dome can de-tune the Target!

The tuning capacitor that is used to properly tune the antenna is accessed from either the top or bottom of the Target. If the tuning capacitor is not accessible when the Target is installed, a tuning-fixture should be constructed.

The tuning-fixture must present the same RF environment to the Target as the piece of equipment in which the Target is to be installed and must provide access to the Target tuning capacitor.

To re-tune the Target, simply make a pickup-loop by connecting the ground lead of an oscilloscope probe to the probe tip, place the loop near the Target, and adjust the Target tuning capacitor for maximum RF amplitude (as displayed on the oscilloscope).

The tuning adjustment is sensitive when near maximum and should be carefully adjusted with a non-conductive tuning tool.

To verify that the tuning-fixture can be used to properly re-tune Targets, use the fixture to re-tune a Target and then install the re-tuned Target into the intended enclosure. Determine that a standard Tag will operate at the expected maximum range.

[1] ***GO CARD*** is a registered trademark of Cubic Automatic Revenue Collection Group.

3. TRANSACTION TIMING

Determining the duration of time that a transaction takes in the ***GO CARD®*** System is a straightforward calculation. One determines 1) the amount of data to be read and written, 2) the number of pages required to hold the data, 3) the number of bits (with overhead) required to transmit and receive the data, 4) the time per bit (and any required turnaround times required), 5) the time required to resolve any collisions, 6) the time required to write the data into the Tag non-volatile memory, and 7) the time required for the application to process the data read and to be written. Add the resulting times together and you have the duration of that transaction.

Other systems may include several additional subtle but important factors that affect transaction timing. Among them are any Target or Tag imposed additional communications (such as any Target enabling commands, any Tag blocks selection commands, and any delays in the transfer of data between the Tag and the application due to Target data buffering) and more importantly, any additional storage and read or write commands required to prevent corruption of Tag data when a Tag is prematurely removed from the Target RF field during a transaction. Any contributions from all these factors must by included in the transaction timing calculations.

It is vitally important that the premature removal of the Tag does not cause an unrecoverable data error. This may be prevented in a variety of ways. The most common way requires the reading and writing of extra pages of data. The ***GO CARD®*** System Tag was designed to overcome this problem. It has the capability of internally buffering up to four pages of data to be written (each page of data can be for a different block of data) and assuring that the buffered data is either not written to any of the intended storage locations or is completely written to all of them.

The ***GO CARD®*** System Tag buffering scheme does not require any extra data storage (for redundant pages or directory structures) and therefore does not impose any extra transaction time for the reading and writing of any extra pages. This not only minimizes transaction time and conserves Tag memory, it also simplifies the application read/write logic.

Other considerations that help assure that Tag data is not corrupted are related to the quality of the protocol checks that are made by the Tag and the application concerning the accuracy of the received data (message CRC, etc.) and to the type and structure of the Tag's non-volatile memory (the early withdrawal must not cause the memory address to change during any attempted write and an incomplete write must only impact the data in the page being written).

The ***GO CARD®*** System Tag imposes a much more stringent test of the accuracy of the received data than the usual 16-bit CRC in common use. The Tag uses a 48-bit message digest to qualify both the accuracy and the security of the received data. The odds against the processing of incorrectly received or falsified data are astronomical.

A ***GO CARD®*** System transaction consists of the collision resolution process and some number of read and write sequences. The collision resolution process, consisting of a wake-up message, a ping, a pong-valid, and an im-awake message (which includes the Tag block directory) takes approximately 6 milli-seconds (at 115.2 KBaud) for a single Tag. Each read or write sequence consists of a Target command and a Tag response. The time for either sequence depends upon both the application baud-rate and the application processor, as indicated below (times are for application to Target communications at 115.2 KBaud):

App. Processor	Clock Rate	Read Sequence	Write Sequence	Comment
68332	20 MHz	~10 msec	~10 msec	Write takes same time as read
386	33 MHz	~10 msec	~10 msec	Application processor limited
Pentium	90 MHz	~5 msec	~5 msec	Baud-rate limited

A transaction will take: 6 + n(read-time) + m(write-time) + Application-processing-time = T(msec).

For example, a read 2, write 1 transaction would (for a slow processor) require 6 + 2*10 + 10 = 36 msec + Application-processing-time, or (for a fast processor) 6 + 2*5 + 5 = 21 msec + Application-processing-time.

4. SIGNAL TO NOISE MEASUREMENTS

One of the most important engineering measurements that can be made on an RF data-link is system signal to noise ratio. This measurement will determine if the system *can* meet its required error rate. A signal to noise value will not guarantee that the requirement will be met in any given installation, but it does indicate that it is theoretically possible to meet the requirement.

The ***GO CARD***® System has an RF data-link. It is the very short range (non-contact) path between the Tag and the Target. The Tag transmits to the Target using impedance (load) modulation and the Target transmits to the Tag by AM modulation. The usual far-field impedance and antenna gain factors do not apply because the Tag is not only in the Target "antenna" near-field, it is almost in contact with the Target's transmitter coil when operating. It has no operating power when away from the coil. A more accurate model of the transmission process is that of a transformer with variable coupling coefficient (the Target "antenna" coil is the primary of the transformer and the Tag coil is the secondary).

The direct measurement of the ***GO CARD***® System signal to noise ratio is not possible because it is complicated by many factors, some of which are as follows:

- The Tag is immersed in the Target's strong RF field;
- The Tag has no ground reference (it is literally suspended in air);
- The Tag receiver is embedded in an ASIC chip and its inputs and outputs are not accessible;
- The Tag receiver includes internal hysteresis hence the output is either high or low (hence receiver input noise appears as jitter in the output bit times);
- The Tag receiver input includes coupled digital noise from the digital part of the ASIC chip (which varies with received data); and
- The Target receiver input is immersed in the Target's RF field and the Target's 13.56 MHz RF field couples into all nearby metal and measuring instruments.

Because of the difficulties in making accurate direct signal to noise measurements, an indirect measurement and calculation is being made. The bit error rate is being measured over a range of Tag and Target conditions and the signal to noise ratio is being inferred by standard statistical methods.

The active transaction data collected to date indicates that the system signal to noise ratio is at least 18 dB when the Tag is within the specified operating range of the Target.

The ***GO CARD®*** System test set-up has, to date, processed over 640,000,000 transactions with only two errors (no retries were attempted to correct the errors). One was a time-out and the other was a MAC (message-authentication-code) error. This is the equivalent of transmitting and receiving a total over 175,000,000,000 bits with approximately two bit errors (any single bit error will cause a time-out or a MAC error).

5. SPECIFICS

Detailed specifics and product specifications are contained in the following sections. These data will allow one to install and operate the Target.

5.1 TARGET/TAG INTERFACE

- Carrier Frequency: 13.560 MHz
- Modulation: 10% AM (Target to Tag), Impedance (Tag to Target)
- Baud Rate: 115.2 Kbaud (MK5), 38.4 Kbaud (MK3 Dual-Mode), 19.2 Kbaud (MK3)
- Collision Avoidance: Similar to Slotted-Aloha protocol

5.2 TARGET/APPLICATION INTERFACE

- Baud Rate: Four switch-selected rates (115.2, 57.6, 38.4, and 19.2 KBaud), see Figure 1
- Multi-drop: Two-wire selection (multi-drop: addresses 0, 1, 2; non multi-drop: address 3)
- Control: Via serial two-byte command from application to Target

Note: Bits in the command message control the operating mode, turn on and off the RF power, invert the receiver's modulation direction, and control the indicator and backlight LEDs.

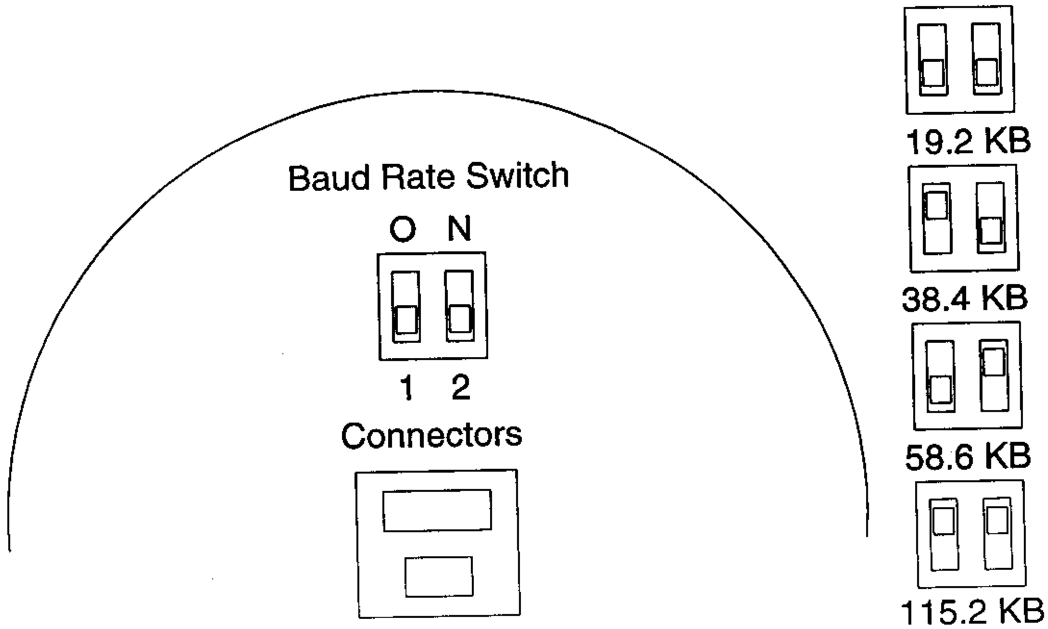

Figure 1. Baud Rate Switch Settings

5.3 COMMUNICATIONS PROTOCOL

- Character Format: Asynchronous, 8 data bits (LSB first), no parity, 1 or more stop bits
- Reserved Characters: None
- Substitution: None
- Synchronization: Inter-character time of >2.2 msec., followed by sync character

5.4 DEFINED SINGLE CHARACTER MESSAGES

- Sync Character: SOM = 0010,0100
- Ping Character: PNG = 8 bit random number generated by Tag
- Pong Valid Character: PVD = 0010,0000
- Pong Invalid Character: PIV = 0010,1111
- Negative Acknowledge: NAK = 0010,0010

Note: The ping message is actually two characters (the ping character followed by it's "inverse").

5.5 DEFINED MESSAGE IDS (MIDS) OF SIGNIFICANCE TO TARGET

- Command Message ID: CID = 1001,10aa (aa = multi-drop address)
- Status Message ID: SID = 0001,01aa (aa = multi-drop address)
- Diagnostic Message ID: DID = 1001,1100
- Response Message ID: RID = 0001,1100
- WakeUp Message ID: WID = 1001,0000
- ImAwake Message ID: AID = 0001,0000

5.6 DEFINED MESSAGES OF SIGNIFICANCE TO TARGET

- Format of Messages (2 + n-characters): SOM MID <message contents>
- Command Message (6 characters): SOM CID CMD1 CMD2 CMD1\ CMD2\
- Status Message (6 characters): SOM SID STA1 STA2 STA1\ STA2\
- Diagnostic Message (6 characters): SOM DID DIA1 DIA2 DIA1\ DIA2\
- Result Message (6 characters): SOM RID RES1 RES2 RES1\ RES2\
- WakeUp Message (14 characters): SOM WID W1 through W12
- ImAwake Message (37 characters): SOM AID A1 through A35

5.7 INITIALIZATION

On power-up or watchdog timer time-out, a status message will be sent to the application unless the multi-drop address is non-zero. The power-up status of the Target will be:

Status:
- First status byte:
  - Red/yellow/green LED off
  - RF normal
  - Modulation direction normal
  - Card Present Threshold low
  - MK3 Protocol
  - Waiting
- Second status byte:
  - Back-lights off.

The state of the baud-rate switches and the multi-drop connector-pins are read at power-up and at least as often as a command message is received.

5.8 BAUD RATE CONVERSION

Baud rate between Target and Tag is determined by the selected protocol. MK5 protocol is 115.2 KBaud for the ASIC Tag and 38.4 KBaud for the MK3 Dual-Mode Tag.

Baud rate between application and Target is switch selected in four steps (19.2, 38.4, 57.6, and 115.2 KBaud) via Target Baud-Rate switch-pair. See Figure 1 for a diagram of the switches.

All characters transmitted from the application to the Target will be passed through to the Tag unless the Target is broadcasting the WakeUp message.

All characters transmitted from the Tag to the Target except Ping will be passed through to the application.

5.9 SYNCHRONIZATION

There is no character substitution in the MK5 protocol and the SOM character is not unique. Therefore, to recognize a valid SOM character, each succeeding character in a message must be transmitted with a minimum delay. If the time between characters exceeds the maximum inter-character time, the message is assumed to be incomplete and the next received SOM character is assumed to be the start of a new message.

5.10 MULTI-DROP

Up to three MK5 Targets can be multi-dropped on the same communications port. The Target receivers have higher than normal input impedance and the Target transmitters can be forced into a high impedance state.

Each Target has two address pins on its data connector. The pins are internally connected to inverting receivers and to pull-up resistors. If the address pins are not connected externally, the Target micro-controller will read the address pins as zeros. A zero address indicates that the Target is not multi-dropped and the Target's RS-232 transmitter will always be enabled. Any non-zero address becomes the multi-drop address for the Target.

At power-up a multi-dropped Target will disable its transmitter and wait for a command message. Any command message which contains that address will select the Target and enable its transmitter, any command message which does not contain that address will de-select the Target and disable its RS-232 transmitter.

5.11 TAG COLLISION RESOLUTION

The MK5 Target is capable of providing power to more that one Tag in its field. If several Tags are presented to the Target at once, the Target can perform collision resolution.

The MK5 Tag does not send any unsolicited messages. The MK5 Tag waits for a WakeUp message from the Target before responding with a Ping message in one of four time-slots. If the Target receives a non-garbled Ping message, it immediately responds (within two bit-times) with a PongValid character. The Tag then sends an ImAwake message (in response to the PongValid character) which the Target passes on to the application. If there are two or more Tags present and there is a collision, the Target responds to the garbled Ping message with a PongInvalid character and the Tag(s) will respond with a new Ping messages in new time-slots.

For the Target to interact with a MK5 Tag and to provide collision resolution:

- It must have been commanded to use the MK5 protocol;
- It must have been selected (if multi-dropped); and
- It must have been sent a wake-up message from the application.

The application to Target WakeUp message will be the first WakeUp message transmitted by the Target. The Target will continue broadcasting WakeUp messages until either commanded to stop doing so or until collision resolution with the first Tag entering the Target's RF field.

Collision resolution will have been completed when the Target receives the first valid SOM from a Tag. The Target will not re-broadcast the WakeUp message after collision resolution until the application again enables broadcasting and sends a new WakeUp message.

6. MK5 TARGET DESCRIPTION

- Size: 3.50-inch diameter x 0.835-inch thick +5-inch diameter x 0.040 inch thick mounting plate (or optional 4-inch diameter mounting plate).
- Weight: 1/4 lb. (about 1 lb. with optional surface-mounting case).
- Indicator: Three color LED (off, red/yellow/green)
- Back Lighting: Four Yellow LEDs (individually controlled)
- Case Material: Optional scratch-resistant, self-colored antenna cover; flame-retardant; 5½-inch diameter, 1 inch thick.
- Environment:
  - — Temperature: -35° C to +70° C operating; -40° C to +85° C storage

- — Humidity: 10% to 90% internal-mounted parts, 5% to 100% external
- Electrical Supply:
  - — Standard: 7 through 28 Volts at less than 2.5 Watts (including back-lighting).
  - — Optional: 5 Volts ±10% at less than 400 mA (less than 340 mA without back-lighting).
- Interface: RS232C, RS422/485 4 wire (see Figure 2), or logic level.
- Connectors (2): 1 signal: (5 wire) TX, RX, Multi-drop address 0 & 1, common
  1 power: (2 wire) +V, return (see Figure 3).
- Range: Depends upon mounting (surface or through-hole and near-by metal).
  Bare target: ~1 cm to ~6 cm; Metal ring: ~ contact to ~5 cm
- Separation: Minimum spacing between operation Targets is 12 inches.

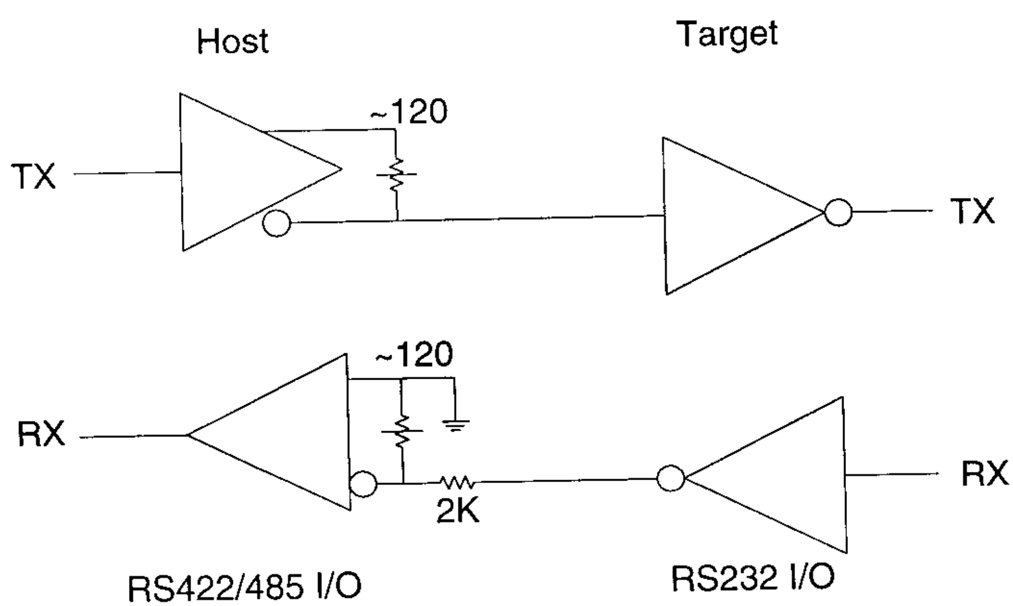

Figure 2. RS422/485 Four Wire Interface

SIGNAL CONNECTOR		
Signal Name	**PIN**	
TX		3
RX		2
Address 1		5
Address 0		4
Common		1

MATING CONNECTOR		
Wire Size		**Amp/PN**
	#22	644042-5
	#24	644020-5
	#26	644043-5

POWER CONNECTOR		
Function	**PIN**	
+V		3
Return		2
Not used		1

MATING CONNECTOR		
Wire Size		**Amp/PN**
	#22	644042-3
	#24	644020-3
	#26	644043-3

Figure 3. Connectors

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