

**ELIMINATING THE USE OF
TICKET TAKERS**

FHWA-OR-RD-98-14

by

Michelle Saunders, RAS

for

Oregon Department of Transportation
Research Unit
2950 State Street
Salem, OR 97310

and

Federal Highway Administration
Washington, D. C. 20560

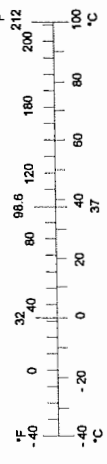
1. Report No. FHWA-OR-RD-98-14		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle Eliminating the Use of Ticket Takers				5. Report Date March 1998	
				6. Performing Organization Code	
7. Author(s) Michelle Saunders, RAS				8. Performing Organization Report No.	
9. Performing Organization Name and Address Oregon Department of Transportation Research Unit 2950 State Street Salem, Oregon 97310				10. Work Unit No. (TRAIS)	
				11. Contract or Grant No.	
12. Sponsoring Agency Name and Address Oregon Department of Transportation Research Unit 2950 State Street Salem, Oregon 97310 Federal Highway Administration and Washington, D.C. 20560				13. Type of Report and Period Covered Final Report Construction Season 1995	
				14. Sponsoring Agency Code	
15. Supplementary Notes					
16. Abstract The Oregon Department of Transportation tested an automated means of collecting data from paving trucks as an alternative to the traditional method of "ticket taking". A computerized communication system was designed and built by Quality Design Systems, Inc. (QDSI) of Eagle, Idaho to track and log information about vehicles and loads. The system's performance was adequate, except when overheated.					
17. Key Words AUTOMATION, COMMUNICATIONS, TICKET TAKERS, TRANSPONDER			18. Distribution Statement		
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of Pages 40	22. Price

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS			
Symbol	When You Know	Multiply By	To Find
		<u>LENGTH</u>	
in	inches	25.4	millimeters
ft	feet	0.305	meters
yd	yards	0.914	meters
mi	miles	1.61	kilometers
		<u>AREA</u>	
in ²	square inches	645.2	millimeters squared
ft ²	square feet	0.093	meters squared
yd ²	square yards	0.836	meters squared
ac	acres	0.405	hectares
mi ²	square miles	2.59	kilometers squared
		<u>VOLUME</u>	
fl oz	fluid ounces	29.57	milliliters
gal	gallons	3.785	liters
ft ³	cubic feet	0.028	meters cubed
yd ³	cubic yards	0.765	meters cubed
		<u>MASS</u>	
oz	ounces	28.35	grams
lb	pounds	0.454	kilograms
T	short tons (2000 lb)	0.907	megagrams
		<u>TEMPERATURE (exact)</u>	
°F	Fahrenheit temperature	5(F-32)/9	Celsius temperature °C

NOTE: Volumes greater than 1000 L shall be shown in m³.

APPROXIMATE CONVERSIONS FROM SI UNITS			
Symbol	When You Know	Multiply By	To Find
		<u>LENGTH</u>	
mm	millimeters	0.039	inches
m	meters	3.28	feet
m	meters	1.09	yards
km	kilometers	0.621	miles
		<u>AREA</u>	
mm ²	millimeters squared	0.0016	square inches
m ²	meters squared	10.764	square feet
ha	hectares	2.47	acres
km ²	kilometers squared	0.386	square miles
		<u>VOLUME</u>	
mL	milliliters	0.034	fluid ounces
L	liters	0.264	gallons
m ³	meters cubed	35.315	cubic feet
m ³	meters cubed	1.308	cubic yards
		<u>MASS</u>	
g	grams	0.035	ounces
kg	kilograms	2.205	pounds
Mg	megagrams	1.102	short tons (2000 lb)
		<u>TEMPERATURE (exact)</u>	
°C	Celsius temperature	1.8 + 32	Fahrenheit °F



* SI is the symbol for the International System of Measurement

ACKNOWLEDGEMENTS

The author would like to thank everyone at Roseburg Paving for the help they provided from conception to completion of this project. Without their support and encouragement, this project would never have been realized.

DISCLAIMER

This document is disseminated under the sponsorship of the Oregon Department of Transportation and the United States Department of Transportation in the interest of information exchange. The State of Oregon and the United States Government assume no liability of its contents or use thereof.

The contents of this report reflect the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official policies of the Oregon Department of Transportation or the United States Department of Transportation.

The State of Oregon and the United States Government do not endorse products of manufacturers. Trademarks or manufacturers' names appear herein only because they are considered essential to the object of this document.

This report does not constitute a standard, specification, or regulation.

ELIMINATING THE USE OF TICKET TAKERS

TABLE OF CONTENTS

1.0 INTRODUCTION.....	1
2.0 METHODS.....	3
3.0 FINDINGS	5
4.0 CONCLUSIONS AND RECOMMENDATIONS	7

APPENDICES

APPENDIX A: DESIGN SPECIFICATIONS

APPENDIX B: MICROSTAMP INFORMATION

1.0 INTRODUCTION

Oregon Department of Transportation (ODOT) construction projects that include materials such as aggregates and hot mix asphalt require an ODOT employee to collect weigh memos from the vehicles delivering the materials. This is necessary in order to establish the weight and document receipt of the material.

The employee responsible for collecting the documentation from the delivery vehicle driver is known as a “ticket taker”. This is one of the most dangerous jobs on a construction project. Any accident, injury or fatality on construction projects is unacceptable. Because of the high accident rate for ticket takers, alternatives to the ticket taker position were desired. Any alternative to the current method must provide a safe, accurate, and reliable means of retrieving the necessary information while still meeting contract and ODOT requirements.

After several discussions with scale companies, Federal Highway Administration (FHWA), other state DOTs, and software design companies, the study of a “scanner” type system was initiated.

The objective of this research was to develop specifications for an automatic data logging system that would eliminate the need for a ticket taker.

The following information is required by project specifications:

- Project identification (preferably the contract number)
- Load number
- Date of load
- Loading time
- Truck identification
- Driver identification
- Type of material
- Quantity (weight) of material
- Station placed (Delivery destination/milepost)

All software and hardware had to be compatible with that of the construction contractors. In anticipation of future enhancements, the system also had to be compatible with ODOT’s computer system. In addition to these requirements, an optimal system should track running weight totals, computer material pulls (ton of material/linear meter), and time of delivery. The system should also be able to note weight differences, if any, between the quantity sent from the plant and the quantity delivered to the project station.

2.0 METHODS

Although it was known what information would be needed from the system, software and hardware that would provide it were not available. It was necessary to find a software design company that could provide the specifications for such a system. ODOT entered into contract with Quality Design Systems, Inc. (QDSI) of Eagle, Idaho.

ODOT and QDSI agreed to the use of a short range radio frequency (RF) transceiver and computer units that would communicate between the pickup site, the transfer vehicle and the delivery site.

The scale and loading system at the loading site would need to send information to the host PC at the pick-up site. Manual entry of the information would also be an option. The system would use a communication unit (CU) to transmit this information to the truck. The truck unit would then store the information until the truck reached the delivery site, at which time it would transfer the information to a CU at the delivery site (located in the paver, handheld, etc.). This unit in turn would send the information to another host PC. Ideally this host PC would be located on a piece of equipment that all of the delivery trucks must approach, such as a paver or a blade at the delivery station.

Once a method of getting the information from the loading site to the delivery site was identified, the next step was to find or develop hardware that would be able to stand up to the demands of a road construction project.

Although this contract was for the development of specifications only, test projects in the Roseburg area were utilized to test for satisfactory results before the final specifications were accepted.

The design and construction of the communication units were the most difficult, costly, and time-consuming portions of the work. Initial engineering and reengineering caused the project to exceed QDSI time and cost estimates. Each unit was designed and built by hand in order to isolate as many potential problems as possible.

One of the main concerns was ensuring that the delivery site CU picked up only those trucks delivering to that project and only once per trip. This was solved by decreasing the "reading" distance between the truck and the delivery unit, by tracking both the truck CU and site CU by project identification number, and by having the truck CU cease transmission a set period of time after the initial reading at the delivery site. In addition, a global positioning type system on the equipment would allow delivery locations (station or milepost) to be picked up.

The host PC on the paver was encased in a clear plexiglass box to protect it from the elements. However, this may have contributed to reduced reliability, as the box and the PC became very hot.

3.0 FINDINGS

The CUs that QDSI designed were subjected to considerable field testing and worked well overall. One exception was the unit placed on the paver at the delivery site. Keeping the host PC within an operational temperature range was a problem. Despite the high temperatures associated with paving operations, the system had a 92.9% success rate in the field, recording 52 of the 56 loads sent from the plant. A higher rate of reliability is desirable if this type of system is to be widely used. Some type of cooling system, such as a fan, may have mitigated this effect on the PC. In addition to field testing, the system was successfully tested in a controlled environment.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Although the host PC at the delivery site was not fully operational (due to high temperatures) before completion of this contract, the research successfully identified components of a workable data logging system for projects requiring material to be run over a scale system. For details about the communication system tested for this project, see Quality Design Systems product specifications in Appendix A. If similar systems are to be used in the future, the communication units should be built to withstand temperature and climate conditions on construction projects.

In the time since this system was designed and tested, Micron Communications of Boise, Idaho has developed and marketed a similar system for commercial use (see Appendix B).

No comparative data on accident rates at sites with and without ticket takers was collected. However, the initial goal of enhancing safety by reducing accidents, injuries, and fatalities on construction projects was addressed by the design specifications. Other possible benefits of this system include:

- Improved efficiency and operations
- Lowered liability insurance for the contractor through reduction of accident potential
- Savings for DOTs through the reduction of FTEs and overtime wages. Ticket takers usually have more overtime hours than other positions.

Considering the potential benefits, both immediate and future, further testing and use of this type of scanner system on construction projects is recommended.

APPENDIX A
DESIGN SPECIFICATIONS

PROJECT DESCRIPTION:

This project deals with the problem of identifying quantities and types of materials being moved between pickup and delivery sites. Currently the driver of the transfer vehicle picks up materials and documentation at the pickup site and delivers them to personnel at the delivery site. This documentation verifies proper disposition of materials.

Since transfer of documentation is required at the pickup and delivery sites, a person is placed in an inherently dangerous situation. There is a significant and unacceptable probability of injury or fatality when a person has to work around heavy machinery. Thus, the client wishes to automate the process so that the field personnel will not be put at risk.

SOLUTION DESCRIPTION:

General:

The proposed solution is to use short range RF transceiver and computer units that will communicate between the transfer vehicle and the pickup and delivery sites. The transfer vehicle unit will store relevant information about identity and payload received from the pickup site unit. Then, upon arrival at the delivery site, it will transmit this information to the delivery site unit.

The pickup site and delivery site computers system should both be able to report, upon request, on the totals and statistics of the individual loads over a specified range of time periods.

The operators should be able reconcile the data collected between the batch plant system and the paver system, thereby matching the loads recorded (sent) by the batch plant system, and the loads recorded (received) by the paver system.

Solution Details:

The solution involves creating a communication unit (CU) using a microprocessor to generate Dual-Tone Multifrequency (DTMF) audio signals containing numeric and handshaking data via a constructed tone transceiver and transmitting the audio via a 49.83MHz FM transmitter. Each unit will be capable of receiving the data and decoding it for transmission via a "RS-232" serial connection to a host PC. Thus two or more of the complete units could communicate with each other bidirectionally and optionally store, manipulate, and translate data.

There will be a host PC at the pick-up site (batch plant) that receives information from the scale and loading system (batch plant computer) or receives information entered manually and uses a CU to transmit the information to the truck. The truck has a CU that stores the information until it reached the delivery site. The delivery site (paver) has a CU

that receives the information from the truck and sends that information to another host PC (laptop etc.).

Software on the batch plant's PC will read the electronic scale and loading data directly from the batch plant computers and format it for transmission to the truck. A manual way of entering this information will also be provided for those batch plant systems that are not automated. For automatic processing the system uses coordinates programmed into the computer to retrieve the data from a ticket by intercepting it before it is printed. These coordinates are programmable for each batch system but will always look for the same information (Gross, Tare, Date, Time, Type, etc.).

Each of the three different versions of the CU contains the following logical components. The differences between the three versions are present in the firmware (programming) of the boxes. The firmware can be uploaded and changed at a later date if it is necessary.

Logical Components:

1. DTMF Encoder (Tone generation and components)
2. DTMF Decoder (Tone translation and components)
3. FM Transceiver (Transmitter/Receiver and components)
4. CPU (Micro-processor and components)
5. Field/Base Computer System

Versions:

1. SCALE Unit designed for interface with a scale house based personal computer.
2. TRUCK: Unit designed for the transfer vehicle
3. PAVER: Unit designed for interface with a field computer located on a highway paving unit.

Scale Operational Logic:

The scale operations are designed to interface with a computer system (Scale Based Computer) that in turn interfaces with the contractor's batch plant system. It involves reading and decoding the contractor's printed tickets and transmitting them via the CU to the truck (Truck Communication Unit).

A. Scale Base Computer Software:

1. Receive ticket information from the contractor's batch system via an RS-232 serial connection.

2. Parse ticket data into the following components based on a position configuration grid that maps the X and Y coordinates of the data on a printed ticket. All data is NUMERIC only:
 - a) Truck ID number (4 digits)
 - b) Job ID number (2 digits)
 - c) Date (4 digits)
 - d) Time (4 digits)
 - e) Gross Weight (4 digits)
 - f) Tare Weight (4 digits)
3. Format ticket information as follows: aaaabbccccddddeeeeffff. Each letter represents a component described above.
4. Transmit the formatted information from step 3 to a comm. unit at 300bps with a 50ms pause between the characters. (a + 50ms pause + a . . .)
5. Wait for an 'ED' error code from the CU. (Timeout 10sec - no error)
6. Record the data in a database with the same data structure as the component description in step 2. Also record if the error was returned from the CU.
7. Return to step 1.

B Scale Version CU Firmware:

1. Receive information string from the base computer in the correct format (aaaabbccccddddeeeeffff) via. the serial port.
2. Use the truck number to page the truck as follows:
 - a) ssnd a DTMF 12 + 11 {command code indicator}
 - b) send a DTMF x + 11 {command number x- 1}
 - c) send a DTMF x + 11 {command length x, 4}
 - d) send a DTMF x + 11 {first digit of truck number}
 - e) send a DTMF x + 11 {second digit of truck number}
 - f) send a DTMF x + 11 {third digit of truck number}
 - g) send a DTMF x + 11 {fourth digit of truck number}
3. Wait for a response from the truck as a command code 2. See Truck version CU Firmware for data format of code 2 (Timeout: variable - redo step 2, 10 times max. or return to step 1 and send error 'E~ vo base computer)
4. Send data as follows:
 - a) send DTMF x + 11 {byte 1}
 - b) send DTMF x + 11 {byte 2}
 - c) etc. {All 21 bytes}

5. Wait for a response from the truck as a command code 3. See Truck version CU Firmware for data format of code 3. (Timeout: variable - redo step 2, 10 times max. or return to step 1 and send error 'EX to base computer).

Truck Operational Logic:

The truck operations are designed to receive information from the scale units (Scale CU) and transfer it to the paver units (Paver CU)

A. Truck Version CU Firmware:

1. Wait for the truck number that matches the unit's number as a command code 1. The truck units are pre-programmed with the unit numbers. See Scale Version CU Firmware for data format of code 1.
2. Send a response to the scale unit as follows:
 - a) send DTMF 12 + 11 (command code indicator)
 - b) send DTMF 2 + 11 (Truck ack. to scale page)
3. Receive the data from the truck. See Scale Version CU Firmware for the data format.
4. Store the data as it is received.
5. Send a response to the scale unit as follows:
 - a) send OTMF 12 + 11 (command code indicator)
 - b) send DTMF 3 + 11 (Truck ack. to scale data)
6. Set the unit's load indicator LED to RED to indicate a stored load.
7. Wait for a page from the paver CU as a command code 4. See Paver Version CU Firmware for the format of code 4. If a command code 1 is received return to step 1.
8. Send the truck number currently stored as a command code 1. See Scale Version CU Firmware for data format of code 1.
 9. Wait for a command code 1 from paver as sent above. See Paver Version CU Firmware for the format of code 1. {Timeout: variable - return to step 7}
10. Send the data. See Scale Version CU Firmware for the format of the data.
11. Wait for a command code 6 from the paver. See Paver Version CU Firmware for the format of code 6. (Timeout: variable - return to step 7)
12. Set the unit's load indicator LED to GREEN to indicate no load.
13. Return to step 1

Paver Operational Logic:

The paver operations are designed to interface with a computer system (Paver Base Computer) and to retrieve information from the truck units (Truck CU) and in turn send that information to the computer system.

A. Paver Base Computer Software:

1. Display current list of loads on the screen
2. Wait for a correctly formatted data string from the CU on the serial port in the following format: aaaabbccccddddeeeeffff. Each letter represents a component described below.
3. Parse the above string into the following components:
 - a) Truck ID number (4)
 - b) Job ID number (2)
 - c) Date (4)
 - d) Time (4)
 - e) Gross Weight (4)
 - f) Tare Weight (4)
4. Store the data in a database of the same data structure.
5. Return to step 1

B) Paver Version CU Firmware:

1. Send a page to the truck as a command code 4 as follows:
 - a) send DTMF 12 + 11 (command code indicator)
 - b) send DTMF 4 + 11 (paver initial page)
2. Wait for a truck number as a command code 1. See Scale Version CU Firmware for the data format of code 1. (Timeout variable - return to step 1)
3. Re-transmit command code 1 as received above.
4. Receive the data. See Scale Version CU Firmware for the format of the data.
5. Send command code 6 to the truck as follows:
 - a) send DTMF 12 + 11 (command code indicator)
 - b) send DTMF 6 + 11 (paver initial page)
6. Send the data to the Paver Base Computer via the serial port at 300bps.
7. Return to step 1.

Specification Summary:

The above specification describes a system that meets all of the requirements as stated above. If there are questions about these specifications, they should be directed to Gene Williams at Quality Design Systems (208) 939-8609.

APPENDIX B
MICROSTAMP INFORMATION



MICRON
COMMUNICATIONS, INC.

MSIMX400D Data Sheet
(U.S.A. Version)

MicroStamp® 4000 Interrogator

General Description

The function of Micron Communications' MicroStamp 4000 RF interrogator is twofold: 1) it receives commands and data from a host computer and sends data packets to remote intelligent communications (RIC) units, and 2) it receives reply packets from RIC units and passes the reply back to a host computer. When an interrogator receives a command from a host computer, the interrogator either executes the command internally, or transmits the command to one or more RIC units. RIC units then execute the command, but may or may not reply, depending on the command's specific function. When a RIC unit replies, the interrogator passes the reply back to a host computer.

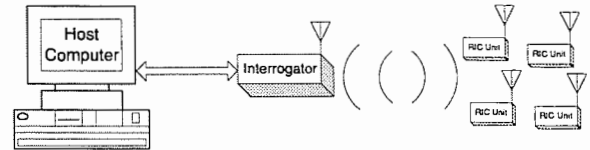
The MicroStamp 4000 interrogator is designed to interface with a host computer via either an enhanced parallel port (EPP) or a serial port. The communication configurations for these formats are further outlined in this document.

Detailed information on the MicroStamp RIC standard interrogator is contained in the *MicroStamp® RIC Standard Programmer's Reference Manual*. To learn more about how the MicroStamp interrogator can work for your business, call toll free (within the U.S.) 1-800-MICROStamp (1-800-642-7678), or visit the Micron Communications web site at www.microncommunications.com. For international calls, dial your country code then 1-208-333-7481.

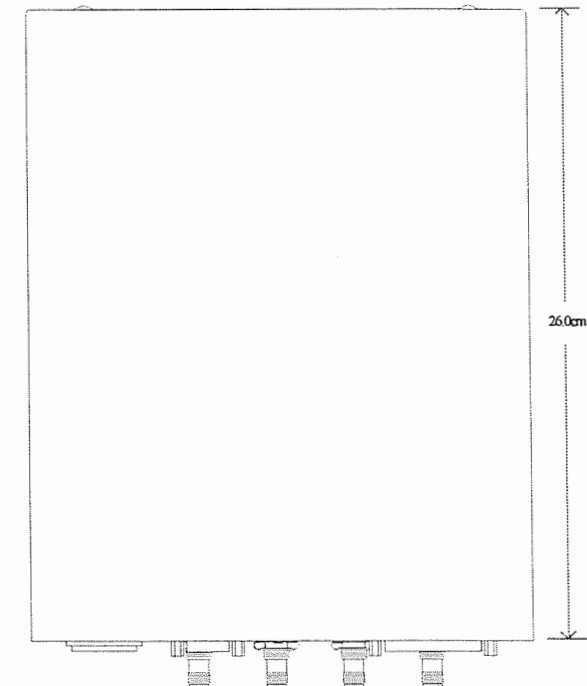
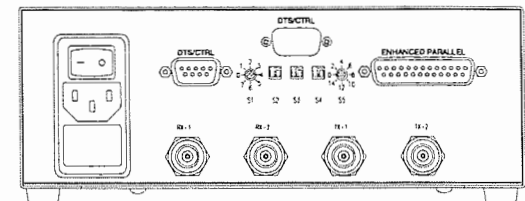
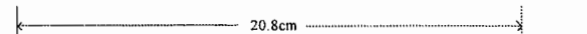
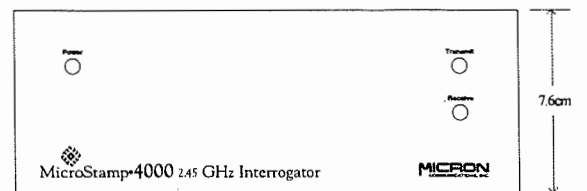
Features and Specifications

- ➔ The MicroStamp remote intelligent communications (RIC) standard protocol is used as its communications platform
- ➔ Forward (down) link is direct sequence spread spectrum (DSSS) with center frequency of 2.442 GHz
- ➔ Return (up) link is Modulated Backscatter (MBS) with 75 hopping channels in 3 bands, using a 596 kHz DPSK modulated subcarrier
- ➔ Two-antenna diversity on both transmit and receive
- ➔ Host-to-interrogator communications:
Enhanced parallel port (IEEE-1284)
or
RS-232, RS-422, or RS-485 serial connection
- ➔ **Physical Dimensions:** 26.0cm x 20.8cm x 7.6cm
- ➔ **Voltage:** 110/220 VAC
- ➔ **VA Rating:** 50 VA, fused at 1 amp, 47-63 Hz, 85-256 VAC
- ➔ **Weight:** 2,900 grams
- ➔ **Optimum Temperature Range:** 0 to 50° C

This device complies with Part 15 of the U.S.A. FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation. The unique identifier for this product is MSINT.



Typical Configuration



Physical Communication Protocol

The interrogator-to-RIC unit (interrogator-to-tag) and the RIC unit-to-interrogator (tag-to-interrogator) communications use different physical protocols. Both communication protocols are discussed in the following paragraphs.

Interrogator-to-RIC Unit Physical Communication Protocol

The interrogator-to-RIC unit physical communications protocol is called the “forward link” protocol. The interrogator sends forward link data in the following order:

Preamble,
Barker Code,
Command Packet,
Checksum.

Spread Spectrum “Chipping” Pattern

A Maximal Length Pseudo Noise (PN) Sequence is used in the Direct Sequence Spread Spectrum (DSSS) communications scheme in the forward link. A linear feedback shift register of the form [5,2] generates the sequence. There are 5 registers, and the output of register 2 is X-ORed with the output of register 5, and the result is fed into the input of register one. This produces a repeating 31 “chip” sequence. The sequence ends with all registers set to one. The sequence is taken from the output of register one. This code is synchronous with the data in that each data bit comprises one, full PN sequence. The chip sequence for each bit is:

001 1010 0100 0010 1011 1011 0001 1111.

A zero bit is transmitted as one inverted full cycle of the PN sequence. A one bit is transmitted as one non-inverted full cycle of the PN sequence. The data is not differentially encoded. The chip sequences are used to AM modulate a 2.442 GHz carrier.

Preamble

The preamble precedes the data. The format for the preamble is:

1. A series of zeros for a duration equal to the wakeup interval (0.5, 4, 16, or 256 ms) plus a guardband followed by
2. A 13-bit start (Barker) code.

The Barker code is defined by the following bit string:

1111 1001 10101.

Command Packet

The command data is grouped into 13-bit words. Each word comprises eight data bits and five ECC (Error Correction Code) bits. The bit transmission order is (with D7 transmitted first):

D7, D6, D5, D4, D3, D2, D1, D0, P4, P3, P2, P1, P0...

The Block ECC bits (P4-P0) are generated using the following equations:

$$P0 = (D1 + D2 + D5 + D7) \text{ modulo } 2$$

$$P1 = [(D1 + D3 + D4 + D6) \text{ modulo } 2] \text{ Complement}$$

$$P2 = (D0 + D2 + D3 + D6 + D7) \text{ modulo } 2$$

$$P3 = [(D0 + D4 + D5 + D6 + D7) \text{ modulo } 2] \text{ Complement}$$

$$P4 = (D0 + D1 + D2 + D3 + D4 + D5) \text{ modulo } 2.$$

The data band has an effective data rate (adjusting for PN and ECC) of 189.3 Kbps.

Checksum

A 16-bit checksum* detects bit errors on the packet level.

RIC Unit-to-Interrogator Physical Communication Protocol

The RIC unit-to-interrogator (tag-to-interrogator) physical communications protocol is referred to as the "return link" protocol. The return link messages are sent in the following order:

Preamble,
Barker Code,
Reply Packet,
Checksum.

Return Link Modulation

After sending a command, the interrogator sends a continuous unmodulated RF signal on one of its pseudo-randomly selected channels. Return link data is Differential Phase Shift Key (DPSK) modulated onto a square wave subcarrier with a frequency of 596 kHz. A data 1 corresponds to no phase change from the previous bit, and a data 0 corresponds to a 180° phase change from the previous bit. The subcarrier is used to modulate a RIC unit's antenna impedance. For a simple dipole antenna, a switch between the two halves of the dipole antenna is opened and closed. When the switch is closed, the antenna becomes the electrical equivalent of a single half-wavelength antenna that reflects a portion of the power being transmitted by the interrogator. When the switch is open, the antenna becomes the electrical equivalent of two quarter-wavelength antennas reflecting very little of the power transmitted by the interrogator.

* The MicroStamp RIC Standard calls for a 16-bit CRC, which will be implemented on future products.

Preamble

The preamble contains the following bit stream:

1. Preamble (2000 bits, alternating zeros and ones, before differential encoding)
2. A 13-bit start (Barker) code.

The following bit string defines the start or “Barker” Code:

1111 1001 1010 1.

Reply Packet

The data is grouped in 13 bit words. Each word is composed of 8 data bits and 5 ECC bits.

The Block Encoded Sequence is D7, D6, D5, D4, D3, D2, D1, D0, P4, P3, P2, P1, P0.

The Block ECC Bits (P4-P0) are generated using the following equations:

$$P0 = (D1 + D2 + D5 + D7) \text{ modulo } 2$$

$$P1 = [(D1 + D3 + D4 + D6) \text{ modulo } 2] \text{ Complement}$$

$$P2 = (D0 + D2 + D3 + D6 + D7) \text{ modulo } 2$$

$$P3 = [(D0 + D4 + D5 + D6 + D7) \text{ modulo } 2] \text{ Complement}$$

$$P4 = (D0 + D1 + D2 + D3 + D4 + D5) \text{ modulo } 2.$$

The bit duration is 6.71 μ s, making the effective data rate 91.75 Kbps.

Checksum

A 16-bit checksum* is provided to detect bit errors on the packet level.

Interleaving

Each pair of data words is interleaved, starting with the Barker code and the first data word. The transmitted bit order for two sequential words, A and B, is D7A, D7B, D6A, D6B, D5A, D5B, D4A, D4B, D3A, D3B, D2A, D2B, D1A, D1B, D0A, D0B, P4A, P4B, P3A, P3B, P2A, P2B, P1A, P1B, P0A, P0B. D7A is the first transmitted bit. DPSK is applied to the interleaved data.

* The MicroStamp RIC Standard calls for a 16-bit CRC, which will be implemented on future products.

Interrogator Hardware Description and Specification

Table 1 outlines the RF specifications for the forward link (interrogator-to-tag) and the return link (tag-to-interrogator) for the MicroStamp system. Two Circuit Card Assemblies (CCAs), a power supply, and a chassis comprise the main components of MCC's interrogator. Figure 1 shows the CCAs for the interrogator. These CCAs are described below.

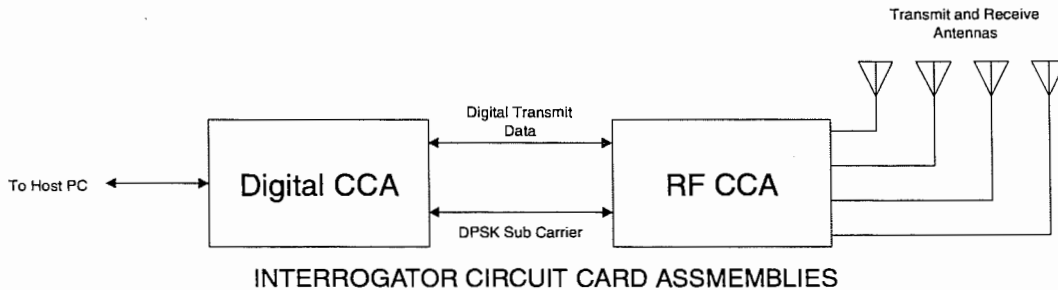


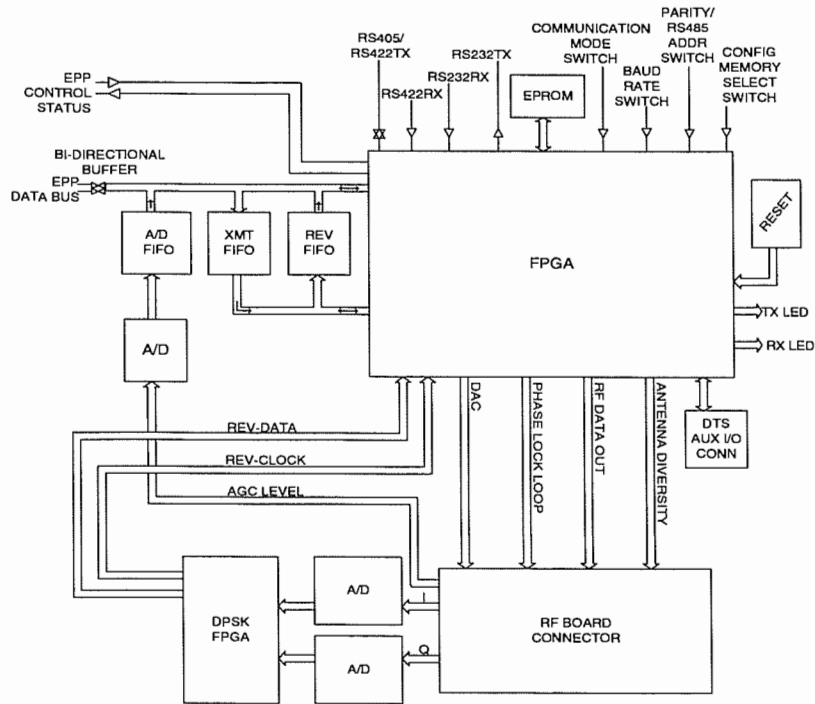
Figure 1

Digital CCA

The Digital CCA may be divided into two sections, a control section and a data demodulation section.

Figure 2 shows a functional block diagram of the control section of the Digital CCA. The interrogator uses an IEEE-1284 (EPP), RS-232, RS-422 or RS-485 port to communicate with a host PC (the serial interfaces, RS-232, RS-422 and RS-485, are industry standard interfaces). The control section provides all the digital logic required to coordinate sending and receiving a message with a RIC unit. The control section buffers host transmission data, converts the data to serial data, and encodes it. The control section then waits for data from the RIC unit, converts it to parallel, and transfers it to the host. Messages consist of up to 64 bytes of user data for MicroStamp RIC units.

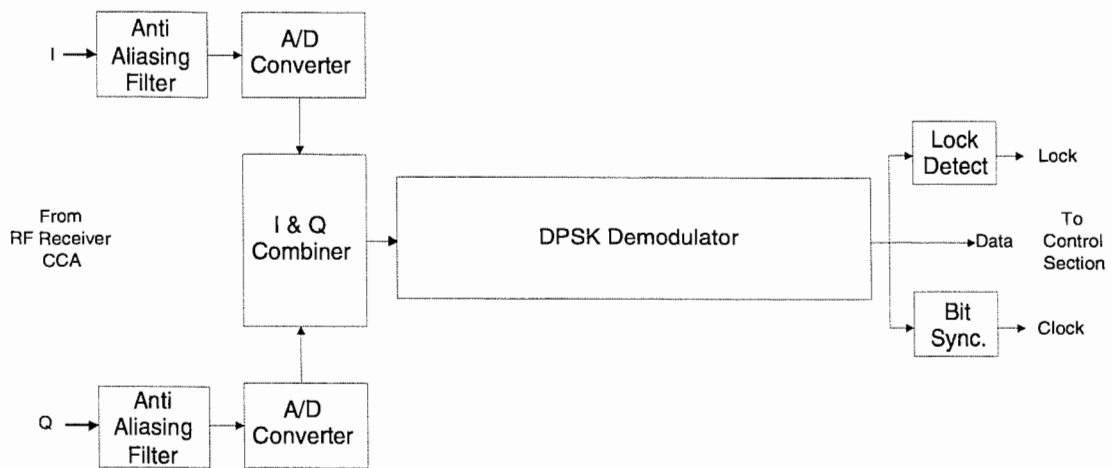
The EPP interface provides an asynchronous, interlocked, byte wide, bi-directional channel that a host device controls. The EPP mode allows the host computer to transfer, at high speed, a data byte to/from the interrogator within a single host computer CPU I/O cycle (typically 0.5 microseconds per byte). The interrogator buffers the EPP interface signals and contains circuits to minimize reflections and ringing. The IEEE-1284 EPP standard supports a maximum cable length of 30 feet.



INTERROGATOR
COMBO CIRCUIT CARD ASSEMBLY

Figure 2

Figure 3 shows a functional block diagram of the DPSK section. The DPSK section receives an I and Q signal, containing the DPSK modulated subcarrier, from the RF CCA. The I and Q signals are anti-alias filtered and converted from analog to digital signals. The signals are then combined and sent to the DPSK demodulator. The data, clock, and a lock detect signal are then sent to the control section.

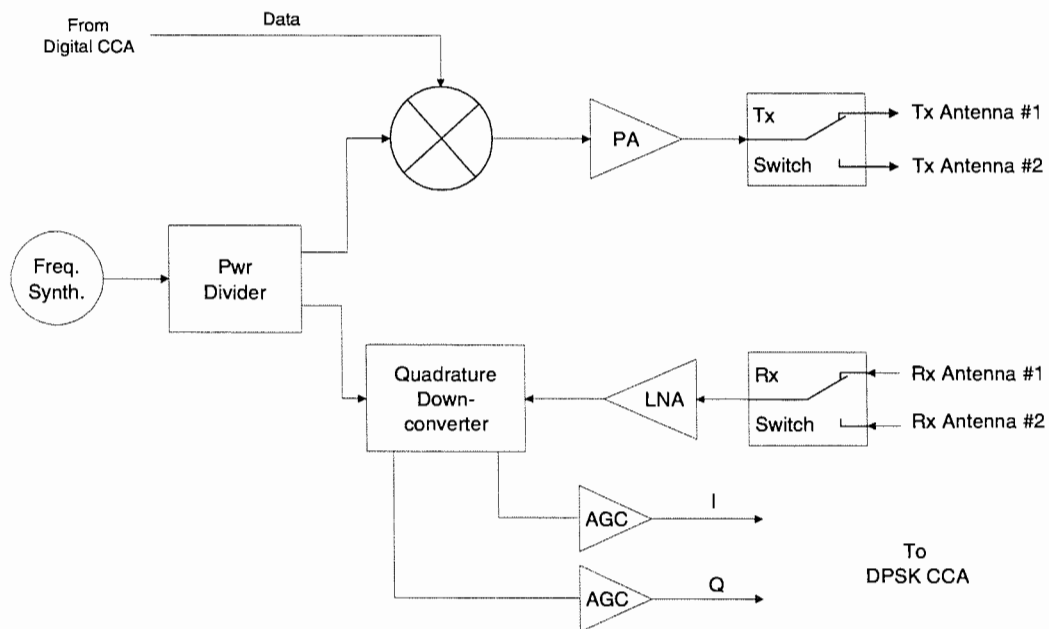


INTERROGATOR
DPSK SECTION BLOCK DIAGRAM

Figure 3

RF (Radio Frequency) CCA

The RF CCA interfaces with the external transmit and receive antennas. The RF CCA performs three main functions: it modulates the data for transmission to a RIC unit, it provides a continuous wave (CW) carrier for the RIC unit backscatter, and it receives and downconverts the backscatter signal from the RIC unit. Also, a synthesizer is built onto the CCA to tune the RF CW carrier for frequency hopping and band selection. Figure 4 shows a functional block diagram of the RF CCA. The transmitter receives data from the Digital CCA. This data is low pass filtered and then AM (amplitude modulated) modulated onto a carrier using a mixer. The signal is then amplified with the power amplifier (PA) and sent to the diversity switch for transmission through one of two antennas. During CW transmission for backscatter mode, the mixer is biased to the on state. When the transmitter is in CW mode, the RIC unit backscatters the signal with a DPSK modulated sub carrier. This signal is received via one of the two diversity antennas and is amplified by the low noise amplifier (LNA). The signal is coherently downconverted using a quadrature downconverter. The amplitude of the signals are then set using automatic gain controls (AGCs). The I and Q signals, which contain the DPSK modulated subcarrier, are then passed to the DPSK CCA for demodulation.

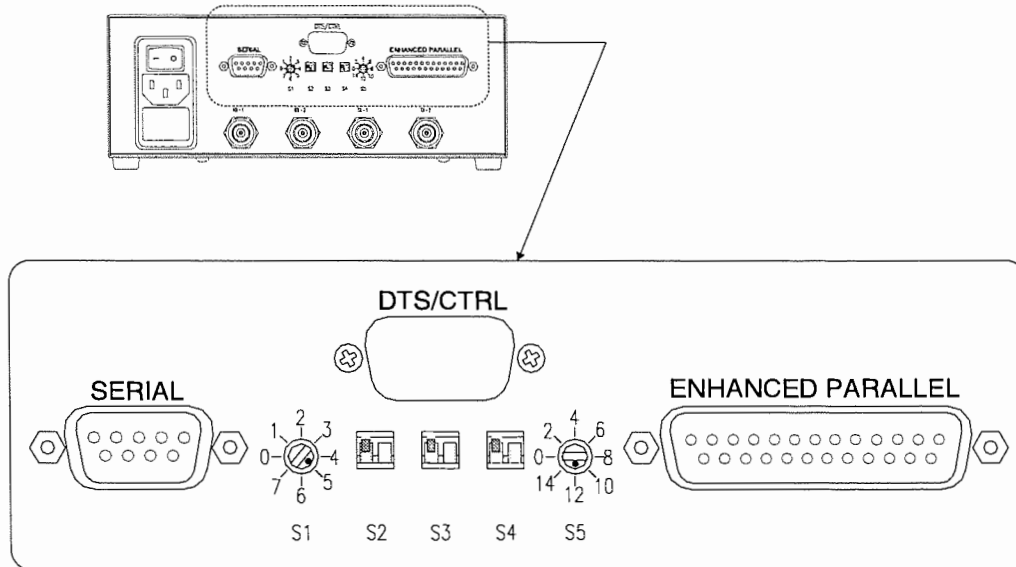


INTERROGATOR
RF Circuit Card Block Diagram

Figure 4

Host Communication Interface Selection

The MicroStamp 4000 Interrogator uses four host communication formats: 1 parallel and 3 serial: RS-232, RS-422, and RS-485. All serial formats use the serial port connector on the back of the interrogator. Enhanced Parallel Port (EPP) communications use the enhanced parallel connector (IEEE-1284 standard). The following sections define the functions of switches one through five (S1--S5). The table below shows the communication format settings.



INTERROGATOR
HOST COMMUNICATION INTERFACE PANEL
Figure 5

The following table identifies each switch, each switch's function, and the type of switch used for each function, on the MicroStamp 4000 Interrogator. The remainder of this data sheet describes these switches in more detail.

Switch	Function	Type
S1	Baudrate Selection for RS-232, RS-422, RS-485	8-Position Rotary
S2	Bus Termination for RS-422 or RS-485	2-pole, single throw
S3	Communication Format EPP, RS-232, RS-422, RS-485	2-pole, single throw
S4	Firmware Configuration selector	2-pole, single throw
S5	RS-232/RS-422 Parity Select or RS-485 address	16-position rotary

Table 1: INTERROGATOR SWITCH ASSIGNMENTS

Baudrate (S1)

To select the baudrate, when using any of the serial communication formats, turn the rotary switch to the corresponding position indicated in Table 2.

The table below shows the dial positions and their associated rates. *Note that the arrow on the switch points to the S1 position.*

Baudrate	S1 Position
115200	7
57600	6
28800	5
19200	4
14400	3
9600	2
undefined	1
undefined	0

Table 2: SWITCH S1--BAUDRATE SELECTION

Bus Termination Selection for RS-422 and RS-485 (S2)

On interrogators using RS-422 and RS-485 formats, the bus may need to be terminated. Generally, the last unit on a bus needs to be terminated in order to prevent unwanted data ringing.

RS-422 bus termination can be selected according to Table 3.

State	Communication Path	S2.Left	S2.Right
Unterminated	receive (host-to-interrogator)	--	up
	transmit (interrogator-to-host)	up	--
Terminated	receive (host-to-interrogator)	--	down
	transmit (interrogator-to-host)	down	--

Table 3: SWITCH S2--RS-422 BUS TERMINATION SELECTION SWITCH

The left side of S2 should be in the down position when terminating RS-422 or RS-485 connections on *transmit* links. The right side of switch two (S2) should remain in the down position when terminating RS-422 connections on *receive* links.

RS-485 bus termination can be selected according to Table 4.

State	Communication Path	S2.Left	S2.Right
Unterminated	receive (host-to-interrogator)	up	--
	transmit (interrogator-to-host)		
Terminated	receive (host-to-interrogator)	down	--
	transmit (interrogator-to-host)		

Table 4: SWITCH S2--RS-485 BUS TERMINATION SELECTION SWITCH

Communication Formats

Switch 3 (S3) specifies the type of communication formats available on the Interrogator. The interrogator can be configured for one of the following formats:

- EPP,
- RS-232,
- RS-422,
- RS-485.

Format	S3.Left	S3.Right
EPP	up	up
RS-485	up	down
RS-422	down	up
RS-232	down	down

Table 5: SWITCH S3--COMMUNICATION FORMAT SELECTION

The EPP, RS-232, and RS-422 interfaces use a dedicated port on the host computer, while the RS-485 uses its address capability to communicate with (up to) sixteen interrogators on the same bus. The interrogator does not support handshaking, supports one or two stop bits when receiving data, and always transmits data with two stop bits.

Personality Module Selection Switch (S4.Right)

The MicroStamp 4000 Interrogator can be configured from two unique memory maps. One memory map is a permanent factory module. The second map is field upgradeable. The factory setting (S4.Right) should be used unless a field upgradeable module has been previously uploaded.

Personality Module Selection	S4.Left	S4.Right
Default Factory Module	unused	down (default)
Uploaded Module	unused	up

Table 6: SWITCH S4--PERSONALITY MODULE SELECTION SWITCH SETTINGS

Parity Select or RS-485 Address (S5)

Switch 5 (S5) is used only with a serial connection and has two functions, depending on the type of serial format (S3). If using RS-232 or RS-422, S5 determines the type of parity, as shown in Table 7. Note: as of this printing, the MSSL supports only parity type "none."

RS-232/RS-422	Dial Position
Mark	15
Even	14
Odd	13
Space	12
None	11
Do not use	0-10

Table 7: SWITCH S5--RS-232 AND RS-422 PARITY SELECTION SWITCH SETTINGS

If using RS-485, the position of S5 determines the unit address (see Table 9). No parity is generated for RS-485.

RS-485 Unit Address	Dial Position
15	15
14	14
13	13
12	12
11	11
10	10
9	9
8	8
7	7
6	6
5	5
4	4
3	3
2	2
1	1

Table 8: SWITCH S5--RS-485 UNIT
ADDRESS SELECTION

Serial and EPP Connector Pin Assignments

The following tables show the pin assignments for the RS-232 9-pin serial cable and the 25-pin EPP cable. RS-422 and RS-485 connections use non-standard pin locations and must be custom manufactured. When manufacturing RS-422 and RS-485 cables, make sure that host transmit data (output data) connects to the interrogator receive pin (similar to a null-modem cable).

Serial Connector Pin Assignments

Pin	Signal
1	unused
2	RS-232 Transmit
3	RS-232 Receive
4	unused
5	Signal Ground (100 ohm pull down)
6	RS-422 Transmit + / RS-485 +
7	RS-422 Transmit - / RS-485 -
8	RS-422 Receive +
9	RS-422 Receive -

Table 9: SERIAL CONNECTION PIN ASSIGNMENTS

EPP Connector Pin Assignments

Pin	Signal
1	Write/
2	D0
3	D1
4	D2
5	D3
6	D4
7	D5
8	D6
9	D7
10	Interrupt/
11	Wait/
12	SP1 (unconnected)
13	SP2 (unconnected)
14	Data Strobe/
15	SP3 (unconnected)
16	Reset/
17	Address Strobe/
18	Signal Ground
19	Signal Ground
20	Signal Ground
21	Signal Ground
22	Signal Ground
23	Signal Ground
24	Signal Ground
25	Signal Ground

Table 10: EPP CONNECTION PIN ASSIGNMENTS

Specifications for the MicroStamp 4000 RF Interrogator

Physical Characteristics

Size	26cm x 20.8cm x 7.6cm
Weight	3,969 grams
Power	115 VAC, 300 mA

Forward Link (interrogator-to-tag)

Master Clock	19.075 MHz
Data Rate	307.66 kbps (effective 189.33 kbps)
Frequency	2442 MHz
Modulation	Filtered OOK
Transmit Power	500mW (+27 dBm) max
Direct Sequence Spread Spectrum	31 chips per bit
Chipping Rate	9.5375 Mcps
Code length	31
Error Correction/Detection	16-bit checksum, 5-bit parity (1-bit correction, 2-bit detection)
Demodulation Technique (on tag)	Diode Detector (Square Law Device)

Return Link (tag-to-interrogator)

Data Rate (instantaneous)	149 kbps (effective 91.75 kbps)
Frequency Bands	low 2418 MHz (2403 - 2433) mid 2442 MHz (2427 - 2457) high 2465 MHz (2450 - 2480)
Modulation	Backscatter with DPSK subcarrier
Sub Carrier frequency	596 kHz
Frequency Hopping	75 Frequencies per band, 400 kHz spacing
Hopping Rate	Once each message
Message Length	varies up to 104 bytes
Receiver sensitivity	-80 dBm min
Sub carrier demodulation	DPSK using DSP
Error Correction	16-bit checksum, 5-bit parity (1-bit correction, 2-bit detection)
Interleaving	Each pair of data words is interleaved

Table 11: GENERAL SPECIFICATIONS



MICRON
COMMUNICATIONS, INC.

MicroStamp® 10ML

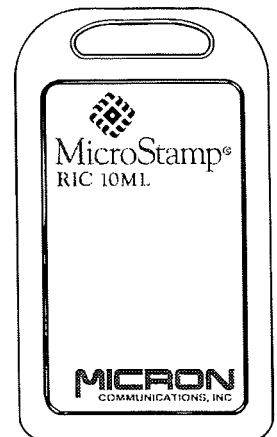
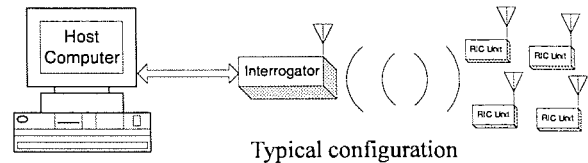
MSMMD256X10S L Data Sheet

General Description

The MicroStamp 10ML is a remote intelligent communications (RIC) tag designed to attach, via a keychain or strap, to any number of portable objects (such as clothing, keys, or luggage). The tag receives and reflects data packets at a frequency of 2.45 GHz. The 10ML is a board-level product that integrates two batteries, a MicroStamp Engine™ 20-pin SOIC, and transmit and receive antennas.

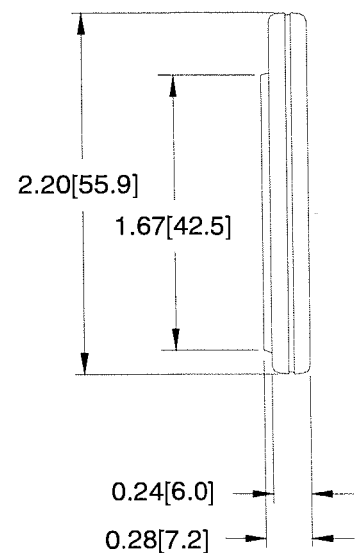
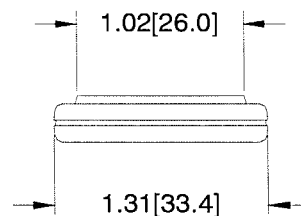
Remote intelligent communications (RIC) units execute functions after receiving commands from an interrogator (illustrated above). In a typical RFID communication sequence, a host computer sends a command to an interrogator; the interrogator either executes the command internally, or transmits the command to one or more RIC units. RIC units then execute the command, but may or may not reply, depending on the command's specific function. When RIC units reply, the interrogator passes the reply back to the host computer.

Detailed information on the MicroStamp RIC standard protocol and the functions associated with MicroStamp products are contained in the *MicroStamp® RIC Standard Programmer's Reference Manual*. To learn more about how the MicroStamp 10ML can work for your business, call toll free (within the U.S.) 1-800-MICROStamp (1-800-642-7678), or visit the Micron Communications web site at www.microncommunications.com. For international calls, dial your country code then 1-208-333-7481.



Features and Specifications

- ➔ "Keychain" or "strap" mounting
- ➔ Uses the MicroStamp remote intelligent communications (RIC) standard protocol as its communications platform
- ➔ Uses the MicroStamp Engine 20-pin SOIC, transmit and receive antennas, and batteries
- ➔ Forward (down) link is direct sequence spread spectrum (DSSS) with center frequency of 2.442 GHz
- ➔ Return (up) link is Differential Phase Shift Keyed (DPSK) Modulated Backscatter (MBS) in the 2.400-2.4835 GHz band, 596 kHz subcarrier
- ➔ Read/write range, (line of sight)*: up to 6 meters
- ➔ 256 bytes of user RAM
- ➔ Water resistant
- ➔ Two non-replaceable batteries
- ➔ **Physical Dimensions:** 55.9mm x 33.4mm x 7.2mm
- ➔ **Operational Temperature Range:** -20 to +50°C
- ➔ **Storage Temperature Range:** -40 to +60°C**
- ➔ **Read/Write Transactions:** 200k read/write transactions at -20°C***
300k read/write transactions at 0°C
500k read/write transactions at 20°C
- ➔ **Weight:** 13 grams



inches[millimeters]

* As tested at Micron Communications in an anechoic chamber with 30 dBm into a 6 dBi antenna (Distances will vary depending on environmental conditions.)

** Storage time at temperature extremes should not exceed one month.

*** (16 msec wakeup interval) Specified number of read/write transactions may vary according to spurious environmental RF energy.