

WM71004 / WM71008 / WM71016

*4/8/16Kbit Secure F-RAM Memory with
Gen-2 RFID Access*

RAMTRON**DESCRIPTION**

The WM710xx is a RFID transponder IC with nonvolatile memory employing an advanced ferroelectric process. A ferroelectric random access memory, or F-RAM, is nonvolatile and performs reads and writes like a RAM. It provides reliable data retention for 20 years while eliminating the complexities, overhead, and system level reliability problems caused by EEPROM and other nonvolatile memories.

Unlike EEPROM's, the WM710xx write operations are zero power – there is no power or speed premium paid for executing writes into the WM710xx as compared to read power and speed. Operation of the memory is fully symmetric: identical read and write characteristics in terms of power, speed, and reliability.

The WM710xx's RFID interface is compliant with the EPC Class-1 Generation-2 UHF RFID Protocol for Communications at 860 MHz – 960 MHz, Version 1.2.0 Specification for RFID Air Interface.

The WM710xx is a two chip configuration offered in various forms: standard IC package or wafers. All specifications discussed herein are applicable to the combined chipset operation.

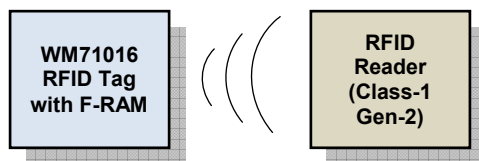


Figure 1. System Block Diagram

FEATURES**4/8/16 Kbit Ferroelectric Nonvolatile RAM**

- Organized as 256/512/1024 x 16 bits
- Very High Read/Write Endurance ($> 10^{15}$)
- 20-Year Data Retention
- Gamma Stability Demonstrated to > 30 kGy
- Symmetric Read/Write Operation
- Advanced High-Reliability Ferroelectric Process

Interface and Security Features

- EPC Class 1 Gen2 (ISO18000-6C) RFID Compliant Interface (revision 1.2.0)
- 192-Bit Memory: 96-Bit Electronic Product Code™ (EPC), 32-Bit Access Password, 32-Bit KILL Password, 64-Bit TID Memory (Factory Programmed and Locked)
- Inventory, Read, Write and Erase features
- Kill Command
- Block Permalock Command
- Access Command
- UHF carrier frequencies from 860 MHz to 960 MHz ISM band, ASK demodulation
- Link frequencies up to 640Kbps and reader-to-tag rates up to 128Kbps read and write transmission

Custom Features

- Stored Address Pointer to Improve Data Write Speed
- Stored Address Pointer Lock
- Block Write Command
- Variable USER Memory Block Size Support

Ultra Low Power Operation

- Memory Read/Write Sensitivity: < -13 dBm, typ.

Industry Standard Configurations

- Industrial Temperature -40° C to $+85^{\circ}$ C
- Bumped Wafers
- 8-pin UDFN

This is a product that has fixed target specifications but are subject to change pending characterization results.

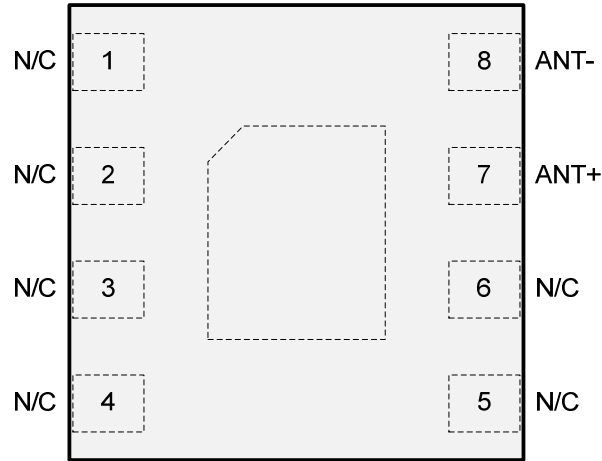
Ramtron International Corporation

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<http://www.ramtron.com>

PIN CONFIGURATION (UDFN PACKAGE)

Top View
(PCB Layout)



3.0 mm × 3.0 mm body, 0.65 mm pad pitch

PIN DESCRIPTION

| Pin Name | Pin Number | Type | Description |
|------------|------------------|-------|---|
| ANT-, ANT+ | 8, 7 | Input | RFID Antenna. Connect to external RFID antenna terminals. |
| N/C | 1, 2, 3, 4, 5, 6 | - | There is no internal connection. |

FUNCTIONAL DESCRIPTION

The WM710xx is a non-volatile memory device with an industry standard UHF RFID interface that enables processing data in and out of memory as a generic passive RFID transponder. Unlike other transponder ICs, the WM710xx transponder IC contains high density symmetric read/write F-RAM memory that enables unique applications of an RFID solution.

When combined with an appropriate antenna design, WM710xx will power up with energy harvested directly from the RF field. Following an internally generated reset state, the IC configures itself according to pre-programmed configuration settings that were stored in F-RAM non-volatile memory at wafer probe, packaged parts test, or end unit transponder personalization at end-user depot. Configuration settings are read out of memory and applied prior to enabling data transmission in or out of memory.

As specified in the Gen2 standard, the chip receives and processes commands transmitted by the RFID interrogator (reader). All required and most optional commands are supported. In addition to these, WM710xx supports a number of custom commands that take advantage of F-RAM's unique ultra low power and symmetrical characteristics.

Referring to Figure 2, the transponder IC's consist of an RFID interface, control and authentication logic, F-RAM memory, and power management unit. The external antenna is connected directly to the RFID interface where the RF signal is rectified with high efficiency Schottky diode based rectifier. The rectified voltage is multiplied up within the Schottky array and then regulated to supply power to on-chip resources.

Also included in the RFID Interface is a modulator/demodulator that detects incoming signals and modulates the input impedance to enable backscattering of returned signals. The control and authentication logic processes commands to enable access in and out of F-RAM memory.

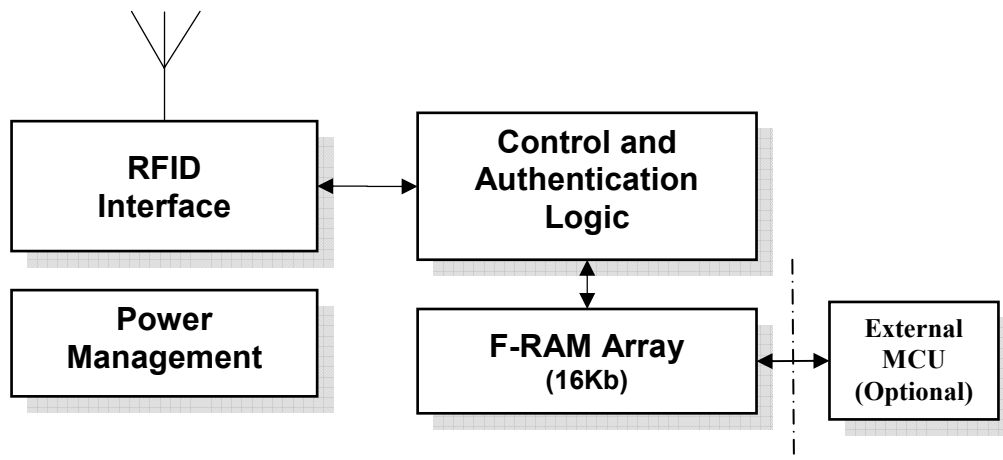


Figure 2. Block Diagram

MEMORY MAP

WM710xx’s memory is partitioned according to the logical and physical mapping shown in Table 1 below.

Table 1: Memory Map

| Physical Word Address | Gen-2 Memory Bank | Logical Word Address | Word Pointer (EBV8) | Description | Memory Size (bits) |
|-----------------------|-------------------|----------------------|---------------------|---------------------------------|--------------------|
| 0x000 | RSVD | 0x000 | 0x00 | Kill Password[31:16] | |
| 0x001 | RSVD | 0x001 | 0x01 | Kill Password[15:0] | |
| 0x002 | RSVD | 0x002 | 0x02 | Access Password[31:16] | |
| 0x003 | RSVD | 0x003 | 0x03 | Access Password[15:0] | |
| 0x004 | EPC | 0x000 | 0x00 | CRC | |
| 0x005 | EPC | 0x001 | 0x01 | PC | |
| 0x006 | EPC | 0x002 | 0x02 | EPC - Word 0 (MSW) | |
| 0x007 | EPC | 0x003 | 0x03 | EPC - Word 1 | |
| 0x008 | EPC | 0x004 | 0x04 | EPC - Word 2 | |
| 0x009 | EPC | 0x005 | 0x05 | EPC - Word 3 | |
| 0x00A | EPC | 0x006 | 0x06 | EPC - Word 4 | |
| 0x00B | EPC | 0x007 | 0x07 | EPC - Word 5 (LSW) | |
| 0x00C | SERVICE | 0x008 | 0x08 | RESERVED | |
| 0x00D | SERVICE | 0x009 | 0x09 | RESERVED | |
| 0x00E | SERVICE | 0x00A | 0x0A | RESERVED | |
| 0x00F | SERVICE | 0x00B | 0x0B | RESERVED | |
| 0x010 | TID | 0x000 | 0x00 | TID - Word 0 | |
| 0x011 | TID | 0x001 | 0x01 | TID - Word 1 | |
| 0x012 | TID | 0x002 | 0x02 | TID - Word 2 | |
| 0x013 | TID | 0x003 | 0x03 | TID - Word 3 | |
| 0x014 | USER | 0x000 | 0x00 | RESERVED | |
| 0x015 | USER | 0x001 | 0x01 | RFU | |
| 0x016 | USER | 0x002 | 0x02 | Control/Status Register | |
| 0x017 | USER | 0x003 | 0x03 | Stored Address Register | |
| 0x018 | USER | 0x004 | 0x04 | | |
| 0x019 | USER | 0x005 | 0x05 | | |
| 0x01A | USER | 0x006 | 0x06 | USER Memory - Start | |
| ... | ... | ... | ... | | |
| 0x0FF | USER | 0x0EB | 0x816B | 4k Memory: END | |
| 0x100 | USER | 0x0EC | 0x816C | | |
| ... | ... | ... | ... | | |
| 0x1FF | USER | 0x1EB | 0x836B | 8k Memory: END | |
| 0x200 | USER | 0x1EC | 0x836C | | |
| ... | ... | ... | ... | | |
| 0x3BC | USER | 0x3A8 | 0x8728 | 16k Memory: END (1 Word/Blk) | |
| 0x3BD | USER | 0x3A9 | 0x8729 | | |
| ... | ... | ... | ... | | |
| 0x3DC | USER | 0x3C8 | 0x8748 | 16k Memory: END (2 Word/Blk) | |
| 0x3DD | USER | 0x3C9 | 0x8749 | | |
| ... | ... | ... | ... | | |
| 0x3EC | USER | 0x3D8 | 0x8758 | 16k Memory: END (4 Word/Blk) | |
| 0x3ED | USER | 0x3D9 | 0x8759 | | |
| ... | ... | ... | ... | | |
| 0x3F4 | USER | 0x3E0 | 0x8760 | 16k Memory: END (8 Word/Blk) | |
| 0x3F5 | USER | 0x3E1 | 0x8761 | | |
| ... | ... | ... | ... | | |
| 0x3F8 | USER | 0x3E4 | 0x8764 | 16k Memory: END (16 Word/Blk) | |
| 0x3F9 | USER | 0x3E5 | 0x8765 | | |
| 0x3FA | USER | 0x3E6 | 0x8766 | 16k Memory: END (>=32 Word/Blk) | |
| 0x3FB | SERVICE | 0x3E7 | 0x8767 | RESERVED | |
| ... | ... | ... | ... | | |
| 0x3FF | SERVICE | 0x3EB | 0x876B | RESERVED | |

GEN2 WM710XX MEMORY BANKS

The RFID memory banks reside in Ramtron's non-volatile F-RAM memory. F-RAM brings many benefits to the WM710xx. The first benefit is the size of the memory itself – up to 16k-bit, most of which is available in the USER memory bank. F-RAM's impact on the Gen2 protocol is most dramatically seen when writing to WM710xx memory. Unlike EEPROM memory, no charge pump or memory soak time is required to write to WM710xx memory, resulting in zero time and zero power penalties. The write cycle is completed immediately, allowing an interrogator to continue writing additional data to memory with no time penalty incurred due to the memory itself. A comparison between F-RAM and EEPROM memories is shown in Figure 3. The figure shows the minimum number of Gen2 instructions required to perform a SELECT, INVENTORY, and ACCESS sequence of commands to write a data word to memory. The same interrogator command sequence is transmitted to the WM710xx and an EEPROM-based RFID. The effect of the EEPROM time penalty is shown within the context of the protocol.

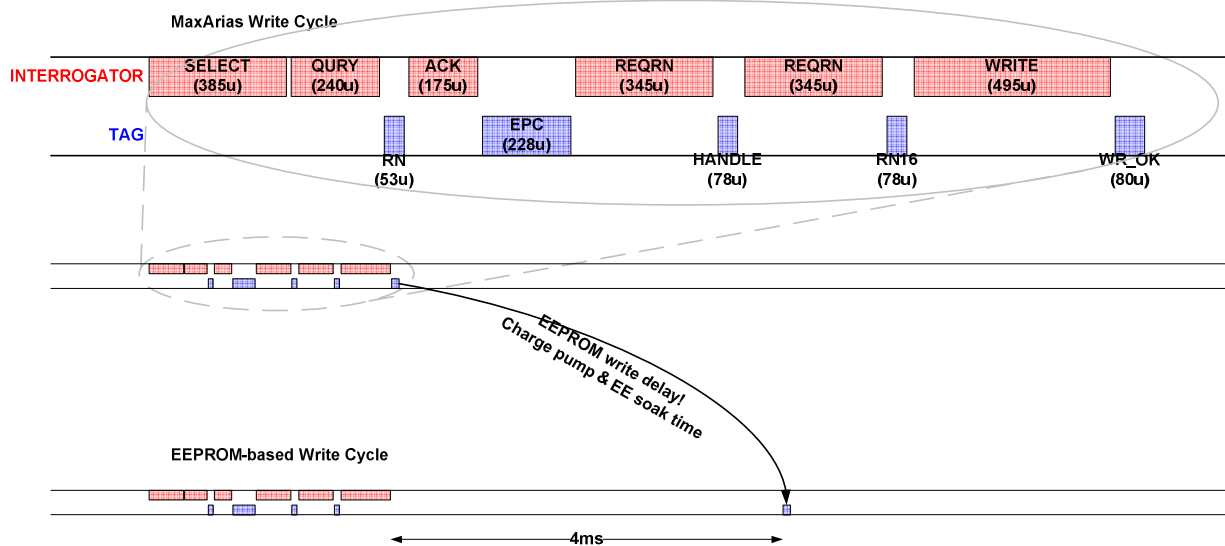


Figure 3. Gen2 Memory Write Cycle Comparison: F-RAM vs. EEPROM Memories

RESERVED: KILL Password:

The kill password provides a mechanism to permanently disable the WM710xx RFID from responding to any and all Gen2 interrogator commands. The mandatory KILL command can be issued by a RFID interrogator in either the OPEN or SECURED states. The WM710xx is permanently killed through a four-instruction sequence of REQRN and KILL commands as detailed in the Gen2 standard. The KILL password is a 32-bit value stored as 2 16-bit data words in reserved memory. The most significant KILL password is stored in reserved memory bank address 0x00 with the least significant word stored in reserved memory bank address 0x01. The kill function can be permanently disabled by setting both KILL password words to 0x0000, and permanently locking the KILL password in the reserved memory bank. Once the kill password has been set, it should be permanently locked using the LOCK command. The WM710xx is shipped from the factory with the kill password memory unlocked.

RESERVED: ACCESS Password:

The access password provides a security mechanism to prevent unauthorized RFID interrogators from writing to WM710xx memory. Non-zero access passwords require the WM710xx be placed in the SECURED state prior to writing to it. This is accomplished through four consecutive REQRN and ACCESS commands as described in the Gen2 standard. An access password with a value of zero requires no authentication prior to writing to WM710xx memory. The ACCESS password is a 32-bit value stored as 2 16-bit data words in reserved memory. The most significant ACCESS password is stored in reserved memory bank address 0x02 with the least significant word stored in reserved memory bank address 0x03. Once the access password has

been set, it should be permanently locked using the LOCK command. The WM710xx is shipped from the factory with the access password memory unlocked.

EPC Memory Bank:

The EPC memory bank accommodates 8 words: 1 protocol control (PC) word, a 6-word (96-bit) memory space for an EPC identifier, and a 1-word CRC. The CRC word is calculated as part of the WM710xx power-on initialization routine and written into the EPC memory bank address 0x00. The PC and 6-word EPC identifier are completely programmable. The Protocol Control field is shown in Figure 4.

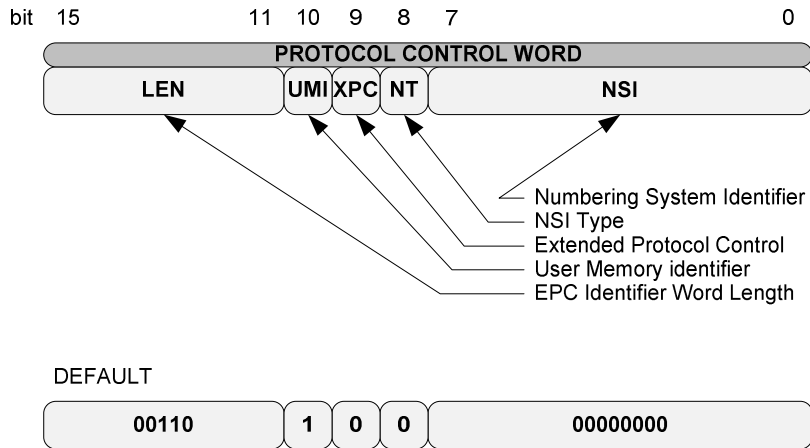


Figure 4. EPC Protocol Control Word

The 5 most significant bits of the PC indicates the size of the EPC identifier in words – for a 96-bit (6-word) EPC identifier, the PC should be programmed to 0b0011_0xxx_xxxx_xxxx. The LEN parameter of the PC word may not be greater than 0b00110 – a LEN parameter of 0b00000 has an EPC identifier length of zero words resulting in only the PC and CRC words when WM710xx is acknowledged. The UMI bit (User Memory Identifier) is asserted to a logic one by WM710xx and mapped to bit 10 of the PC word. In the event the host writes a logic zero to the UMI bit, the memory location will be written with a logic zero, however the backscattered EPC identifier will assert the UMI bit to a logic one which is also used in the calculation of the CRC. WM710xx does not support extended protocol control and should be written with a logic zero. PC word bits 8 down to 0 of the PC word are factory-initialized to zero. The WM710xx is shipped from the factory with the EPC memory bank unlocked.

TID Memory Bank:

The TID memory bank consists of 4 words (64 bits), and is defined as shown in Table 2:. The TID memory bank is permanently locked at the factory and obeys the ISO/IEC 15963 numbering convention.

Table 2: TID memory Bank Fields

| Bit Field | Value (hex) | Description |
|-----------------------------------|---------------|------------------------------|
| 00 _h – 07 _h | xE0 | 15963 class-identifier value |
| 08 _h – 0F _h | TBD | Manufacturer identifier |
| 10 _h – 3F _h | <i>Unique</i> | 48-bit unique identifier |

USER Memory Bank:

The USER memory bank comprises two special-function control words, factory-reserved words, and up to 993 available memory locations. Refer to Table 1: for detail on the WM710xx memory structure. The USER memory bank may be completely locked through the LOCK command. WM710xx also supports the BLOCKPERMALOCK command providing the ability to lock contiguous words of USER memory, with word block sizes as small as a single word up to a maximum block size of 128 words.

CONTROL/STATUS REGISTER

Accessing the unique features of WM710xx is accomplished through the Control/Status register in F-RAM non-volatile memory. The register is located at physical address 0x016 or USER memory address 0x002. The Control/Status word register is organized as shown in Table 3: below. Care should be exercised when writing the Control/Status register word if it is to remain unlocked.

Table 3: Control/Status Word Register

| Bit | Mnemonic | Function | Initial Value | | | | | | | | | | | | | | | | | | | | |
|-------------|---|---|---------------|-------------|-------------|---|-----|--|-----|----|-------------------------------|---|-----|--|-----|---|-----------------------------|----|-----|---|-----|-----|---|
| 15 | LOCK | Memory locking of this register. | 0 | | | | | | | | | | | | | | | | | | | | |
| 14 | PERMALOCK | <table border="1"> <thead> <tr> <th>LOCK</th> <th>PERMALOCK</th> <th>DESCRIPTION</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>Register unlocked</td> </tr> <tr> <td>0</td> <td>1</td> <td>Register permanently unlocked</td> </tr> <tr> <td>1</td> <td>0</td> <td>Register writeable only from the SECURED state</td> </tr> <tr> <td>1</td> <td>1</td> <td>Register permanently locked</td> </tr> </tbody> </table> | LOCK | PERMALOCK | DESCRIPTION | 0 | 0 | Register unlocked | 0 | 1 | Register permanently unlocked | 1 | 0 | Register writeable only from the SECURED state | 1 | 1 | Register permanently locked | 0 | | | | | |
| LOCK | PERMALOCK | DESCRIPTION | | | | | | | | | | | | | | | | | | | | | |
| 0 | 0 | Register unlocked | | | | | | | | | | | | | | | | | | | | | |
| 0 | 1 | Register permanently unlocked | | | | | | | | | | | | | | | | | | | | | |
| 1 | 0 | Register writeable only from the SECURED state | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | Register permanently locked | | | | | | | | | | | | | | | | | | | | | |
| 13 | RFU | <i>Reserved for future use</i> | 0 | | | | | | | | | | | | | | | | | | | | |
| 12 | RFU | <i>Reserved for future use</i> | 0 | | | | | | | | | | | | | | | | | | | | |
| 11 | RFU | <i>Reserved for future use</i> | 0 | | | | | | | | | | | | | | | | | | | | |
| 10 | RFU | <i>Reserved for future use</i> | 0 | | | | | | | | | | | | | | | | | | | | |
| 9 | RFU | <i>Reserved for future use</i> | 0 | | | | | | | | | | | | | | | | | | | | |
| 8 | RFU | <i>Reserved for future use</i> | 0 | | | | | | | | | | | | | | | | | | | | |
| 7 | BLKWREN | Enables use of the custom command BLOCKWRITE. | 1 | | | | | | | | | | | | | | | | | | | | |
| 6 | BLKSIZ[2] | USER memory block size. | 1 | | | | | | | | | | | | | | | | | | | | |
| 5 | BLKSIZ[1] | <table border="1"> <thead> <tr> <th>BLKSIZ[2:0]</th> <th># words</th> <th>BLKSIZ[2:0]</th> <th># words</th> </tr> </thead> <tbody> <tr> <td>000</td> <td>1</td> <td>100</td> <td>16</td> </tr> <tr> <td>001</td> <td>2</td> <td>101</td> <td>32</td> </tr> <tr> <td>010</td> <td>4</td> <td>110</td> <td>64</td> </tr> <tr> <td>011</td> <td>8</td> <td>111</td> <td>128</td> </tr> </tbody> </table> | BLKSIZ[2:0] | # words | BLKSIZ[2:0] | # words | 000 | 1 | 100 | 16 | 001 | 2 | 101 | 32 | 010 | 4 | 110 | 64 | 011 | 8 | 111 | 128 | 1 |
| BLKSIZ[2:0] | # words | BLKSIZ[2:0] | # words | | | | | | | | | | | | | | | | | | | | |
| 000 | 1 | 100 | 16 | | | | | | | | | | | | | | | | | | | | |
| 001 | 2 | 101 | 32 | | | | | | | | | | | | | | | | | | | | |
| 010 | 4 | 110 | 64 | | | | | | | | | | | | | | | | | | | | |
| 011 | 8 | 111 | 128 | | | | | | | | | | | | | | | | | | | | |
| 4 | BLKSIZ[0] | <table border="1"> <thead> <tr> <th>BLKSIZ[2:0]</th> <th># words</th> <th>BLKSIZ[2:0]</th> <th># words</th> </tr> </thead> <tbody> <tr> <td>000</td> <td>1</td> <td>100</td> <td>16</td> </tr> <tr> <td>001</td> <td>2</td> <td>101</td> <td>32</td> </tr> <tr> <td>010</td> <td>4</td> <td>110</td> <td>64</td> </tr> <tr> <td>011</td> <td>8</td> <td>111</td> <td>128</td> </tr> </tbody> </table> | BLKSIZ[2:0] | # words | BLKSIZ[2:0] | # words | 000 | 1 | 100 | 16 | 001 | 2 | 101 | 32 | 010 | 4 | 110 | 64 | 011 | 8 | 111 | 128 | 0 |
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| 000 | 1 | 100 | 16 | | | | | | | | | | | | | | | | | | | | |
| 001 | 2 | 101 | 32 | | | | | | | | | | | | | | | | | | | | |
| 010 | 4 | 110 | 64 | | | | | | | | | | | | | | | | | | | | |
| 011 | 8 | 111 | 128 | | | | | | | | | | | | | | | | | | | | |
| 3 | WRPSTAT | Indicates if the Working Stored Address has wrapped. <table border="1"> <thead> <tr> <th>Logic State</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>Wrapping has not occurred</td> </tr> <tr> <td>1</td> <td>Wrapping has occurred at least once</td> </tr> </tbody> </table> | Logic State | Description | 0 | Wrapping has not occurred | 1 | Wrapping has occurred at least once | 0 | | | | | | | | | | | | | | |
| Logic State | Description | | | | | | | | | | | | | | | | | | | | | | |
| 0 | Wrapping has not occurred | | | | | | | | | | | | | | | | | | | | | | |
| 1 | Wrapping has occurred at least once | | | | | | | | | | | | | | | | | | | | | | |
| 2 | WRPEN | Enables wrapping of the Working Stored Address when it reaches the top of logical memory. <table border="1"> <thead> <tr> <th>Logic State</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>DISABLE memory wrapping</td> </tr> <tr> <td>1</td> <td>ENABLE memory wrapping.</td> </tr> </tbody> </table> | Logic State | Description | 0 | DISABLE memory wrapping | 1 | ENABLE memory wrapping. | 0 | | | | | | | | | | | | | | |
| Logic State | Description | | | | | | | | | | | | | | | | | | | | | | |
| 0 | DISABLE memory wrapping | | | | | | | | | | | | | | | | | | | | | | |
| 1 | ENABLE memory wrapping. | | | | | | | | | | | | | | | | | | | | | | |
| 1 | AUTOLOCK | Enable Automatic Locking of all user memory between the start of USER memory and the Working Stored Address register. <table border="1"> <thead> <tr> <th>Logic State</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>Auto-lock DISABLED</td> </tr> <tr> <td>1</td> <td>Auto-lock ENABLED</td> </tr> </tbody> </table> | Logic State | Description | 0 | Auto-lock DISABLED | 1 | Auto-lock ENABLED | 0 | | | | | | | | | | | | | | |
| Logic State | Description | | | | | | | | | | | | | | | | | | | | | | |
| 0 | Auto-lock DISABLED | | | | | | | | | | | | | | | | | | | | | | |
| 1 | Auto-lock ENABLED | | | | | | | | | | | | | | | | | | | | | | |
| 0 | AUTOINCR | Enable the Working Stored Address word to Auto-Increment when performing an unaddressed write cycle. <table border="1"> <thead> <tr> <th>Logic State</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>DISABLE auto-increment of stored address register</td> </tr> <tr> <td>1</td> <td>ENABLE auto-increment of stored address register</td> </tr> </tbody> </table> | Logic State | Description | 0 | DISABLE auto-increment of stored address register | 1 | ENABLE auto-increment of stored address register | 0 | | | | | | | | | | | | | | |
| Logic State | Description | | | | | | | | | | | | | | | | | | | | | | |
| 0 | DISABLE auto-increment of stored address register | | | | | | | | | | | | | | | | | | | | | | |
| 1 | ENABLE auto-increment of stored address register | | | | | | | | | | | | | | | | | | | | | | |

Upon power up, WM710xx's control logic reads the Control/Status word out of memory and configures itself accordingly. User applications may change the Control Word as needed providing the register has not been permanently locked. The Control/Status word may be read by the application at any time.

Register Locking: The LOCK and PERMALOCK control bits are implemented in a similar manner as locking bits used for Gen2 memory bank locking with the exception that the lock control bits are incorporated into the

register they are locking. As such, attention needs to be placed on how the contents of the Control/Status word are written when the register is not completely unlocked.

Table 4: Control/Status Word Locking

| LOCK | PERMA-LOCK | Description |
|------|------------|--|
| 0 | 0 | Register unlocked. All control bits, including the LOCK and PERMALOCK bits can be written to from the OPEN or SECURED states. |
| 0 | 1 | Register permanently unlocked. All control bits can be written from the OPEN or SECURED states. The LOCK and PERMALOCK bits must be set to logic values 0 and 1 respectively when writing the Control/Status word. |
| 1 | 0 | Register locked. All control bits can be written to only from the SECURED state. The register cannot be written to in the OPEN state. The LOCK and PERMALOCK bits must be set to logic values 1 and 0 respectively when writing the Control/Status word. |
| 1 | 1 | Register permanently locked. The register cannot be written in any circumstance. |

Block Write Enable: The BLKWREN control bit enables usage of the WM710xx custom command BLOCKWRITE. The BLKWREN parameter is internally updated during power-on WM710xx initialization. In the event the host application toggles the state of BLKWREN, a WM710xx power cycle is required to reflect the change.

Block Size: The 3 BLKSIZ[2:0] control bits adjust the USER memory block sizes as shown in Table 5:. This provides the RFID application the ultimate flexibility in determining a balance between the USER memory requirements and the granularity of the number of USER memory words per block. For the WM71016, the larger the granularity of the block size, the greater amount of available USER memory; block size has no effect on WM71004 or WM71008 memory. The effect of the block size on available USER memory is shown in Table 1:. The total number of USER memory words available as a function of the block size is shown in Table 5: below. It is of utmost importance that the 3-bit block size is not modified once set, which would result in corruption of block permalock status bits.

Table 5: Available USER Memory

| Memory | BLKSIZ | Words/Block | Free USER Memory (words) |
|--------|--------|-------------|--------------------------|
| 4k | xxx | x | 230 |
| 8k | xxx | x | 486 |
| 16k | 000 | 1 | 931 |
| 16k | 001 | 2 | 963 |
| 16k | 010 | 4 | 979 |
| 16k | 011 | 8 | 987 |
| 16k | 100 | 16 | 991 |
| 16k | 101 | 32 | 993 |
| 16k | 110 | 64 | 993 |
| 16k | 110 | 128 | 993 |

Wrap Status: The WRPSTAT status bit is asserted to a logic one when the following conditions are true:

- WRPEN=1, AUTOINCR=1 and AUTOLOCK=0,
- The contents of the Working Stored Address register address the last USER memory location, and
- An unaddressed WRITE command is received.

The WRPSTAT can be cleared by the RFID interrogator by writing a logic zero to the WRPSTAT bit.

Wrap Enable: Asserting the WRPEN control bit to a logic one enables the USER memory wrapping feature. The wrap enable feature allows the stored address pointer to wrap back to the factory-set initial stored address value of 0x006. In this manner, the WM710xx memory acts as a circular buffer. Clearing the WRPEN control bit disables wrapping resulting in a write-once memory. In this case, when the Working Stored Address reaches the end of user memory, no additional unaddressed write cycles will be possible. The WRPEN and

AUTOLOCK control bits are mutually exclusive – only one of the two control bits may be asserted at any given time.

Auto Lock Enable: Asserting the AUTOLOCK control bit to a logic one enables memory locking of the USER memory span between the start of USER memory and the Working Stored Address. The AUTOLOCK and WRPEN control bits are mutually exclusive – only one of the two control bits may be asserted at any given time. The automatic locking feature can only be used when AUTOINCR is asserted to a logic one.

Auto Increment: Asserting AUTOINCR control bit to a logic one enables the Working Stored Address increment function. Upon receiving an unaddressed write cycle, the WM710XX increments the pointer stored in the Working Stored Address register to point to the next free memory location then writes the cover-coded data word to the respective memory location. This functionality removes any requirement for a RFID interrogator to determine where free USER memory is located and manipulating the memory pointer itself.

WORKING STORED ADDRESS

To better utilize the F-RAM’s fast write capability, memory has been architected using an optional Working Stored Address register. The stored address function enables automation of the storage of large blocks of user data, such as pedigree or tracking information. This feature enables a RFID interrogator the ability to use a standard Gen2 WRITE command using a designated address of 0x3FFF (0xFF7F EBV-formatted) as a redirect pointer to use the contents of the Working Stored Address register – this is referred to as an *unaddressed write (UNADDR_WRITE)*. The Working Stored Address is a USER memory address pointer addressing the last unaddressed memory write cycle as shown in Figure 5 below. The Working Stored Address is a read/write register located in USER memory, address 0x003. It may be manually updated by simply writing to USER memory address 0x003 or automatically increment when the AUTOINCR control bit in the Control/Status register is asserted to a logic one and an unaddressed write command is received.

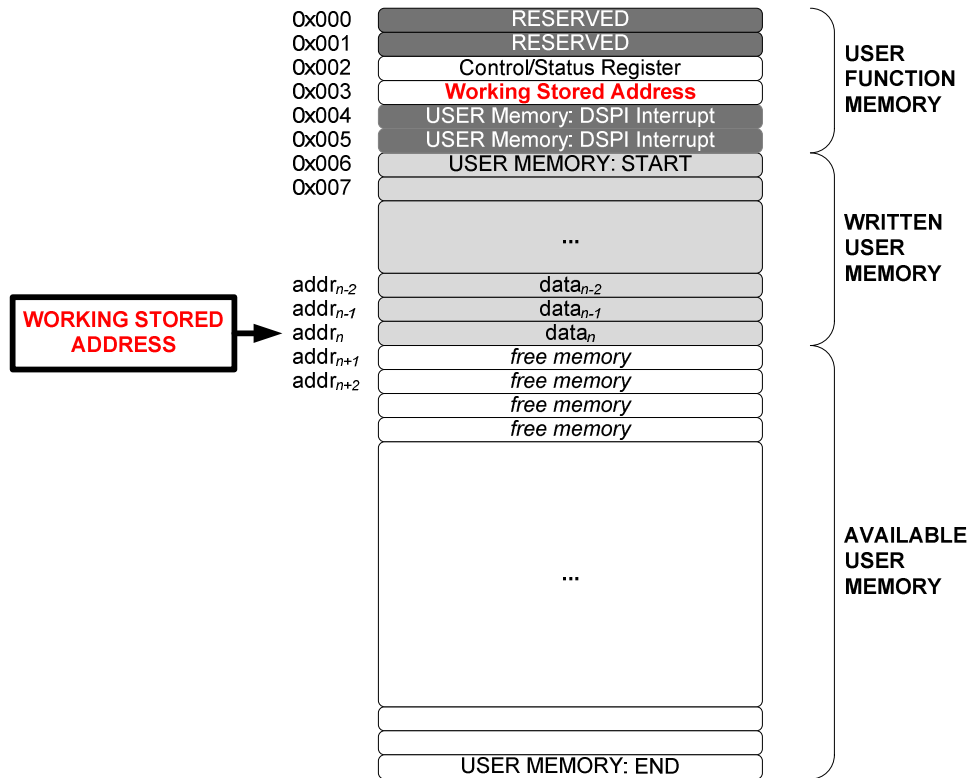


Figure 5. USER Memory Bank: Working Stored Address Register

The syntax for an unaddressed write command is shown in Figure 6 below. All protocol requirements governing implementation of a WRITE command also apply to the UNADDR_WRITE command.

| | | | | | |
|------------------------|--------------------------|----------------------------|--|---------------------------|---------------------------|
| WRITE (0xC3) | Membank (0b11) | WordPtr (0xF7FF) | 16-bit Data (cover-coded) (0xNNNN) | Handle (0xHHHH) | CRC-16 (0xCCCC) |
|------------------------|--------------------------|----------------------------|--|---------------------------|---------------------------|

Figure 6. Unaddressed Write Syntax

Upon reception of a valid UNADDR_WRITE command, the WM710xx examines the state of the AUTOINCR control bit:

AUTOINCR=0: The 16-bit data word cover-coded in the UNADDR_WRITE instruction is written to the memory address stored in the Working Stored Address register. The contents of the Working Stored Address register remain unaltered.

AUTOINCR=1: The Working Stored Address register is incremented by one, followed by the 16-bit data word being written to memory. The contents of the Working Stored Address register will reflect the memory address just written to. Figure 7 depicts 8 discrete unaddressed write cycles (REQRN command for cover-coding not shown). Prior to the unaddressed write commands, the Working Stored Address has a memory address of $addr_n$. The first UNADDR_WRITE command with data payload $write_data_0$ is written to $addr_{n+1}$; the second UNADDR_WRITE command with data payload $write_data_1$ is written to $addr_{n+2}$, and so on. Upon completion of the final UNADDR_WRITE command, the memory pointer contents of the Working Stored Address will be $addr_{n+8}$, reflecting the memory address of the last unaddressed write cycle. In this manner, the RFID interrogator does not have to read the memory contents to discern the next available memory location. **This substantially reduces the time required in the RF field yielding greater throughput of a population of tags.**

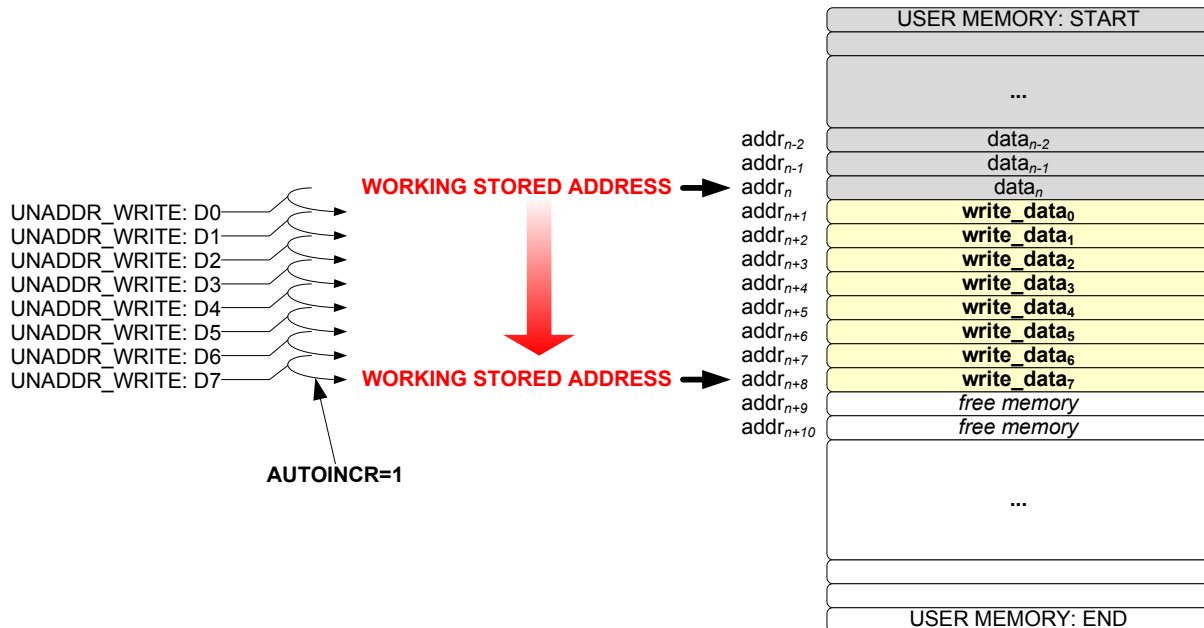


Figure 7. Unaddressed Write Cycles, AUTOINCR=1

The Working Stored Address pointer will be factory-initialized to the start of USER memory then managed by the memory controller or the host application as required.

SUPPORTED COMMANDS

The WM710xx supports the following Select, Inventory, and Access commands as described in the [EPCglobal class 1 generation 2 UHF RFID Specification](#). Please refer to the referenced document for detailed descriptions of these commands.

- Select
- Query
- QueryAdjust
- QueryRep
- ACK
- NAK
- Req_RN
- Read
- Write
- Kill
- Lock
- Access
- BlockWrite *
- BlockPermalock

MAXARIAS GEN2 CUSTOM COMMAND: BLOCKWRITE

The WM710xx supports a customized version of the BLOCKWRITE command to support unique features within the device. The BLOCKWRITE command optional feature is enabled by asserting the BLKWREN control bit in the Control/Status register to a logic one, after which the WM710xx will require a power cycle to initialize itself. To support other features within the WM710xx, the BLOCKWRITE command uses the address stored in the Working Stored Address register. The address pointer passed in the BLOCKWRITE command is the physical address 0x3FFF (EBV formatted address = 0xF7FF), representing the same address used for unaddressed write cycles. A single BLOCKWRITE command carries a maximum data payload of 127 words. BLOCKWRITE commands with data payloads greater than 127 words may optionally be written to unlocked memory, however the WM710xx will not acknowledge the BLOCKWRITE command with a success message. In this event, the host interrogator may perform one or more READ cycles to verify USER memory data contents.

Prior to transmitting a BLOCKWRITE command, the interrogator must set the Working Stored Address register through a standard Gen2 WRITE command. The BLOCKWRITE command is shown in Figure 8 below.

| | | | | | | |
|---------------------------|-------------------|---------------------|-------------------|-----------------------------|--------------------|--------------------|
| BLKWRITE (0xC7) | Membank (0b11) | WordPtr (0xF7FF) | WordCnt (0xNN) | Data (xNN × 16-bit data) | Handle (0xHHHH) | CRC-16 (0xCCCC) |
|---------------------------|-------------------|---------------------|-------------------|-----------------------------|--------------------|--------------------|

Figure 8. Block Write Syntax

BLOCKWRITE commands do not support the auto-increment feature used for UNADDR_WRITE commands. As such, the Working Stored Address must be manually updated by the host interrogator and will not be altered by a BLOCKWRITE command. When using the streaming capabilities of the BLOCKWRITE command, care should be taken to consider the logic state of the AUTOINCR control bit. As with UNADDR_WRITE commands, the Working Stored Address register is incremented prior to writing data to memory when AUTOINCR=1 affecting the first USER memory address written to, as shown in Figure 9. The figure depicts a BLOCKWRITE cycle of 8 words.

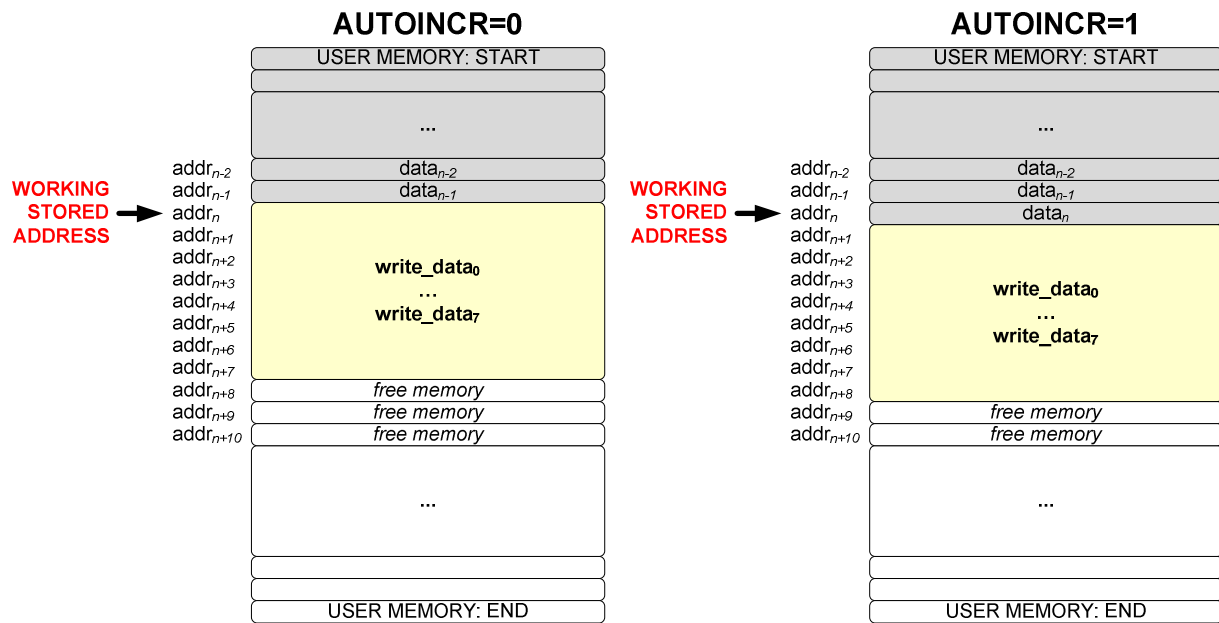


Figure 9. Block Write Command: Effect of AUTOINCR

SPECIFICATIONS

WM710xx's RFID Interface conforms to the *Specification for RFID Air Interface EPC Class-1 Generation-2 UHF RFID Protocol for Communications at 860 MHz – 960 MHz, Version 1.2.0.*

Options and Exceptions are noted here:

State Persistence Requirements

WM710xx features infinite state retention for S1, S2, S3, and SL State flags. State flag S0 has no persistence and will always return to state 'A' upon a power cycle.

ELECTRICAL SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

| Symbol | Description | Ratings |
|-------------------|--|----------------------------|
| T _{STG} | Storage Temperature | -55°C to + 125°C |
| T _{OP} | Operating Temperature | -40°C to +85°C |
| T _{LEAD} | Lead Temperature (Soldering, 10 seconds) | 260° C |
| V _{ESD} | Electrostatic Discharge Voltage - Human Body Model (JEDEC Std JESD22-A114-B) - Charged Device Model (JEDEC Std JESD22-C101-A) - Machine Model (JEDEC Std JESD22-A115-A) | TBD TBD TBD |
| ME | Memory Endurance: Read or Write or Erase | 1x10 ¹⁴ |
| RF _{exp} | RF Exposure | +10dBm (800 ~ 1000 MHz) |
| | Package Moisture Sensitivity Level | MSL-2 |

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only, and the functional operation of the device at these or any other conditions above those listed in the operational section of this specification is not implied. Exposure to absolute maximum ratings conditions for extended periods may affect device reliability.

AC Operating Characteristics (T_A = -40° C to + 85° C unless otherwise specified)

| Symbol | Parameter | Min | Typ | Max | Units | Notes |
|-----------------|---|-----|-----------|-----|---------|-------|
| S _R | Read Sensitivity | | -13 | -10 | dBm | |
| S _W | Write Sensitivity | | -13 | -10 | dBm | |
| Fr | Max Sustainable Read Rate @ S _R | | 640 | | Kbits/s | |
| Fw | Max Sustainable Write Rate @ S _W | | 160 | | Kbits/s | |
| t _{ST} | Power-on time | | 2 | | ms | |
| ΔΓ | Change in Modulator Reflection Coefficient | | TBD | TBD | | |
| Z _{IN} | Input Impedance @ f _{IN} =910MHz | | 10 – j100 | | Ohms | |

SPECIFICATION & COMPLIANCE SUMMARY

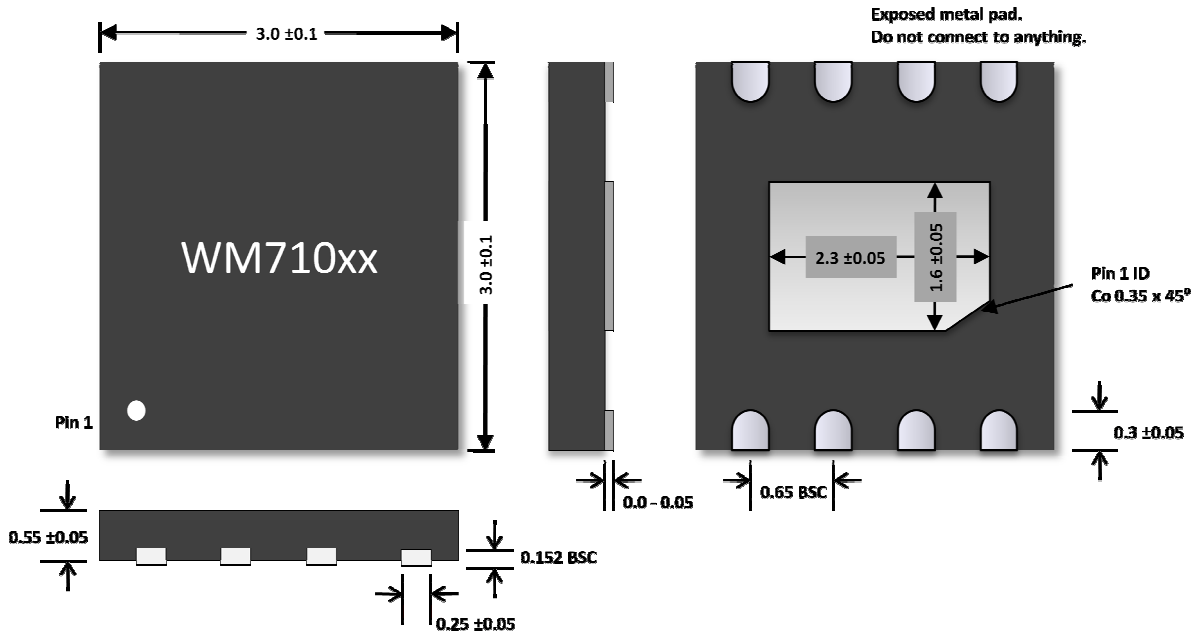
Refer to *EPCTM Radio-Frequency Identity Protocols Class-1 Generation-2 UHF RFID Protocol for Communications at 860MHz-960MHz Version 1.2.0* for all critical RFID specifications.

Link to specifications page:

<http://www.epcglobalus.org/Standards/EPCglobalSpecifications/tabid/335/Default.aspx>

MECHANICAL DRAWINGS

8-pin UDFN (3.0 mm x 3.0 mm body, 0.65 mm pad pitch)

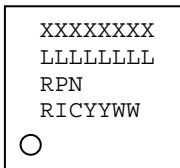


Note: All dimensions in millimeters. Care must be taken to ensure PCB traces and vias are not placed within the exposed metal pad area.

UDFN PACKAGE MARKING SCHEME FOR BODY SIZE 3MM X 3MM

Legend:

- XXXXXXXX= base part number (WM71004, WM71008, WM71016)
- LLLLLLLL= lot code
- R=revision, P=package (D=DFN), N=split designator (numeric)
- RIC=Ramtron Int'l Corp, YY=year, WW=work week



Example: WM71004, "Green" UDFN-8 package, Lot 0411702, Rev B., Year 2010, Work Week 12

WM71004
0411702
BD1
RIC1012

ORDERING INFORMATION

| Product | Description | Delivery & MOQ |
|-------------------|-----------------------------|--------------------------|
| WM71004-NBSD-DA | 8-pin UDFN with 4Kb memory | Tube – 160 units |
| WM71004-NBSD-DATR | 8-pin UDFN with 4Kb memory | Tape & Reel – 3000 units |
| WM71008-NBSD-DA | 8-pin UDFN with 8Kb memory | Tube – 160 units |
| WM71008-NBSD-DATR | 8-pin UDFN with 8Kb memory | Tape & Reel – 3000 units |
| WM71016-NBSD-DA | 8-pin UDFN with 16Kb memory | Tube – 160 units |
| WM71016-NBSD-DATR | 8-pin UDFN with 16Kb memory | Tape & Reel – 3000 units |

REVISION HISTORY

| Revision | Date | Summary |
|-----------------|-------------|--------------------------------|
| 0.1 | 12/12/2008 | Initial release. |
| 0.2 | 3/8/2010 | Documentation updates. |
| 1.0 | 3/12/2010 | Changed to Preliminary status. |