RFID Part Tracking Guideline

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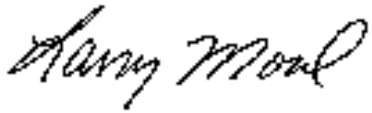

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Table of Contents

1 Scope **2**

2 RFID Tag Data **4**

3 Controls Components **6**

4 Machine / Process Design Considerations **7**

5 Balluff Network Interface Module: **8**

6 RFID PLC Logic **11**

Appendix A – Tag Layout Example **13**

Appendix B - Balluff RFID Components **14**

1 Scope

1.1 This guideline was developed for RFID Part Tracking applications. In RFID Part Tracking (RFID on-the-part), process data for each part needs to be available and used at subsequent operations. As such, RFID Part Tracking is a subset of part traceability.

1.2 For the purpose of this guideline, RFID Part Tracking applications typically include the RFID tag mounted on or otherwise connected to the part, independent of the part transfer method used between operations or stations.

1.3 RFID tags mounted to pallets for pallet identification (RFID Pallet ID) are also covered by the scope and purpose of this guideline.

1.4 This guideline is intended to document basic principles of well designed RFID Part Tracking system configuration and control logic. It should not be considered as the sole source of information. Additional information is available from device suppliers such as Balluff Industrial Controls literature. Device suppliers' recommendations should always be followed. Conflicts between device suppliers' literature and this guideline should be brought to the attention of the appropriate Nexteer personnel.

1.5 The RFID tag memory structure will be provided by Nexteer engineering after issue of the PO. An example is included in Annex A of this guideline.

- In general, a section of low-address bytes are dedicated to information used by every station; higher address bytes are dedicated to operation specific data. Spare bytes (typically adjacent to dedicated operation specific data) can be used by any operations that need to share data not specifically required by RFID Part Tracking.

1.6 This guideline documents antenna and RFID tag mounting mechanical requirements in Section 4.

1.7 This guideline applies to the purchase of new equipment and machine retools when RFID part tracking has been required by the Manufacturing Engineer's purchase specification (T-Spec). It should not be implied that any existing equipment be required to be retrofitted in order to comply with this guideline. Nexteer's specification hierarchy is such that the T-Spec may override this guideline.

1.8 Each application is unique, and in all cases good engineering practices should be used. For device applications not explicitly covered in this guideline the principles established in this guideline should be followed.

- Example 1: Ethernet port configurations for both an RSLogix5000 PLC and a Balluff Network Interface Module (BNI) are detailed within this guideline.
- Example 2: The logic structure, and the configuration menus, detailed in this guideline have been developed on RSLogix 5000. An RSLogix5000 series PLC / PAC must be used with the Balluff RFID system (does not work with MicroLogix).
- Example 3: Communications structure and logic commands are well documented within Balluff literature, and therefore have not been documented herein. However, requirements from this document such as RFID tag memory and typical station sequence shall be followed.

1.9 PLC logic reflecting this RFID Part Tracking philosophy can be found in the *Toolkits, Templates and Forms* link at NexteerDataExchanges.com.

1.10 The use of the word “shall” indicates requirements and the use of the word “should” indicates recommendations. The use of the word “may” indicates permission or allowance and the use of the word “can” indicates a possibility.

1.11 For a detailed explanation of logic and instruction to import the standard templates, refer to Controls Guideline: CSE-420 RFID Importation Instructions and Logic Oveview.docx.

1.12 The Allen Bradley CompactLogix and ControlLogix PLC term for a specific address is a *PLC tag name.* This should not be confused with the term *RFID tag* which is used within this guideline to indicate the EMS memory device.

2 RFID Tag Data

2.1 RFID Part Tracking data (RFID tag data) includes such information as model number, serial number, time stamps, previous or current step (or operation number) in the assembly process, part quality data, and pass/fail status.

2.2 Most of the RFID tag data is more than one byte in length, using multiple adjacent bytes (addresses). For consistency in this guideline single-byte data is depicted in hexadecimal as 0x00, two-byte data is hex 0x0000, etc.

2.3 Some of the RFID tag data is used and/or updated by each station. Some of the data is used only by specific stations.

2.4 In all cases the station logic shall only write RFID tag data generated by that station.

2.5 RFID tag data is used in a typical station sequence as follows:

- With the load of a new part, and cycle initiation, the logic reads the appropriate RFID tag memory and checks such data as the previous operation number and the part status (good part being 0xFFFF).
- If the above is correct, the station takes ownership of the part by writing to the RFID tag setting the operation number and setting the part status to all zero's (0x0000). The part shall not be processed until the ownership data is complete. Note: To save cycle time limited machine motions (which do not work on the part) may be initiated prior to the ownership data being completed, but this is not the preferred sequence and should only be used when the station requires this cycle time savings.
- When the station finishes processing the part (when the part quality status has been established) the logic can write all of that station's data to the RFID tag. The cycle is not complete (nor the part released to next station) until the results write complete bit is set by the RFID controller.
- The part status bits are set. In the case of a good part, all part status bits are set to one (0xFFFF). In the case of a reject part, the most significant bit of the part status word is set to one (binary 1xxx xxxx xxxx xxxx) and the remaining part status bits set to a reject code as desired based on pass/fail data of the station.
- The station's process tracking bit is set. In the case of a good part the appropriate bit is set to one. Note: Since the RFID system does not have the ability to communicate with a single bit, the logic reads and stores the entire RFID tag byte that the process tracking bit is associated with. When the part status has been established, the station logic shall set the appropriate process tracking bit, and only that bit, and then write the entire byte back to the RFID tag. This shall be done by setting the bit with a coil, not by writing data to the entire byte or word, indirectly setting that bit. Caution should be taken not to modify any other station's process tracking bit. Refer to the Nexteer logic template for additional guidance.

Note: Writing of the part status can take place while machine motions (such as retracting of cylinders) are still occurring.

2.6 The lead-off station (the first station to read and use RFID data) shall include logic to pre-populate the RFID tag, differing from the above typical station. The lead-off station will be identified in the T-Spec.

- With the load of a new part, and cycle initiation, the logic reads the RFID tag and stores the tag life counter in the PLC.
- The station logic shall prohibit the station from processing a part when the tag life counter has exceeded a maximum limit. The station logic shall generate a fault, prompting the operator to replace the RFID tag. *Note: At the time of the printing of this document the maximum limit value has not been determined.*
- On a normal cycle, the station writes all general information to the RFID tag, information such as model, serial number, and the tag life counter (incremented by one). The station also takes ownership of the part by writing to the RFID tag setting the operation number and setting the part status to all zero's (0x0000). All other RFID tag addresses shall be cleared (set to 0x00). Note that to save cycle time machine motions may be initiated prior to the ownership data being completed, but the part shall not be processed until the writing of ownership data is completed.
- When the station finishes processing the part (when the part quality status has been established) the logic can write all of that station's data to the RFID tag. The cycle is not complete (nor the part released to next station) until the results write complete bit is set by the RFID controller..

2.7 The part status bits are set. In the case of a good part, all part status bits are set to one (0xFFFF). In the case of a reject part, the most significant bit of the part status word is set to one (binary 1xxx xxxx xxxx xxxx) and the remaining part status bits set to a reject code as desired based on pass/fail data of the station.

2.8 The station's process tracking bit is set. In the case of a good part the appropriate bit is set to one; for the lead-off station this bit is typically the least significant bit of the first process tracking byte.

2.9 Note: Writing of the part status can take place while machine motions (such as retracting of cylinders) are still occurring.

2.10 The final RFID station (the last station to read and use RFID data) follows the typical station sequence detailed above. Additionally, with the load of a new part the station logic also checks the part tracking bits to verify that the part has been processed as a good part at all of the previous operations. The final RFID station will be identified in the T-Spec.

3 Controls Components

3.1 In general, control components for the machine's control system shall be selected from SD-007, Nexteer's Approved Components List which includes Balluff approved components for RFID systems. Balluff part numbers have been included in this section.

3.2 The system will use BISM-111-02/L tags for Part ID (unless the purchase T-Spec indicates otherwise). Tags shall meet iCODE ISO 15693

3.3 The BISM-111-02/L tags have a 2000 byte limit.

3.4 Nexteer will provide RFID tags and tagholders to each machine supplier unless the T-Spec indicates otherwise.

3.5 A Balluff Network Interface (BNI) module #BNI EIP-502-105-Z105 will be connected over Ethernet IP to the PLC.

- A single BNI module will support up to 4 Read / Write heads. Refer to Appendix B for part numbers.
- The BNI module contains 8 configurable I/O points (Ports 0, 1, 4, and 5). These ports may only be used for inputs (no output signals) related to the RFID process. These inputs could include:
  - Part Present in Position to read tag
  - Pallet Present
  - Read head in Position / Returned, etc.
  - Part assembly motions (sensors from slides, etc. are prohibited)

Exceptions to this must be approved by Nexteer engineering prior to purchasing of components.

3.6 An antenna will then be connected to the BNI module over a IO-Link network. Approved antennas include:

- 30mm cylindrical body RFID head #BIS M-400-045-001-07-S4
- 84.5mm x 80mm x 40mm rectangular body RFID head #BIS M-401-045-001-07-S4.
  - Connection between the BNI module and the antenna will be a standard M12 prox switch type M/F patch cable.
  - Maximum allowed length is 10 meters. For cables greater than 2 meters, a shielded cable must be used.

3.7 The machine control components used in this document's examples include:

3.8 Balluff BNI EIP-502-105-Z015 Network Interface Module

3.9 Allen Bradley 1769-L35E CompactLogix Controller processor ethernet port.

3.10 RSLogix 5000 v20.01 software.

4 Machine / Process Design Considerations

4.1 Mounting Location / Antenna Usage

4.2 There should be no lost operator time or processing time at the station.

4.3 Wherever possible, a fixed antenna shall be mounted to read the RFID tag while the part is seated in the fixture or pallet.

4.4 Where RFID tag positioning necessitates the antenna to be located above the part or otherwise in the part's load/unload path, fixed-antenna mounting can include simple pivoting or gravity-returned mounting brackets such that the operator-task of loading the part moves the antenna into the read/write location.

4.5 Where part or process geometry prevents a fixed location, another option is for a RFID antenna to be mounted on a controlled slide which advances to read/write the RFID tag at the start/end of the cycle and retracts at completion of processing. This motion should be powered by a cylinder if a safety violation does not occur. A cylinder-powered motion is preferred over an operator-powered motion, to minimize lost operator time. If powered, this motion must be included in the safety risk assessment process.

4.6 The least desirable option is to hand-scan the part, either with a fixed antenna while the part is being held by the operator or with a hand-held scanner while the part is in the fixture. This option should be avoided whenever possible, and requires prior approval by the Nexteer engineer. The station logic requirements for hand-scan applications are detailed in section 6.2 of this guideline.

4.7 The system shall include an audible signal and operator prompts (messages) indicating the completion of each successful read or write function

4.8 The antenna may be fixed mounted such that the operator is required to present the part in front of the antenna, or the antenna may be hand-held such that the operator loads the part to the station fixture and then places the antenna in front of the part. The hand-held antenna is the most desirable option for ergonomic reasons and because of the ability for the machine to contain the part until the RFID tag has been properly written to, and verified, at the end of the cycle.

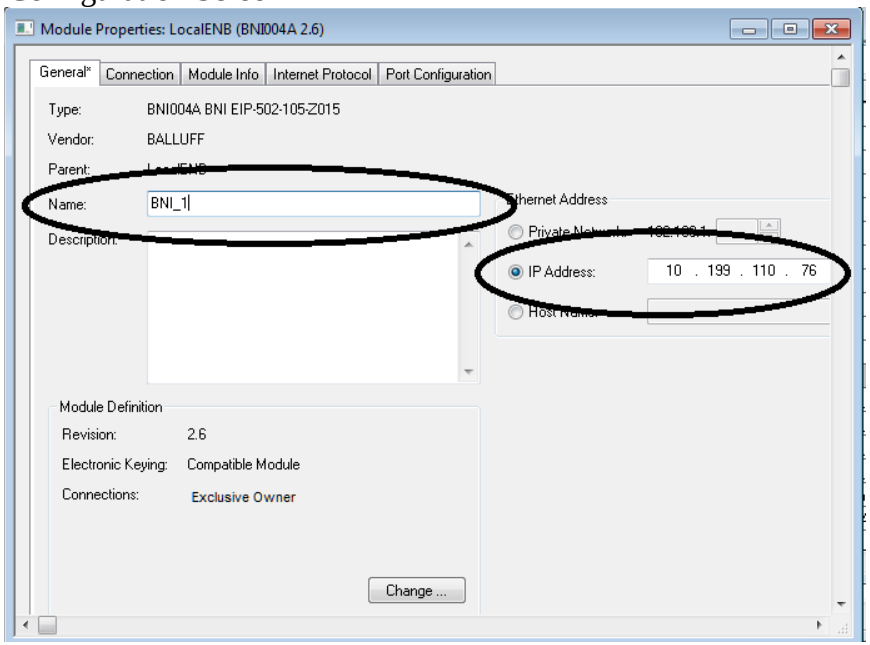
4.9 Once an attempt to write RFID tag data occurs, whether this write is to take ownership of the part at the beginning of the station cycle or the part quality write when the station has cycled the part, the part shall stay clamped or otherwise contained until the write has been verified.

4.10 Nexteer will provide the location of the tag/holder on the part during initial machine concept development. The location will be developed which is most effective for all process operations.

5 Balluff Network Interface Module:

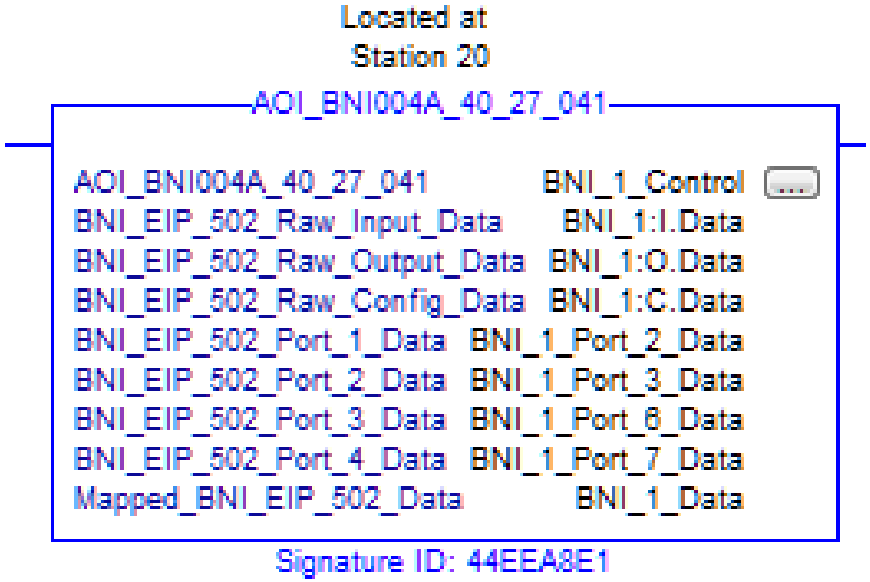
This section details the Balluff BNI Hardware configuration.

5.1 Main Configuration Screen



The BNI Module is added to the Ethernet Hardware configuration in the same fashion as any other Ethernet compatible module in the RSLogix5000 library. IP address must be set and *device name* is critical, as tags used in the associated Add On Instruction (AOI) instruction will reference this device name.

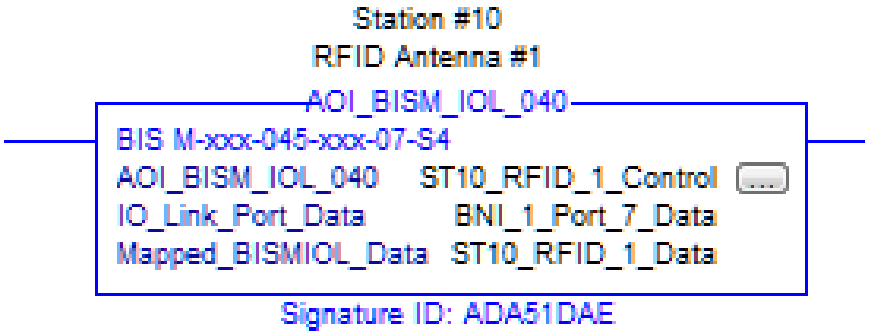
5.2 BNI Module Add On Instruction:



The Nexteer provided file contains routines, rungs, tags, etc. with generic names. The OEM must rename all tags to remove the generic names as shown below:

- For multi-station machines, the comment of the AOI instruction will indicate the physical location of the BNI module.
- If a machine or system contains multiple BNI modules, the number of the BNI module will be incremented for each module (BNI_2, BNI_3, etc.).
- The imported logic also includes a tag that is aliased to the inputs on each BNI module. This aliased tag must also be renamed to match the application. Open the Tag Editor and rename imported tag IBx. The “x” represents the BNI block number (using the above example, the tag would be IB1).

5.3 RFID Antenna Add On Instruction:



The Nexteer provided file contains routines, rungs, tags, etc. with generic names. The OEM must rename all tags to remove the generic names as shown below:

- In the above screen shot, the RFID antenna would be the first antenna located at Station 10.
- The antenna would be connected to BNI #1, Port #7.
  - By cross referencing the tag for BNI #1, the reference to the BNI_Master routine will take the programmer to the AOI instruction, where the instruction comment will indicate the physical location of the BNI module (refer to 5.2 above).
- Stand-alone machine will follow a similar format except that the Station number will not be required (using the above example, the ST10_RFID_1_Data tag would be named RFID_1_Data)

Note: IO_Link_Port_Data tag name was defined in the BNI AOI instruction and references the port of the BNI module that the antenna is plugged in to.

6 RFID PLC Logic

6.1 RFID Logic Requirements

Several logic requirements and recommendations are detailed throughout this guideline. Additionally general RFID logic requirements are detailed herein.

Note: Verification of written data is no longer a function of PLC logic. The Balluff RFID controller performs the verification automatically before returning a "write complete" signal to the PLC.

6.2 In the RFID_OEM routine, there will be common fault bits available to display faults to the operator. In general, faults should prompt the operator with an immediate stop fault such as *"Data Failure – Re-read Tag"* or *"Tag Removed Before Read Complete Fault"*. These bits are fully documented in the Nexteer supplied templates.

6.3 The station logic shall only write RFID tag data in the general part quality data addresses, plus only the specific RFID tag addresses affected by or pertaining to that station. This typically requires multiple write commands at each station, one for station ownership data and one for the station results data.

6.4 Station logic for communications to RFID antennas should follow the Nexteer logic template as described below in section 6.8.

6.5 After a tag read has been completed, the data from the tag will be placed in a 30 element array (type SINT) for the OEM to use in performing the station functions. Conversion of the data from this file to ASCII, REAL, DINT, etc will be the responsibility of the OEM.

6.6 In preparing data to be written to the tag (station ownership or results), the data must be loaded to an array (type SINT). There are separate arrays for station ownership and results. The OEM will be responsible for converting ASCII, Real, DINT, etc data to SINT format for these data tables

6.7 The routine and PLC tag naming conventions shall comply to the Nexteer logic template.

6.8 Routine Names and Function

The Nexteer Logix5000 template includes functional logic for RFID antenna communication through the BNI module to a RFID antenna. The complete logic is not described in this guideline.

The Nexteer Logix5000 template includes the following routines:

6.9 Routine *R33_BNI_Master* contains:

- The AOI for the BNI master module
- Logic for configuring the IO-Link ports of the BNI module
- Logic for detection of fault condition of the BNI module. Fault conditions shall be used to generate faults in the R08_Fault routine

6.10 Routine R34_RFID_OEM contains:

- The AOI instruction for the RFID antenna
- Tags for the OEM where they can define certain parameters required for read and write operations, including:
  - Starting Byte address of tag for read / write operation
  - Number of bytes to read / write
  - Triggers to initiate read / write function
  - Interlocks that the read / write functions are complete
  - Fault bits to indicate if an error was detected during the read / write operation

6.11 Routine *R35_RFID_Routine* contains the actual logic to perfom reads, write and tag fill (initialize data on a tag).

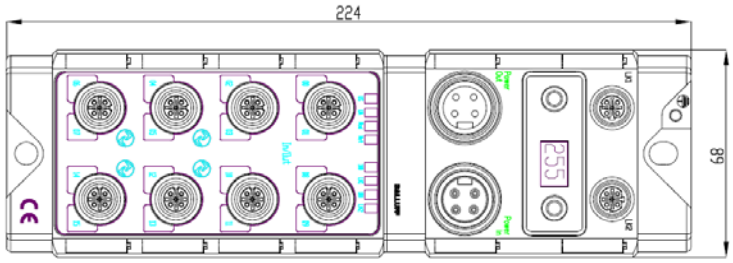
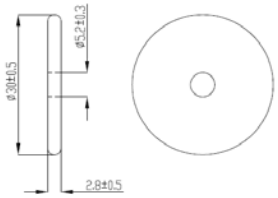
- *The logic in this routine should **not** require any modifications by the OEM.*

Refer to CSE-420 RFID Importation Instructions and Logic Overview for a detailed explanation of the logic.

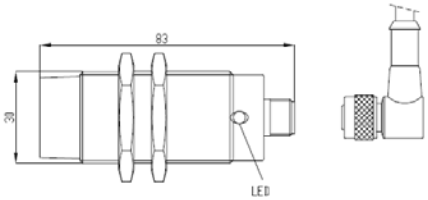
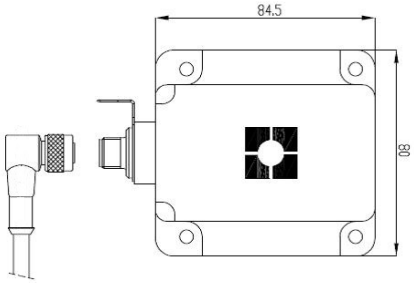
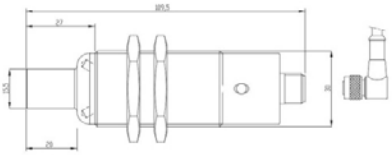
Appendix A – Tag Layout **Example**

***(EXAMPLE)* LWR REPS RFID MEMORY MAP 22 JN 2013**						
General Information	**Length**	**Address**	**Data Type**	**Comment**	**Supplier**	**OP #**
Tag Life Counter	2	0	16-bit integer	read and increment at first operation	Pro-Tech	OP10
Last Assembly Operation Number (Reference OP Number Definition Tab)	2	2	16-bit integer	updated at each station with RFID	all	all
Last Assembly Operation Status (FFFF=Good Part, 0000=part in process, 8001=reject part)	2	4	16 bits	updated at each station with RFID	all	all
Failure Code (unique number, starting at 1, to identify reason a station rejected a part)	2	6	16-bit integer	updated by rejecting station	all	all
Assembly Model Code (bushing def/input shaft def, etc) (Reference Barcode and RFID Definitions Tab)	14	8	ASCII bytes	example 1A3A5A7A9AXXXX	all	all
unused	10	22		10 bytes not used		
Rework Counter - BSI Line	2	32	16-bit integer	Updated by Teardown/Evaluation Area	TBD	TBD
Rework Counter - Sensor Asm.	2	34	16-bit integer	Updated by Teardown/Evaluation Area	TBD	TBD
Rework Counter - Final Asm	2	36	16-bit integer	Updated by Teardown/Evaluation Area	TBD	TBD
unused	10	38		10 bytes not used		
Special Manufacturing Designator (Plant use to designate specific test and calibration assemblies)	8	48	ASCII bytes	LWR examples: L01EP001 = Model L01, Error Proof #001; W01EP002 = Model W01, Error Proof #002 and L02MN001 = Model L02, Master Noise Test Gear #001	Nexteer	TBD
unused	10	56		10 bytes not used		
Housing Serial Number (applied initially to housing) (Reference Barcode and RFID Definitions Tab)	20	66	ASCII bytes	example (xxxxxxxxYYDDDzssss00)	Pro-Tech	TBD
unused	10	86		10 bytes not used		
Input Shaft Process Serial Number (Reference Barcode and RFID Definitions Tab)	20	96	ASCII bytes	example (xxxxxxxxYYDDDzssss00)	Whirlway	TBD
Pinion Process Serial Number (Reference Barcode and RFID Definitions Tab)	20	116	ASCII bytes	example (xxxxxxxxYYDDDzssss00)	Whirlway	TBD
unused	10	136		10 bytes not used		
Motor Process Serial Number	10	146	ASCII bytes	example X0123-M1234 per 24079068 specified format	ATS	TBD
unused	10	156		10 bytes not used		
Rack Process Serial Number (Reference Barcode and RFID Definitions Tab)	20	166	ASCII bytes	example (xxxxxxxxYYDDDzssss00)	BSI, P&R	TBD
unused	10	186		28 bytes not used		
Belt Weight	2	196	16-bit integer	weight up to 99.99 grams (decimal point implied)	BSI, P&R	TBD
Belt Tension	2	198	16-bit integer	Freq up to 999.9 Hz (decimal point implied)	BSI, P&R	TBD
Rack Clearance	2	200	16-bit integer	Dist up to 99.99 microns (decimal point implied)	BSI, P&R	TBD
Avg Backdrive Force	2	202	16-bit integer	Force up to 9999 Newtons	BSI, P&R	TBD
unused	10	204		10 bytes not used		
BSI Line #	2	214	16-bit integer	1 or 2	BSI, P&R	TBD
Noise Test Machine #	2	216	16-bit integer	1 or 2 or 3	BSI, P&R	TBD
Backdrive Test Machine #	2	218	16-bit integer	1 or 2 or 3	BSI, P&R	TBD
Sensor Line #	2	220	16-bit integer	1 or 2	Mapro	TBD
Final Function Test Machine #	2	222	16-bit integer	1 or 2	Mapro	TBD
Final Line #	2	224	16-bit integer	1 or 2	Miller	TBD
Scratchpad for temp use or expansion as req'd	10	226		10 bytes reserved but not defined for Data		
*******SPARE BYTES**********	1764	232		********SPARE BYTES*********		
Total Bytes Used		**2000**				

Appendix B - Balluff RFID Components

Network Interface Module BNI EIP-502-105-Z015 Ethernet Interface Module 4 Port I/O Link	
RFID Tag BISM-111-02/L RFID Tag (Data Carrier) 2000 byte, 30mm x 2.8mm	

Available Antennas

BIS M-400-045-001-07-S4 30mm Cylindrical Body RFID Head 0 – 36mm sensing range (with BISM-111-02/L tag)	
BIS M-401-045-001-07-S4 84.5mm x 80mm x 40mm RFID Head 0 – 60mm sensing range (with BISM-111-02/L tag)	
BIS M-400-045-002-07-S4 30mm Cylindrical mounting with 15.5mm sensing head 0 – 20mm sensing range (with BISM-111-02/L tag)	

Note for Read / Write Heads connection to I/O Link Port:

- For applications where Read / Write head is 2 meters or less to BNI Module, use standard M12 Male / Female patch cable
- For Lengths Greater than 2 Meters, must use shielded M12 Male / Female patch cable

RECORD OF REVISIONS

Revision	Date	Section	Description
001	30AU10	All	Original Approval and Issue Date
002	30NO11	6 (now 5), and related	Replace 1734-232ASC Module with Real Time Automation 435NBX Gateway, (plus revisions to all related sections)
003	30 NO13	All	Replace obsolete EMS RFID components with Balluff Ethernet communication based components
004			
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