Design Controls

User Manual
RFID Reader Board

IFU-010-140

Welbilt

i FCC Interference Statement (Part 15.105 (b))

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

Reorient or relocate the receiving antenna.

Increase the separation between the equipment and receiver.

Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

Consult the dealer or an experienced radio/TV technician for help.

ii FCC Part 15 Clause 15.21

"Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment"

iii FCC Part 15.19

"This device complies with part 15 of the 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."

iv ISED RSS-Gen Notice

"This device complies with Industry Canada's licence-exempt RSSs. Operation is subject to the following two conditions:

(1) This device may not cause interference; and

(2) This device must accept any interference, including interference that may cause undesired operation of the device."

"Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

1) l'appareil ne doit pas produire de brouillage;

2) l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement."

v FCC RF Exposure Guidance Statement

"In order to comply with FCC/ISED RF Exposure requirements, this device must be installed to provide at least 20 cm separation from the human body at all times.

"Afin de se conformer aux exigences d'exposition RF FCC / ISED, cet appareil doit être installé pour fournir au moins 20 cm de séparation du corps humain en tout temps."

Contents

1. Purpose

The purpose of this document is to describe the functionality of the RFID reader module. The intent is to provide RFID reader capability customized for Welbilt commercial foodservice products.

2. End Product Labelling

The end product labelling shall provide the following FCC ID information for the reader module:

“Contains FCC ID: 2AQ4D-RFIDREADER”

“Contains IC: 24291-RFIDREADER”

On the ISED Canada ICES-003 Compliance Label:

“CAN ICES-3 (B)/NMB-3(B)”

3. Definitions, acronyms, and abbreviations

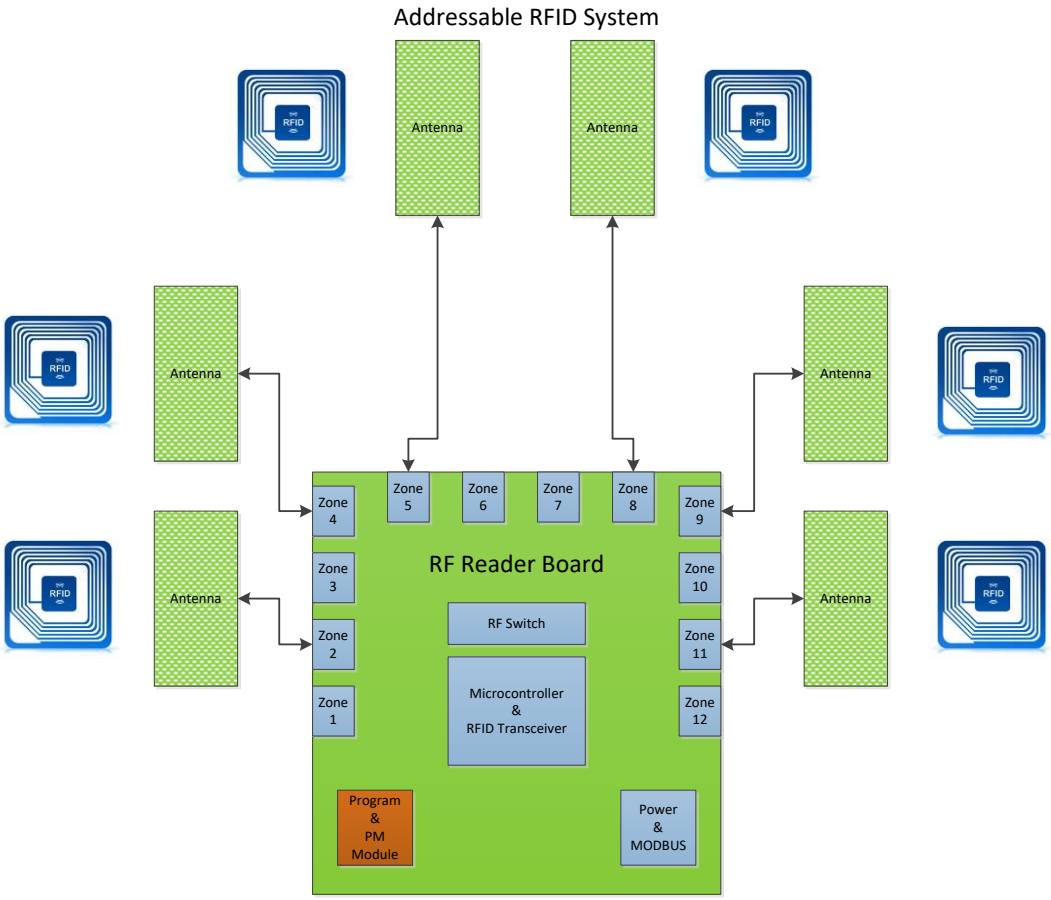
Abbreviation or Term	Definition
UID	Unique Identification Code
NFC	Near Field Communication
RFID	Radio Frequency Identification
PCBA	Printed Circuit Board Assembly
CAN	Controller Area Network
PM	Personality Module
MTW	Manitowoc Foodservice
SOP	Standard Operating Procedure

4. Reference Documents

Document Name	Number	Ref	Revision
RFID Reader Board Schematic	10000100-100	[1]	3
RFID Reader Board VHC SW		[2]	0.4.0
VHC RFID Tag HRS	HRS-010-700	[3]	1.1
VHC RFID Antenna Schematic	10010005-300	[4]	1

5. Product Description

5.1 System Diagram



5.2 External Connections

5.2.1 MODBUS Connector

The power and P-BUS/C-BUS signals are located on the RJ45 “MODBUS” connector. **The connector type is Molex 4320288113 or equivalent. This connector is keyed.**

Signal Name	Signal Type	Pin Number
CBUS+	RS-485	J14-1
CBUS-	RS-485	J14-2
5V_RAW_SRB	Power	J14-3
PBUS-	RS-485	J14-4
PBUS+	RS-485	J14-5
GND	Ground	J14-6
12V_RAW_SRB	Power	J14-7
GND	Ground	J14-8

5.2.1.1 Program Connector

The connector is a Hirose DF9-11P-1V(32).

Signal Name	Signal Type	Pin Number
MCLR	Data	J15-1
3V3_VDC	Power	J15-2
AGND	Ground	J15-3
PGEDI	Data	J15-4
PGECI	Data	J15-5
10k_pullup	Data	J15-6
SPI_MOSI	Data	J15-7
SPI_SCLK	Data	J15-8
SPI_MISO	Data	J15-9
PM_CS	Data	J15-10
NC	NC	J15-11
AGND	Ground	J15-12
AGND	Ground	J15-13

5.2.1.2 RF Connector

The MMCX connector is a **Molex 0734150961.**

Signal Name	Signal Type	Pin Number
RF_ANT	Data	J1-1
RF_ANT_RTN	Ground	J2-2
RF_ANT_RTN	Ground	J3-3

5.2.1.3 ID Select Connector

The header connector is a **TE Connectivity 5-146280-3 or equivalent.**

Signal Name	Signal Type	Pin Number
ID_SEL_0	Power	J13-1
AGND	Ground	J13-2
ID_SEL_1	Data	J13-3

6. Hardware Description

6.1 Power

6.1.1 Input Power

The RFID reader board derives all power from the 12VDC(+/-10%) and 5VDC(+10%/-5%) as defined per the MODBUS connector. The reader generates 3V3 from the 5VDC rail using an MCP1700T LDO rated at 250mA. The 5V2 voltage is generated from the 12VDC rail using an AZ1117LDO rated at 800mA.

6.1.2 RF Output Power

When configured for 5-V operation (see section 6.6), the RF amplifier voltage can be set from 4.3V to 5V in 100mV steps via software. In 3-V operation, the RF amplifier can be set from 2.7V to 3.4 in 100mV steps. The typical output power at maximum setting is 17dBm@3-V operation and 23dBm@5-V operation.

6.2 ID Select Jumper

The MODBUS ID of the reader board can be set using a standard 100 mil jumper on J13 per the following table:

MODBUS ID	JUMPER POSITION
RFID_ ID1	Jumper across J13-1 and J13-2
RFID_ ID2	Jumper across J13-2 and J13-3
RFID_ ID3	No jumper installed

6.3 Indicators

The reader board provides an LED for each of the power rails; 5V2_VDC(GREEN), 3V3_VDC(GREEN).

The reader board provides a BLUE LED for each of the RF antenna zones 1 through 12 (as shown in appendix B). Each LED will illuminate whenever a valid tag is detected on an attached RFID antenna.

The reader board provides a GREEN LED to indicate the status of the microcontroller as well as an ORANGE LED to indicate the communication on the MODBUS.

6.4 Microcontroller

6.4.1 Microcontroller

The RFID reader board uses Microchip PN PIC24EP512GU810-I/PF in a 100 pin TQFP package. The micro has the following standard features:

- 512kB Program Flash Memory
- 52kB RAM
- 4 Channel UART
- 2 Channel SPI
- 83 General Purpose I/O pins

6.4.2 Clock

The microcontroller is clocked externally from the signal SYS_CLOCK from the RFID transceiver.

6.4.3 Debug/Personality Module Support

The reader board can be programmed and/or debugged from a Microchip ICD 3 module via J15. The connector is also compatible with Manitowoc's personality module for applications that desire external flash memory.

6.4.4 Reset

The reader board can reset by momentarily grounding (~100ms) J15-1 pin. This will cause the entire board to reset and restart the initialization routine.

6.5 Communication Peripherals

6.5.1 MODBUS Interface

The reader board translates UART signals from the microcontroller to RS-485 levels using ST485EBDR transceivers. Both a peripheral bus (P-BUS) and a communication bus (C-BUS) are provided. Both buses are terminated using the Manitowoc scheme shown in Appendix A, filtered and routed to J14.

6.5.2 SPI Interface

The reader board utilizes SPI protocol (and is so configured) for communications from the microcontroller and the RFID transceiver. The signals RFID_CS, MISO, MOSI, and SPI_CLOCK are used.

The SPI bus runs at 2MHz.

The reader board also has the capability to communicate to a PM via the same SPI bus using the PM_CS signal on the J15 connector.

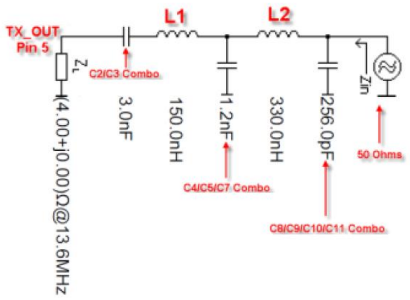
6.6 RFID Transceiver

The reader board utilizes TI's TRF7970A multiprotocol 13.56MHz RFID and NFC transceiver IC. It provides a built-in data framing engine for several protocols including ISO15693, ISO18000-3, ISO14443A/B, and FeliCa as well as the integrated analog front end. It is also configured for single-ended output (signal ground referenced) which facilitates multiplexing applications.

The power supply for the transceiver can be run from 5V2 or 3V3 voltage rail by populating either R1(5V2) **OR** R2(3V3) zero ohm resistor.

The transceiver runs from a 13.56MHz crystal, which in turn supplies SYS_CLOCK to the microcontroller at 13.56MHz, 6.78MHz, or 3.39MHz depending on software configuration.

An impedance-matching circuit from the 4 Ohm (TX output) to 50 Ohm impedance designed for 50 Ohm tuned antennas and cabling systems is provided on board and is shown below:



The transceiver is enabled via RFID_EN (active-high) from the microcontroller. Anytime a new tag is detected the transceiver will drive the RFID_IRQ low and hold it until the package is read by the microcontroller.

The signals RFID_ASK and RFID_MOD are provided to microprocessor for applications that desire to use the RFID transceiver in DIRECT_MODE. Although most applications will want to take advantage of the data format engine included in the chip.

6.7 RF Analog Multiplexor

The reader board switches the main RF channel to any one of the 12 available RF ports using Peregrine 4 SP4T PE42440 RF switches. This part feature ESD protection as well low series resistance and insertion loss at the 13.56MHz carrier frequency. The RF switches are the reflective type as absorptive are not required for this application.

The active channel is selected by the microcontroller per the following table:

Zone	Conn	MUX_SEL0	MUX_SEL1	MUX_SEL2	MUX_SEL3
1	J3	1	0	1	0
2	J9	1	1	1	0
3	J10	0	1	1	0
4	J4	0	0	1	0
5	J5	1	0	0	1
6	J11	1	1	0	1
7	J12	0	1	0	1
8	J6	0	0	0	1
9	J1	1	0	0	0
10	J7	1	1	0	0
11	J8	0	1	0	0
12	J2	0	0	0	0

6.8 Inductive Antenna Tuner

Each zone provides footprints to allow tuning for a wide range of custom antennas at each RF port. The technique of tuning a particular antenna goes beyond this specification; however the goal of the tuning circuit is to convert the inherent impedance of the antenna loop (@13.56MHz) to match the 50 Ohm impedance of the RFID transceiver circuit.

For example the VHC (Visual Holding Cabinet) RFID antenna measures 1.5uH@13.56MHz using a network analyzer. To convert the impedance to 50Ohm, a 68pF series capacitor along with a 12pF parallel capacitor was used to allow the antenna to resonate at 13.56MHz. This results in a matched antenna with a read range of ~5 inches in air (no conductive metal near).

7. Software Description

7.1 Bootloader Support

The bootloader program is programmed in the auxiliary program flash memory and the microcontroller is configured to reset to auxiliary flash reset location. The application is programmed to user program flash memory and the bootloader is used to write application updates to user program flash memory in the field without using MCU programmer devices.

The bootloader is using the peripheral bus (P-BUS) to receive firmware update packets.

On power-up the bootloader checks if the user program memory has a valid application by calculating and comparing the application CRC16 value. If a valid application is detected then the bootloader will jump to user program memory and start the main application. If the user program memory application is not valid then the bootloader will not start the main application and wait for receiving firmware update packets from the master device.

To start the bootloader application the master device command the RFID reader board to switch to bootloader program using modbus interface (P-BUS). When the firmware update is done, the master device commands the RFID reader board to start execution of the main application.

Each frame has address, function code, packet data and CRC16. The function codes of boot loader are as follow:

- #define MODBUS_CMD_START_APP 0x55 /* exit boot loader and start main application */
- #define MODBUS_CMD_START_BOOT 0x56 /* exit main application and start boot loader */
- #define MODBUS_CMD_WRITE_FLASH 0x57 /* write firmware data to flash memory */
- #define MODBUS_CMD_READ_OK 0x58 /* response from slave board when command is ok */

For the write flash command, the first 4 bytes are the address (in little-endian format) in flash memory and the next 128 bytes are the data to write (128 bytes = 32 program memory words). For the other commands the packet data is not used and should filled with 0's.

7.2 Microcontroller Configuration

The microcontroller is configured to reset to auxiliary flash program memory where the bootloader is programmed to auxiliary flash memory.

The oscillator is configured to use external clock source where the microcontroller is clocked externally from the signal SYS_CLOCK from the RFID transceiver. The PLL is enabled and configured to provide 120 MHz Fosc. The CPU clock (instruction execution speed) is 60 MHz.

The watchdog timer is always enabled (by hardware) and the post-scale and pre-scale are configured so that the WDT period is 4.096 second.

The microcontroller In-Circuit Serial Programming is configured to communicate on PGEC1 and PGED1. The JTAG is disabled.

7.3 RFID Transceiver Configuration

The RFID transceiver is configured to provide 3.39 MHz system clock for MCU. The modulation Type and depth is set to OOK (100%).

The RFID Transceiver regulators configuration is set automatic setting - VDD_RF = 4.9 V, VDD_A = 3.4 V, VDD_X = 3.4 V.

The RFID is configured to operate in 5V V_{IN} voltage range and to operate in RFID mode. The RFID is configured to use ISO15693 protocol.

In RFID Reader software, the RFID transceiver is controlled by ReaderController active object. The software is reading the first 2 blocks in user data area from the RFID tag using ISO15693 READ SINGLE BLOCK command.

7.4 RFID Zone Scanning

The RFID zone scanning is done by selecting the analog input to read by controlling the output status of MUX_SEL0 to MUX_SEL3 signals and then trigger the ReaderController to start read the tag on the selected channel. The RFID zone scanning is controlled by SystemController active object. The system controller reads channels sequentially and each channel is read twice, the first time block 0 is read and the second time block 1 is read from user data memory in the RFID tag.

When a read is completed successfully, SystemController update the modbus registers with the read value. If no tag is detected then the channel data is set to 0's.

7.5 Communication Bus Drivers

7.5.1 MODBUS Interface

The UART4 module is configured to be used for modbus communication on the P-BUS. The UART4 is configured to run at 115200 baud rate, no parity and one stop bit.

The driver is developed to be interrupt driven and non-blocking functions to be suitable for use with the QP frame work. Timer module is also imported from the same project where this timer module is required for the UART driver operations.

The RFID reader board is a slave modbus device. The modbus interface is implemented in QpModbusServer active object.

7.5.2 SPI Interface

The SPI port is used for communication with the RFID transceiver chip. The SPI driver is used and accessed by ReaderController active object to read and write to the RFID transceiver chip.

The SPI port is configured to run at 2MHz, 8 bit data, SPI clock mode is set to mode 0 (Serial output data changes on transition from idle clock state to active clock state and Idle state for clock is a low level; active state is a high level) and Input data is sampled at end of data output time.

The SPI driver is developed to be interrupt driven and non-blocking functions to be suitable for use with the QP frame work.

8. Specifications (Typical)

Protocol	ISO15693
Interface	Modbus RS-485 115kbit@8N1
RF Output Power (13.56MHz)	100mW@3.3VDC or 200mW@5VDC
Input Power	12VDC and 5VDC
Operating/Storage Temp	0 to 70°C (10 to 95% Relative Humidity – non-condensing)

9. Appendix A

RS-485 MODBUS Termination Scheme

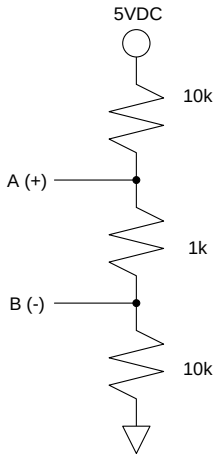


Figure 2: ETC CCA MODBUS termination

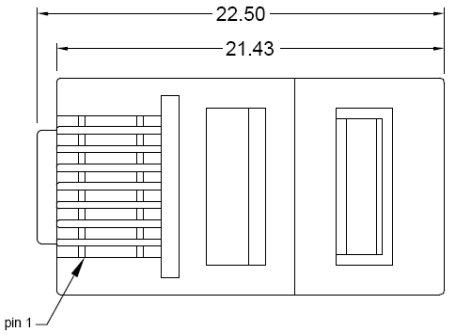


Figure 3: ETC EIA/TIA-485 C/P-Bus 2x2W Modbus 8P8C Plug

Pin	Name	EIA/TIA-485	Description
1	CDA	A/A'	C-Bus Data (+)
2	CDB	B/B'	C-Bus Data (-)

3	VDC	--	+5 VDC
4	PDB	B/B'	P-Bus Data (-)
5	PDA	A/A'	P-Bus Data (+)
6	GND	C	Signal and Supply Common
7	12VDC	--	Auxiliary Power
8	GND	--	Auxiliary Power Common

10. Appendix B (RF Reader Assembly Rev 2)