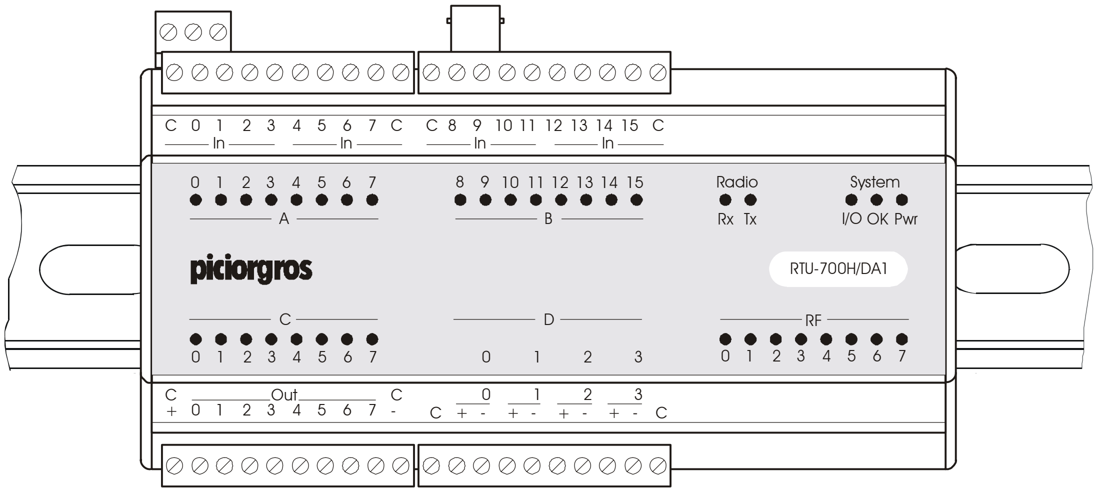
RTU-710H
Wireless I/O Module
With On-Off and Analog I/O

Version 4.30



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1 Introduction

1.1 Overview

This document contains information about installation, settings, and operation of the Model RTU-710 Wireless I/O Module. Additional information is also available over the Internet, at the website **www.piciorgros.com,** in the FAQ pages. This includes practical guidance relating to antenna selection and installation, operating range, expansion modules, software support, etc.

1.2 Safety Precautions

This equipment transmits radio waves in the frequency range 400 to 470 MHz. Under certain circumstances, these radio waves could be harmful to any living being or electronic equipment near it. Care should be taken to ensure that the radio and antenna systems are installed and set up only by trained persons.
This radio equipment should not be used in life support systems or in safety systems without our prior written permission..

1.3 Disclaimer

We have carefully checked the contents of this document and the hardware and software described in it for compatibility. We cannot however exclude possibilities of deviations and cannot guarantee complete conformity of the document with the equipment it describes. If any corrections or improvements are to be made, they will be taken into consideration in the next edition of this document.
Important instructions are marked by the expression **“Caution!”.** These should be carefully observed. Explanations regarding these precautions can be found in the website **www.piciorgros.com**, in the FAQ pages

2 Software Versions

The firmware version and document edition valid for the specific product supplied with this document are:

Firmware Version	Document Version	Changes / Comments
1.10	1.2 - Released 01/2001	**RTU-710:** First delivered version
1.40	1.4	A greater selection of 16 Expansion Modules now available, with the addition of the following modules: • EM-UCL-16DO.N1 • EM-UCL-16DO.P1 • EM-UCL-32DO.P1 • EM-UCL-32DO.N1 Parameter setting can be done through an internal configuration interface.
1.60	1.6	Transmission of pulse signals over point-to-point radio link supported.
1.62	1.62	The first analog output channel in the master unit can be optionally configured as a pulse output. Dual-range water meters (with dual pulse signal outputs) now supported for remote pulse transmission.
1.80	1.80	Version RTU-710H/D3 (16 on-off inputs + 16 on-off outputs) now available. Timeout status bit 3 introduced: this bit is set to " 1" whenever an x-timeout or t-timeout occurrence causes the RTU's outputs to be switched off.
2.20	2.20	2.20 The RTU-710 now has 32 "mapping registers". Any arbitrary selection of registers of the RTU-710 can be mapped into these consecutive registers and then transmitted as a single block. If an I/O error on the Expansion Bus occurs for longer than 5 seconds, then all outputs of the RTU-710 are automatically switched to the safe (off) state.
	2.20B	Write mask for the mapping registers implemented.
3.00	3.00	RTU-710 variant with "PicoLogo" compatible micro-PLC functions introduced
3.10	3.10	3.10 The RTU-710 now supports the following function codes of the old models FMC-V24/DA1 and DA2: • Code 21: V24/DA1 Single-cycle polling • Code 23: V24/DA1 Masked single-cycle polling • Code 41: V24/DA2 Single-cycle polling • Code 43: V24/DA2 Masked single-cycle polling

		• Code 28: Reset status
3.20	3.20	Special "pipeline" operating mode implemented.
4.00	4.00	**RTU-710** • New version of the RTU-710, with the same radio interface, communication protocols and registers. Similar to the RTU-710 except for differences described in this document. • Compatible with radio equipment classes SR-150 and SR-450: RF output power 6W max., with 16 adjustable output power levels. • The RTU-710 has a serial interface for set-up programming and downloading PicoLogo PLC programs. • LED lamp added to indicate PicoLogo mode ("F" LED). • Event counters and timers are now retentive (they retain their counts even when power to RTU is switched off). • Most set-up parameters can now be programmed via the DIP-switches, with 5 programming levels. • Supports MoP2 protocol with 16-bit check-sum
4.10		• Event counters and timers can now be user-programmed to be either retentive or non-retentive (the latter for compatibility with the earlier RTU-700) • Two consecutive (16-bit) counters can now be combined into one 32-bit counter
4.20		• PicoLogo PLC functions upgraded (PicoLogo V1.10)
4.30	4.30	• Optional M-Bus serial communication protocol available for communication with Kamstrup "MultiCal" instruments

3 RTU-710: General Description

3.1 Functions and Features

The RTU-710 is a general-purpose wireless remote I/O module, widely used in industrial monitoring and control, water and effluent treatment plants, pipeline monitoring, and other applications where long distances or other obstacles make it difficult or uneconomical to use wire communication. The Basic Module has 16 on-off inputs, 8 on-off outputs, and optionally 4 analog inputs. Adding one or more Expansion Modules connected through a Local Bus can expand the I/O capacity of a Basic Module. Its DIN rail mounting enclosure and plug-in screw terminal blocks make it easy to install and replace.

Counter/timer functions are available for each of the 16 on-off inputs of the Basic Module. Each input can be individually configured for timing or counting function.
Inputs and outputs are isolated and protected against voltage spikes, using reliable suppression techniques. In a point-to-point system configuration, consisting of two radio-linked RTUs, the Master RTU can be programmed to deliver a pulse signal output. Pulse signals can therefore be conveniently transmitted through a radio link.

The RTU-710 is compatible with MODBUS-RTU and MoP (MODBUS over Piciorgros) communication protocols.

The RTU-710 is available with integrated "PicoLogo" micro-PLC functions.

3.2 RTU Versions

The RTU-710H is available with and without analog inputs. It is available in high RF output power (6W) and medium power (500mW) versions. The RTU version is identified on its product identification label, as follows:

RTU-710x/DA1	RTU with 16 on-off inputs, 8 on-off outputs, 4 analog inputs
RTU-710x/DA2	RTU with 16 on-off inputs, 8 on-off outputs
RTU-710x/DA3	RTU with 16 on-off inputs, 8 on-off outputs
RTU-710x/PL1	RTU with 16 on-off inputs, 8 on-off outputs, 4 analog inputs, PicoLogo microPLC compatible
RTU-710x/PL2	RTU with 16 on-off inputs, 8 on-off outputs, PicoLogo microPLC compatible
RTU-710x/PL3	RTU with 16 on-off inputs, 8 on-off outputs, 4 analog inputs, PicoLogo microPLC compatible
RTU-710H/xxx	High power version: RF power up to 6 W
RTU-710M/xxx	Medium power version: RF power up to 500 mW

Up to April 2002 RTUs had to be specified for one of two available supply voltages (12 VDC or 24 VDC, nominal). These RTU Modules were designated with a suffix added to their respective model numbers, indicating their operating voltage: e.g., e.g. RTU-710H/DA1.12 for an RTU Modules operating on 12 V supply.

3.3 Certification and Approvals

The model RTU-710H is certified in accordance with R&TTE standards, with the following reference numbers:

ISM-Band 433.100 - 434.750 MHz:

Product Designation:	FTR-700
Output Power:	10 mW
Product Description:	SRD
Registration Number:	E811319M-EO
Marking:	CE 0682 (!)

Frequency Range 420.000 - 470.000 MHz:

Product Designation:	HFT-700
Output Power:	500 mW
Product Description:	SRD
Registration Number:	E811062M-EO
Marking:	CE 0682 (!)

Frequency Range 420.000 - 470.000 MHz:

Product Designation:	HFT-700
Output Power:	0.1 - 6 W
Product Description:	Land Mobile Service
Registration Number:	E811063M-EO
Marking:	CE 0682 (!)

Caution!

Products that are marked with the symbol (!) did not have harmonized European certifications at the time of preparation of this document. They should therefore be used according to prevailing local regulations with regard to frequency, transmitting power, operating limitations, etc.

4 Mechanical Details, Connections and Wiring

4.1 Mechanical Details

The external dimensions of the RTU-710 conform to DIN 43880, making it suitable for standard DIN rail installation. Power supply and input / output signal connections are all through plug-in screw terminal blocks.

4.1.1 Dimensions

The dimensions for the RTU-710 conform to DIN standards for rail mounted electrical apparatus. It can be installed on a standard 35 mm rail in accordance with DIN EN 50022. All variants have a width of 9 units (9T)..

4.1.2 Mounting

The DIN rail mounting adaptor is at the base of the RTU-710. The lower spring-loaded lip is engaged with rail flange first. The body is then pressed upwards, and the top of the body is forced down gently to clamp the upper lip onto the upper flange of the DIN rail.

4.1.3 Dismounting

A module is removed in the reverse sequence. It is forced upward, then the top is tilted downward to disengage the upper lip, and finally the lower lip is disengaged to free the Module from the DIN rail.

4.1.4 Wiring

External wiring of these RTU Modules must conform to local laws and guidelines relating to electrical equipment. Detailed information can be obtained from local authorities.

4.2 Power Supply Connections

The RTU-710 operates with a supply voltage in the range 10 - 28 V. Expansion Modules require 12V supply. If the RTU-710 Basic Module is provided with a 12V supply, connected Expansion Modules get their power directly from the Basic Module. The Basic Module can support a total load of 1A for Expansion Modules connected to it. The load of the Expansion Modules must be added to that of the Basic Module when selecting a power source. If the RTU-710 is provided with a 24V supply, an auxiliary power adaptor (EM-UCS-53.924) must be connected between the Basic Module and the Expansion Modules.

If the power supply voltage at the expansion bus connector of the RTU-710 Basic Module rises above 14.4V, the voltage supply to the Expansion Modules is automatically switched off for their protection. Such an occurrence during system operation results in the RTU station generating an error message (I/O error). Therefore, if Expansion Modules are supplied power from the Basic Module directly, care must be taken that the power supply voltage should never exceed 14.4 V.

Expansion Modules with analog I/O must not be subjected to supply voltage above 13.2 V, in which case the supply voltage to the Basic Module cannot exceed 13.7 V.

The supply voltage is connected via a 3-pole plug-in screw terminal block. The polarity is as follows (front panel of the RTU viewed head-on, with the screw terminal block above):

Outside (left):	Housing
Centre:	+12 VDC or +24 VDC
Right:	GND

Caution!

Expansion Modules must be connected via the Local Bus connector, before switching on the power supply to the Basic Module. With 24 VDC versions, an additional Power Adaptor Unit must be used with the Expansion Module.

4.2.1 RTUs With Fixed Power Supply Voltage (Prior To April 2002)

RTU-710 Modules manufactured before April 2002 required one of the specified fixed input supply voltages. For these Modules, the operating voltage is indicated on the product identification label as follows:

Model:	Voltage:	Expansion Module Power Supply:
RTU-710H/DAx.12	12 Volt DC	Supplied directly
RTU-710H/DAx.24	24 Volt DC	Requires Power Adaptor Unit

Over-voltage protection is not provided for these units. If Expansion Modules are connected without the necessary Power Adaptor Unit to an RTU that is connected to a 24 V supply, the Expansion Modules will be damaged.

4.3 Input / Output Connections

4.3.1 On-Off Inputs

The 16 potential-free on-off inputs of the RTU are divided over ports A and B into groups of 4 inputs each, each with a common return terminal “C”. The inputs may be in any polarity, with a voltage range of 12 to 24 VDC. If the “C” terminal of a group is connected to GND, the separate on-off input signals in that group of 4 would be at +12 to +24 VDC, and vice versa for reverse polarity.

When an input is activated, the corresponding LED lights up.

Assignment of inputs to the bits in Register 2:

Port A									
C	0	1	2	3	4	5	6	7	C
Common 1-4	Input 1 (Pulse signal input)	Input 2 (Pulse signal input)	Input 3	Input 4	Input 5	Input 6	Input 7	Input 8	Common 5-8
Register 2	Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	

Port B									
C	8	9	10	11	12	13	14	15	C
Common 9-12	Input 9	Input 10	Input 11	Input 12	Input 13	Input 14	Input 15	Input 16	Common 13-16
Register 2	Bit 8	Bit 9	Bit 10	Bit 11	Bit 12	Bit 13	Bit 14	Bit 15	

4.3.2 On-Off Outputs

The eight on-off outputs C0....C7 (Port C) are switched by PNP transistors, with potential-free emitter-collector terminals. Power for on-off outputs must therefore be supplied from an external source. Each output can switch a load of 500 mA, maximum. When an output is switched on, its corresponding LED lights up.

The version RTU-710x/DA3 has 16 solid-state switch type on-off outputs. In these Modules, Port D is also occupied by on-off outputs.

The + and – lines of the power supply for energizing the on-off outputs (9 to 30 VDC) must be connected, respectively, to the + and – terminals of the on-off output terminals group. The individual on-off output lines are of +ve polarity (when switched on).

The output C0 can be configured as a pulse signal output.

Assignment of outputs to the bits of Register 300:

Port C									
C	0	1	2	3	4	5	6	7	C
+ 9-36V	Output 1 (Pulse signal output)	Output 2 (Pulse signal output)	Output 3	Output 4	Output 5	Output 6	Output 7	Output 8	-
Register 300	Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	

Port D (Only In -/DA3 Version)									
C	8	9	10	11	12	13	14	15	C
+ 9-36V	Output 1	Output 2	Output 3	Output 4	Output 5	Output 6	Output 7	Output8	-
Register 300	Bit 8	Bit 9	Bit 10	Bit 11	Bit 12	Bit 13	Bit 14	Bit 15	

4.3.3 Analog Inputs (Model RTU-710H/DA1)

The four isolated analog inputs of Model RTU-710H/DA1, grouped in Port D, accept current loop signals in the range 0-20 mA. Each input has 2 connecting terminals (+ and -). Use only shielded twisted-pair cables for analog input signals. Analog signal cables should be kept as short as possible, and should not be routed near power cables.

Port D									
C	1+	1-	2+	2-	3+	3-	4+	4-	C
Shield	Input 1	Input 1	Input 2	Input 2	Input 3	Input 3	Input 4	Input 4	Shield

Caution!

Only twisted-pair cables should be used for carrying analog input signals, and these should be kept as short as possible!

4.4 Using Expansion Modules

The total number of inputs and outputs of an RTU-710 station depends on the Expansion Modules used in addition to the Basic Module. Up to 16 Expansion Modules (max 1000 mA) can be connected to one Basic Module, through the Local Bus connectors (RJ-45 type). The following Expansion Modules are available:

- EM-UCL-16DI.D1: 16 on-off inputs (max. 45mA)
- EM-UCL-32DI.D1: 32 on-off inputs (max. 80mA)
- EM-UCL-08AI.D1: 8 analog inputs (max. 180mA)
- EM-UCL-08DO.R1: 8 on-off relay outputs (max. 200 mA)
- EM-UCL-16DO.P1: 16 on-off open-collector outputs (max. 80mA)
- EM-UCL-04.AO.D1: 4 analog outputs (max. 300mA)
- EM-UCL-16DO.N1: 16 on-off outputs, open collector NPN (max. 80mA)
- EM-UCL-32DO.P1: 32 on-off outputs, open collector PNP (max. 170mA)
- EM-UCL-32DO.N1: 32 on-off outputs, open collector NPN (max. 170mA)
- EM-UCL-16DIO.P1: 16 on-off inputs and16 on-off outputs, open collector PNP (max. 100mA)

When adding Expansion Modules, they should be connected to the RTU-710 only when the power is switched off. About 2 seconds after the Basic Module has been switched on, the “System OK” and “System I/O” LEDs light up, indicating that the RTU is ready for operation and that one or more Expansion Modules are connected.

The “System OK” and “System I/O” LEDs on the connected Expansion Modules should be continuously lit. A fault in an Expansion Module will cause the “System I/O” LED to switch off, and the “I/O” LED of the Expansion Module to start blinking. This also occurs when an Expansion Module is disconnected, or if an Expansion Module is added, without first switching off the Basic Module).

If any of these conditions occur, switch off the power to the Basic Module, then switch it on again. If the same symptoms recur, one of the expansion modules is clearly defective. Disconnecting Expansion Modules one by one can help identify which one is defective.

There is no fixed order in which Expansion Modules are to be connected to a Basic Module.

Caution!

When connecting Expansion Modules to a Basic Module that uses 24VDC supply voltage, an external 12 Volt Power Supply Adaptor is required between the Basic Module and the Expansion Modules.

4.5 Power Supply For Expansion Modules

Expansion Modules must be provided with only 12 V (nominal) supply. If the RTU-710 Basic Module is provided with a 12V supply, connected Expansion Modules get their power directly from the Basic Module. The Basic Module can support a total load of 1A for connected Expansion Modules. The load of the Expansion Modules must be added to that of the Basic Module when selecting a power source.

If the total load of the connected Expansion Modules exceeds 1A, then a Power Adaptor Unit (EM-UCS-53.924) must be connected between the Basic Module and the Expansion Modules. All Expansion Modules connected to the same Expansion Bus are then supplied power through the Power Adaptor Unit, which accepts 12-48 VDC input voltage and can support an output load of 1.3 A.

The power supply compatibility of the Expansion Modules are listed in Section 3.7.

If the RTU-710 Basic Module is operated with a power supply of more than 14.4 V, the voltage supply to the Expansion Modules will be automatically switched off for their protection (see the Section" Power Supply Connections"). In such cases, a Power Adaptor Unit must be connected between the Basic Module and the first connected Expansion Module.

4.6 PicoLogo PLC Programming

The RTU-710/PLx version features integrated PicoLogo compatible micro-PLC functions. The PLC functions are programmed from a PC connected to the serial interface of the RTU-710/PLx. For this the module must be in the programming mode. (Switch off power to the module, set DIP-switch 8 "ON" and DIP-switches 1-7 "OFF". The "OK" LED will blink when it is switched on again.)

4.7 LED Functions

LED	Function
System Pwr	Power supply on
System OK	Operating mode and error indication (*)
System I/O	Lights up if one or more expansion modules are connected and in operation
Time Syn	Indicates DCF time synchronization signal (only "M" version)
Time Slot	Indicates that the time-slot is active (only "M" version)
Radio Tx	Lights up while data is being transmitted over the radio channel
Radio Rx	Lights up while data is being received over the radio channel
A0...A7	Indicate status of on-off inputs 1-8
B0...B7	Indicate status of on-off inputs 9-16
C0...C7	Indicate status of on-off outputs 1-8
RF	Indicates field strength of received radio signal

(*) Under normal operating conditions the “System OK” LED is permanently lit. Errors are indicated by coded blinking patterns, described below:

Blinking Codes: OK LED	Condition
LED off	Basic Module fault; or not ready
LED continuously on	In operating condition; no faults
LED on, goes off briefly every 2 seconds	In operating condition, no errors. PicoLogo Micro-PLC program executing correctly (RUN mode).
LED blinks with equal on and off periods	The RTU is a master in a point-to-point or point-to-multiple-point network, and one or more of the slave stations are not responding
2 short blinks followed by a long pause	Invalid address. Slave station addresses must be in the range 1-239. A master station address must be in the range 0-235.
3 short blinks followed by a long pause	One of the Expansion Modules has a fault. Or, an Expansion Module has been removed or added, while the station is active (i.e., while the Basic Module is powered on)
4 short blinks followed by a long pause	Radio fault: transmitter/receiver fault

4.8 Start Up

When a Basic Module is switched on, all the LEDs (except the OK, Radio Rx, and Radio Tx LEDs) light up for about 2 seconds, to confirm that the LEDs are functional. This is followed by the software version number being displayed on the 16 on-off input status LEDs, as 4-bit BCD numbers (on = 1; off =0).

Example:

Port A : Port B : Software Version:

0000 0001	0010 0100	01.24

These LEDs are then extinguished, and the OK LED lights up. The RTU is now ready for operation. If a fault exists, this is indicated through a coded blinking sequence of the OK LED, as listed above.

5 PicoLogo® Micro-PLC

The RTU-710/PLx version features integrated PicoLogo compatible PLC functions. This feature is treated as a distinct software component of the product, with its own technical documentation that is included with the RTU-710/PLx version. The details of the PicoLogo feature are therefore not given in this document. For that information, refer to the separate PicoLogo manual.

PicoLOGO PLC programs are created off-line through a Windows based PLC programming tool (compiler). After creating the program on the PC, it is uploaded to the RTU-710/PLx through the serial interface.

6 Additional Functions

6.1 Counters / Timers

Each of the 16 internal on-off inputs has a counter and a timer function available: i.e., up to 16 event counters and timers are possible in a single RTU-710 Basic Module. A 16-bit register containing the counter/timer value is assigned to each input. The first counter/timer register is assigned to Input 0 (Port A) and the last counter/timer register to Input 15 (Port B).

6.1.1 Counters

If an input has been configured as a counter, pulses (each consisting of a logic low plus a logic high transition) at the input are counted. This feature can be used to measure outputs of pulse type sensors such as flowmeters.

Input pulses are continuously counted, from the instant the RTU-710 becomes operational.

The inputs of Port A are configured as counters, at the factory before dispatch. This configuration can be changed via the control register 918.
The 16-bit counters have a counting range of 0 to 65535 (0000h to FFFFh). After reaching the end of the range, the counter starts again from zero.

A master station would count the number of pulses accumulated in a counter register as the difference between the register values read during successive radio polling cycles. Counter overflow at FFFFh should be taken into account.

The counters are retentive: i.e., their registered values are retained even when power supply to the RTU is switched off. After power is restored, the RTU will restart from the count values that accumulated up to the instant the power stopped. The occurrence of a power supply interruption is registered by a status byte that is read when the next radio query is received from a remote RTU. The maximum counting rate of these inputs is f = 10 Hz. If required, the user can set up the RTU so that the counters become non-retentive (by setting Bit 3 of the Operating Mode Register 917 to bit value "1").

Example: flow measurement using the counter function

A flowmeter connected to an on-off input generates 10 pulses per litre. The RTU-710 is polled at 09.45 by the remote master station and returns the counter value for that input as 12700. The next polling takes place at 09.48, by which time the count value has increased to 13060. Therefore 360 pulses have been counted in 3 minutes, corresponding to 36 litres in that time, or 12 litres per minute.

6.1.2 Timers

If an input is configured as a timer, the value of the corresponding register is incremented at the rate of 1 count per second, with a timing resolution of 1/10 second.

The inputs of Port B are configured as timers, at the factory, before dispatch. This configuration can be changed via the control register 918.
The 16-bit counters have a counting range of 0 to 65535 (0000h to FFFFh). After reaching the end of the range, the counter starts again from zero.

A master station would count the number of pulses accumulated in a timer register as the difference between the register values read during successive radio polling cycles. Counter overflow at FFFFh should be taken into account.

The timers are retentive: i.e., their registered values are retained even when power supply to the RTU is switched off. After power is restored, the RTU will restart from the time values that accumulated up to the instant the power stopped. The occurrence of a power supply interruption is registered by a status byte that is read when the next radio interrogation is received from a remote RTU. The maximum counting rate of these inputs is f = 10 Hz. If required, the user can set up the RTU so that the timers become non-retentive (by setting Bit 3 of the Operating Mode Register 917).

The scanning (reading) rate of these inputs is over 10 per second, and therefore the residual error is less than +/- 100mS.

Example: monitoring pump running time in an effluent treatment plant

While Pump 1 is running, the on/off input B0 of an RTU-710 is activated (Timer 1). While Pump 2 is running, input B1 is active (Timer 2). At 08:00 Timer 1 registers a value 7455, and Timer 2 a value of 65430.

The next polling by the master station takes place at 08:15, at which time the Timer 1 registers a value 7892. The difference between the successive values is 437. Therefore, between 08.00 and 08.15, Pump 1 has run for a total time of 437 seconds (7 minutes and 17 seconds).

At time 08.15, Timer 2 registers a value of 462. It has run to its maximum value of 65535 and then reset itself to 0. Therefore the total time that this pump has run, between the successive polling cycles, is the difference between of 65535 and 65430 (=105) plus the difference between 0 and 462 (= 463; the “0” is also counted as a second). In other words, between 08:00 and 08:15 hrs., Pump 2 has run for a total of 568 seconds (= 9 minutes and 28 seconds).

6.1.3 Making The Counters And Timers Non-Retentive (V4.10 Onward)

The counters and timers can be made non-retentive if desired, making the operation of the RTU-710 similar to the RTU-700. When the RTU-710 is set up this way, all counters and timers reset to zero whenever the power supply to the unit is turned off.

To make the RTU-710 operate in this mode, Bit 3 of the Operating Mode Register is set to value "1".

6.1.4 Combining Two Counters Into A 32-Bit Counter (V4.10 Onward)

Two contiguous counters can be set up to operate as a single 32-bit counter. This is done through Register 951.

Each bit of this register is assigned to a counter: Bit 0 corresponds to the first event counter (Input A0), Bit 1 the second event counter (Input A1), ... Bit 8 the first timer (Input B8),... etc.

If a bit in the register is set, then an overflow of the lower order counter causes the addition of 1 count in the higher order counter. The higher order counter no longer counts the on-off events of the input to which it is assigned in the default mode.

Example:

If Bit 0 of Register 951 is set, then each overflow of the counter assigned to Input 0 (jump from 65535 to 0) causes the adjacent higher order counter to count up by 1. In this condition, on-off events at the input next to A0 (i.e., Input A1) are not counted.

6.2 Analog Inputs: High and Low Limit Detection, and Averaging

If analog inputs exist in an RTU-710 station, either in the Basic Module or in one or more Expansion Modules connected to it, the minimum, maximum, and average values are automatically determined for the first 4 analog inputs.

An averaging period of 60 seconds is set in the RTU-710 at the factory, before delivery. The user can change this averaging period, by altering the contents of the control register 919. A value of 0 in effect disables the averaging function.
The minimum and maximum values of measurements are updated every 1 second. This interval setting cannot be altered.

The 60-second averaging period results in an operating time of 2 years, determined by the RTU's memory capacity. If this period is exceeded, the average value is reset and the calculation begins once again.

There are two identically configured sets of registers for storing these values, respectively for the current set of values and the previous set of values. When at least one of the "current" registers in a group is read, all the registers (min. max. and average) of this set, corresponding to this channel, are copied to the "previous" registers, and the "current" registers are reset. The remote master station can then read the "current" set of values. If a message frame transmitted by an RTU is not received, for any reason, by the remote master station, these values are always available in the "previous" set of registers (after the "current" values have been reset by the reading action). This means that any lost values can be read from the "previous" registers.

Note that 4 registers are assigned to each analog input channel: corresponding to minimum, maximum, and average values, plus the redundancy counter. As soon as even one of these registers is read, and the data is transmitted, all the registers corresponding to that analog input channel are reset (minimum and maximum values are reset, and averaging starts again). It is important to read all registers of a channel during transmission so that the data for all channels relates to a common point of time. If the corresponding radio message frame is lost, these values can then be read as many times as required from the "previous" registers.

Each set of registers has a redundancy counter. Repeated or missing message frames can be detected with the help of this counter. The “current” counter is increased by 1 every time that set of registers is accessed and read. If the counter and the value-register of a channel are read, the redundancy counter increments by 1.

If a transmitted radio message frame is lost, it could be for one of two reasons: either the polling message frame from the remote master station was not received, or the master station did not receive the response message frame transmitted by the RTU-710 slave station.
If the polling message frame is lost, the slave RTU does not receive the command to read out the register. As a consequence, the contents of the “current” registers are not copied to the “previous” registers. If the “previous” registers are read, only old values will be transmitted. Therefore, in this event, the “current” registers must be read out again.
If the slave RTUs response message frame is transmitted but lost, it has correctly understood the command to read out the register, so the required values are copied into the “previous” register. In this condition, the valid data is available in the “previous” register.

The redundancy counter is used to cope with this situation. The current value of the redundancy counter is read and stored by the master station, every time it polls a slave station. If a response message frame transmitted by the station is lost, the “previous” register can be read during the next polling access. If the redundancy counter value here is higher than the value obtained during the previous polling access, then the values of the lost message frame are here. If the latest redundancy counter reading by the remote master station is the same as the previous polling access, the current values are obtained by reading the “current” registers.

The redundancy counter size is 16 bits. After reaching the value 65535 (FFFF Hex) it starts again from 0. This should be considered during the evaluation of the counter.

Whenever the RTU-710H is reset, the first resetting of the minimum, maximum, and average value registers is delayed by 3 seconds. This ensures that the correct values of analog input channel measurements are available.

The structure of the register block for the minimum, maximum and average values of the analog inputs is shown below. An absolute register address cannot be specified here, because the registers can have different addresses after the RTU has been configured. Therefore only the register offset can be indicated as a reference here.

Register Offset	Function	Note
0	Current min. value 1	Current minimum value analog input 1
1	Current max. value 1	Current maximum value analog input 1
2	Current average value 1	Current average value analog input 1
3	Current redundancy 1	Current redundancy value analog input 1
4	Current min. value 2	Current minimum value analog input 2
5	Current max. value 2	Current maximum value analog input 2
6	Current average value 2	Current average value analog input 2
7	Current redundancy 2	Current redundancy value analog input 2
8	Current min. value 3	Current minimum value analog input 3
9	Current max. value 3	Current maximum value analog input 3
10	Current average value 3	Current average value analog input 3
11	Current redundancy 3	Current redundancy value analog input 3
12	Current min. value 4	Current minimum value analog input 4
13	Current max. value 4	Current maximum value analog input 4
14	Current average value 4	Current average value analog input 4
15	Current redundancy 4	Current redundancy value analog input 4
16	Previous min. value 1	Previous minimum value analog input 1
17	Previous max. value 1	Previous maximum value analog input 1
18	Previous average value 1	Previous average value analog input 1
19	Previous redundancy value 1	Previous redundancy value analog input 1
20	Previous min. value 2	Previous minimum value analog input 2
21	Previous max. value 2	Previous maximum value analog input 2
22	Previous average value 2	Previous average value analog input 2
23	Previous redundancy value 2	Previous redundancy value analog input 2
24	Previous min. value 3	Previous minimum value analog input 3
25	Previous max. value 3	Previous maximum value analog input 3
26	Previous average value 3	Previous average value analog input 3
27	Previous redundancy value 3	Previous redundancy value analog input 3
28	Previous min. value 4	Previous minimum value analog input 4
29	Previous max. value 4	Previous maximum value analog input 4
30	Previous average value 4	Previous average value analog input 4
31	Previous redundancy value 4	Previous redundancy value analog input 4

Caution!

The register contents of the RTU-710H are deleted when its power supply is interrupted.

6.3 Pulse Signal Transmission (Point-To-Point System)

A pulse signal can be transmitted over a point-to-point system consisting of one RTU-710 at each end. The pulse signal is fed as an input to the RTU designated as the slave, and is reproduced transparently as a pulse signal output by the other RTU, designated as master. For this special purpose, input A0 of the slave RTU has to be set up as a special counter input (factory setting). Output C0 of the master RTU is set up as a pulse signal output through Register 960. When this is done, this output can no longer be addressed through the corresponding bit in Output Register 300.

A pulse signal with frequency of up to 10 Hz can be fed to input A0 of the slave RTU. The pulses are counted and transmitted to the master RTU at measuring intervals of 20 seconds. This interval is adjustable through Register 960. The slave RTU reproduces the pulse signal as an output with a 1:1 relationship with, and frequency as close as possible to, the original pulse input signal at slave RTU. A minimum width of 5 msec is guaranteed for each part (on/off) of the pulse cycle.

The measuring interval is usually expanded when the time-slot method of radio communication is used. It can happen that a measuring interval ends after the current time-slot ends. In this case, the measuring interval is extended until the next radio time slot.

6.3.1 Pulse Signal Transmission For Dual-Range Water-Meters

Pulse signals from a dual-range water-meter can be transmitted by the RTU-710. For this Bit 3 ("VW") of the Configuration Register must be set to value "1", and the slave RTU must be pre-configured (factory setting) for pulse signal input handling (see Section 6.3 above). If this is done, pulses at inputs A0 and A1 of the slave RTU are added, and reproduced as a summed pulse signal output at channel C0 of the master RTU. Alternatively, the RTU can be set up to convert the pulse rate to an analog output at the master RTU. The value of the analog output is proportional to the measured flow rate.

Under this dual-range water-meter compatible set-up, the pulse signal output of the master RTU can have rate of up to 20 Hz if each of the two pulse signal inputs at the slave RTU are at the maximum rate of 10 Hz.

In this set-up, the on-off output C1 of the master RTU is deactivated, since the corresponding input A1 of the slave RTU has been assigned to the dual pulse signals of the water meter.

6.3.2 Pulse Signal Transmission: Modes Of Operation

The pulse signal transmission mode is selected by setting the "IM" bit of Configuration Register 960.

6.3.2.1 Pulse Count Priority Transmission (Factory Setting)

This feature has been implemented giving priority to the count accuracy of pulse signal transmission: i.e., every pulse counted at the input of the slave RTU is reproduced reliably at the corresponding output of the master RTU. The cumulative number of pulses totalized by the slave RTU since the last data transmission is subtracted from the new total at the end of the next measuring interval. The difference is divided by the time, yielding a measurement of frequency. This value of frequency is transmitted to the master along with the value of total pulses received at the slave RTUs input since the last data transmission. The master RTU reporduces pulses with the exact count and approximate frequency of the pulse signal received by the slave RTU. If this count data is transmitted before the end of the current measuring interval, the count of the input pulses that was not included in that transmission frame is added to the pulse count difference calculated at the end of the next measuring interval. Thus accuracy of pulse counts and pulse frequency are both accurately transmitted.

If radio communication is interrupted, the master RTU will suspend the pulse signal output, after is has passed on the pulses received by it from the slave RTU up to that time. The master RTU will then await the next transmission from the slave RTU, when the updated count of pulses and frequency is received. Therefore pulses are not missed even if radio communication is temporarily interrupted. However, this can result in a higher pulse frequency being measured (compared to the actual frequency), because in this mode of operation priority is given to accuracy of pulse count rather than pulse frequency.

If radio communication is interrupted for more than 130 seconds and if during that time only one pulse is registered, this will not be included in the current transmission, but will be stored temporarily and added to the count of the next measuring interval

If radio communication is interrupted due a timeout occurrence, resulting in the outputs of the master RTU being switched off, the remaining count of pulses registered by the master RTU are first sent out before its outputs are switched off. In effect, when interruption of radio communication occurs, the switching-off of outputs by the master RTU is delayed until all of the currently buffered pulses are sent out.

6.3.2.2 Pulse Frequency Priority Transmission

For some applications, pulse signal frequency is the measured value of interest, not the pulse count. This would be necessary, for example, if flow rate is to be measured and not the flow volume. The pulse frequency needs to be reproduced at the master RTU as accurately as possible, in spite of temporary interruption of radio communication, at least up to the instant of timeout switch-off of all outputs.

When pulse frequency is required to be reproduced as exactly as possibly, the count difference etc. is processed the same way as when the pulse count is the objective.
The minimum time of the measuring interval is added to the time between the last and next radio transmission. The total number of pulses counted is divided by this total time interval, to get a measurement of frequency. This value of frequency is then included in the next radio transmission. In this mode of operation, the reproduced pulse signal output is maintained by the master RTU at the frequency last computed, until it is updated with the next computation of frequency of the received pulse signal, or until all outputs are switched of by the timeout function (in the event of radio signal loss).

For example, if the pulse signal is received at the input of the slave RTU at a frequency of 2.4 Hz, and if the radio link is interrupted for 5 minutes, the master RTU will continue to produce a pulse signal output at 2.4 Hz during this radio-interruption time. As soon as the radio link is restored, the slave RTU will compute the average frequency during the radio interruption period, and transmit an updated frequency value to the master RTU in the next message frame.

If the radio interruption period exceeds the timeout limit, the outputs of the master RTU will be switched off.

6.3.3 Analog Output Of Pulse Frequency

Frequently, a pulse frequency needs to be presented as an analog output, e.g., if a flow rate is to be indicated on an analog meter. To meet this need, an RTU-710 configured as a master can convert a pulse frequency value to an analog value and send this through its first analog output channel.

This frequency-to-analog conversion function can be implemented by setting Bit 2 ("AA") of Register 960 to the bit value "1". When this is done for the master RTU-710, its first analog output is dedicated to sending out the analog value of the measured frequency. The output register of the RTU-710 that normally generates the value of the output on this analog output is consequentially disabled. In a point-to-point RTU system, if analog measurements are to be transmitted, the reservation of this analog output of the master RTU must be remembered. In this case the first analog input of the slave RTU cannot be used because its corresponding analog output at the master RTU has been committed for analog output of pulse frequency.

Also, when the master RTU is set up for this mode of operation, its on-off output C0 is disabled (Bit 0 of Register 960 is set to value 1). This is because the corresponding on-off input at the slave RTU is now tied to another (analog) output of the master RTU.

The analog output is scaled so that the maximum input pulse frequency (10 Hz) corresponds to the maximum value of the analog output (20 mA or 10 VDC), through the internal digital value of 4095. The span and zero of the analog output is also user-programmable.

When set up for "group water meter" mode of operation, pulses at both on-off inputs A0 and A1 of the slave RTU are counted. Because the maximum frequency of each input is 10 Hz, the maximum throughput frequency is now 20 Hz. This should be noted when defining the values of the gain registers. If this maximum throughput frequency of 20 Hz is to correspond with the analog output span value of 20 mA, then the gain value must be set to 50 (factor 0.5).

The analog output value corresponding to the input pulse frequency can be adjusted by selecting an appropriate value between 0.01 and 100.00 for the "Impulse Gain" Register. This register value is determined by multiplying the desired gain factor by 100. For example, if the gain factor is 1.70 then the register value will be 170. If the gain is 08.5, then register value will be 85, and so on. A gain register value of 0 results in a gain factor of 1: i.e., setting a value of 0 in the gain register has the same effect as setting a value of 100.

An offset value (in the range 0-4095) can be added to the analog output through bits 0-11 of the Impulse Offset Register. Bit 15 of this register determines if the offset value is to be added to, or subtracted from, the analog output value. If Bit 15 = 0 the offset value is added; if Bit 15 = 1 it is subtracted.

6.3.3.1 Example

In a point-to-point RTU-710 system, the master RTU has 4 analog outputs (0-20 mA). A flowmeter with pulse signal output is connected to the slave RTU. At maximum flow rate, the flowmeter signal frequency is 5 Hz, which is to correspond to an analog output of 20 mA at the master RTU, in the range 4-20 mA. A flowmeter output of 0 Hz will be represented by an output of 4 mA. Therefore the pulse frequency range of 0 - 5 Hz is covered by an analog output range of 16 (= 20 - 4) mA. The gain must be calculated such that an input pulse rate of 5 Hz generates an analog output signal value of 20 mA. Based on the fact that with a gain factor of 1, an input frequency of 10 Hz will be represented as an analog output of 20 mA, the gain factor for this example is computed as follows:

$$((10Hz / 5Hz) / 20mA) * 16mA = 1.6$$

To implement a gain factor of 1.6, the gain register value must be set at 160.

However, then a frequency of 0 Hz would produce an output of 0 mA, and a frequency of 5 Hz an output of 16 mA at Analog Output 1 of the master RTU. Therefore a positive offset of 4 mA must be added to the analog output of the master RTU, to shift the range to 4 - 20 mA.

Because a 12-bit D/A converter is used to create the analog output, the binary-coded (internal) value of 4095 corresponds to the output span value of 20 mA. 4 mA therefore corresponds to the internal digital (D/A converter input) value:

(4095 / 20mA) * 4mA = 819

The binary equivalent of this value (819) is to be written into the 12 lowest bit positions of the Impulse Offset Register. Also, Bit 15 of this register has to be set the value 0, so that offset value is added to (and not subtracted from) to the analog output.

With this configuration an input pulse signal of 0 - 5 Hz is reproduced at a remote location as a 4 - 20 mA analog signal.

If the value of the internal digital factor calculated by the RTU exceeds 4095 after applying gain and offset, the analog value is set automatically to the maximum value of 4095. In the example described above, an input frequency of 7 Hz will result in an output signal value of 20 mA. Similarly, if the internal digital factor calculated by the RTU is less than 0 (zero) (e.g., if the gain value is calculated at 100, but the offset is calculated at 300), the analog output signal will be set to zero.

6.3.3.2 Analog Output: Time Considerations

The analog output value is updated with every new radio transmission (message frame) received by the master RTU from the slave RTU, provided at least one new measuring interval has been completed since the previous message frame. This analog value is held constant until the next such update. In the event of radio interruption the analog value of the pulse frequency is held constant during the specified timeout period. If all outputs are switched off consequent to a timeout event, the analog output is also set to zero.

6.3.4 Slave RTU Behavior On Loss Of Power / Reset

On occurrence of power supply interruption or reset of a slave RTU, its counters are reset to zero. In this event a count difference calculation will result in a false measurement.

The master RTU recognizes a restart of the slave RTU and rejects the count value received immediately after the slave RTU restart as invalid. Only after receipt of a message frame after the completion of the next full measuring interval is the next valid count difference determined. Therefore a restart of the slave RTU can result in a loss of pulses that were received at its pulse signal input during the previous measuring interval (i.e., immediately after the restart).

6.3.5 Pulse Signal Transmission: Operational Limitations

Some technical points should be noted regarding pulse signal transmission.

The internal clock rate of the RTU guarantees that on-off cycles as low as 100 msec and pulse signal input/s (*) of up to 10 Hz frequency will be detected. On-off and pulse signals should be within these limits. (* Normally, when used, a single pulse signal input channel is provided, except in a RTU-710 version specifically configured for use with dual-range water meters that have two pulse signal outputs each. This RTU version has 2 pulse signal input channels, each up to 10 Hz).

If radio communication is interrupted for more than 130 seconds and if during that time only one pulse is registered, this will not be included in the current transmission, but will be stored temporarily and added to the count of the next measuring interval. For immediate transmission, more that 1 pulse should be detected per 130 seconds interval between two successive radio transmissions (or 2 pulses per 260 seconds, and so on).

This is not a major consideration in most applications, because even in point-to-point RTU systems operating in the time slot mode, data transmission intervals rarely exceed 60 seconds. The maximum time between two successive radio transmissions (i.e., length of radio interruption) should not exceed 655 seconds (nearly 11 minutes), otherwise significant errors can occur when pulse frequency is the remote measurement objective. If a radio interruption longer than this occurs, the frequency measurement is rejected by the system.

The number of input pulses at the slave RTU during radio linkage outage must not exceed 65536, and the frequency must not exceed 10 Hz. If the number of pulses during this period exceeds 65535, the entire lot will be lost. This valid only for count mode operation. In frequency mode operation, as mentioned earlier, the latest frequency measurement is rejected if the period between two successive radio transmissions exceeds 655 seconds.

7 Registers Assignment

7.1 Registers Structure

The RTU-710 Series use the industry-standard MODBUS RTU communication protocol. This means that all registers have a word width of 16 bits, and are arranged in 3 consecutive groups. A write operation is executed by transmitting the start address, followed by the number of the transmitted registers and the data words. A read operation is executed by transmitting the start address, followed by a 16-bit number that defines the number of data words that will follow immediately.
In addition to read and write registers, the RTU also contains special registers: read-only “RP registers”, and “E-registers” whose contents are saved to a non-volatile memory area as soon as they are written to, so that these contents are protected against power interruptions.

Types of access:

(R): Read register
(W): Read/write register
(WP): Read register containing operational settings (this register cannot be written)
(E): EEPROM backed-up register (contents protected against power interruptions)

The register numbers before the brackets in the following table correspond to the actual transmitted addresses in the data message frames that have to be accessed. The logical MODBUS addresses are additionally shown in brackets for clarity.

RTU-710: Read and Write Registers

Register	Function	Remarks
0 (40001)	RTU Address	MODBUS address, set on DIP-switches, through which communication can be established with an RTU station (R)
1 (40002)	Status	Status byte. If a value is written in this register it resets the status byte (R/W)
2 (40003)	Input Register	Input (R). Sequence: on/off inputs, analog inputs, counter/timer (Port A/B), min./max./ average values/redundancy counter (current) min./max /average values /redundancy counter (backup)
99 (40100)	Virtual Input Register (PicoLOGO)	Virtual input register through which the PicoLogo can access an RTU-710/PLx
300 (40301)	Output Register	Outputs (W) in the following sequence: On-off outputs, analog outputs
399 (40400)	Virtual Output Register (PicoLOGO)	Virtual output register through which the PicoLogo can access an RTU-710/PLx
598 - 599 (40599 - 40600)	Write Mask For Mapping Register	One bit of the Write Mask is assigned to each Mapping Register: Register 600 is assigned to Bit 0 of Write Mask Register 599, Register 631 is assigned to Bit 15 of Write Mask Register 598. The use of the Write Mask is optional and applies only when the Write Mask Registers are accessed.
600-631 (40601-40632)	Mapping Register	Any arbitrary registers can be mirrored in this contiguous block of registers. This allows a number of scattered registers to can be reached in a single read/write access. The registers that are so mirrored here are to be specified in the Configuration Registers 1000 through 1031. For example, if the value of Register 1000 is "0001", then Register 1 can also be found at position 600.

RTU-710: Special Registers

Register	Function	Remarks
900 (40901)	Radio Address	Address of the radio layer (R/WP/E)
901 (40902)	T-Timeout	Time based timeout, in seconds (R/W/E)
902 (40903)	X-Timeout	Message frames based timeout, in number of message frames (R/W/E)
906 (40907)	Station (RTU) ID	Sends the ID of the station (RTU) (R)
907 (40908)	Firmware	Firmware version (R). e.g., 0115Hex corresponds to version 01.15
910 (40911)	Radio Channel	Currently used radio channel (R/W)
911 (40912)	Default Radio Channel	Radio channel used when next switched on (R/W/E)
912 (40913)	Transmitter Power	Transmitter power output setting (0-100) (R/W). At the factory this is set to the maximum value specified by the customer.
913 (40914)	Default Transmitter Power	Transmitter power output when next switched on (R/W/E)
914 (40915)	Received Radio Field Strength	Received field strength of the last received message frame, in percent (R)
916 (40917)	Station Address	Logical address of station (R/W/E)
917 (40918)	Operating Mode	Bits 0 -2: RTU operating mode, programmable via DIP-switches. Bit 3: If set to value = 1, makes timers and counters non-retentive
918 (40919)	Pin Configuration Timer/Counter	Each internal input corresponds to a bit (Port A7=MSB, port B8=LSB). If the bit is 1, this input has a counting function If the bit is 0, it has a timer function
919 (40920)	Averaging Time	Averaged values of analog inputs in seconds (R/W/E)
930 (40931)	On/Off Inputs	Number of available on-off inputs (R)
931 (40932)	Analog Inputs	Number of available analog inputs (R)
932 (40933)	On-Off Outputs	Number of available on-off outputs (R)
933 (40934)	Analog Outputs	Number of available analog outputs (R)
934 (40935)	Event Counter	Number of available event counter (R)
935 (40936)	Time Counter	Number of available operating time counter (R)

951 (40952)	Counter Doubling Register	This register makes it possible to combine two adjacent counters into one 32-bit counter
960 (40961)	Pulse output enabling register	Configures Output C0 for pulse output in a point-to-point system
961 (40962)	Gain register: frequency analog output	Sets the gain (span) value of the analog output of measured pulse signal frequency
962 (40963)	Offset register: frequency analog output	Sets the offset value of the analog output of measured pulse signal frequency

Mapping Table (600 through 615) and Mapping Pointer (1000 through 1015)

1000 through 1031 (41001 through 41032)	Mapping Pointer	Points to the registers linked through the Mapping Table (R/W/E)

600 through 631 (40601 through 40632)	Mapping Table	The mapped registers (R/W) are mirrored here

7.2 Description of Register Functions

7.2.1 RTU Addresses

This register contains the logical address set via the DIP-switch. The address range is 0-255. Addresses 0 and 241-255 are reserved for the master station and should not be used for RTU-710 slave stations..

7.2.2 Status

The operating condition of the RTU can be determined from the status register. The following status messages are supported at the present time:

Bit	Meaning
0	Internal fault 1
3	This bit is set to value = 1 if the RTUs outputs have switched off due to a t-Timeout or x-Timeout occurrence
4	RTU reset of the radio component during operation
5	RTU faulty radio component
6	Fault in one or more Expansion Modules
7	Power interruption/restart: counters and timers are reset

Caution!

Except for bit 6 (Expansion Module fault) all status bits are reset when any of the register bits are re-written. Bit 6 remains in its previous state until the Expansion Module fault is cleared.

7.2.3 On-Off and Analog Input Registers

The input registers block is arranged with on-off input registers first, followed by the analog input registers, and finally the 16 registers for the counter/timer functions for the 16 on-off inputs of the Basic Module. The first register after the analog input values is the counter/timer register of input A0; the 16th register after the analog values is the counter/timer register of input B7.

Since the registers are 16 bits wide, eight on-off inputs occupy half a register word. Port A occupies the low bits of register 2, Port B the high bits. If analog inputs exist, these begin with the next complete register. Each analog input occupies 12 bits of a full register, with the upper 4 bits unused.

The number of on-off and analog inputs, counters and timers of an RTU-710 can be checked by reading the respective status registers.

Assignment of the inputs A0-A7 and B8-B15 of the RTU-710 to the bit positions of Register 2:

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Inp	B15	B14	B13	B12	B11	B10	B9	B8	A7	A6	A5	A4	A3	A2	A1	A0

Example: on/off and analog input registers assignment:

An Expansion Module with 16 on/off inputs, and another with and 8 analog inputs are connected to an RTU-710/DA1 Basic Module. For this configuration, the input registers are assigned as follows:

- Register 2 contains the states of the 16 on-off inputs of the Basic Module
- The high bits of Register 3 contain the states of Port A of the Expansion Module with 16 on-off input
- The low bits of Register 3 contain the states of Port B of the Expansion Module with on-off inputs
- The four registers containing the values of the analog inputs of the RTU-710/DA1 Basic Module begin with Register 4
- The eight registers containing the values of the analog inputs of the Expansion Module begin with Register 8
- The 16 counter/timer registers start with Register 16. The first of these corresponds to Port A0, the last to Port B15
- The “current” registers containing the minimum, maximum, and average values of the first four analog inputs start with Register 32.
- The “previous” registers containing the minimum, maximum, and average values of the first four analog inputs start with Register 48.

7.2.4 On-Off and Analog Output Registers

The output registers block is arranged with on-off output registers first, followed by the analog output registers.

Since the registers are 16 bits wide, eight on-off outputs occupy half a register word. Port A occupies the lower part of a register. If analog outputs exist, these begin with the next complete register. Each analog output occupies 12 bits of a full register, with the upper 4 bits unused.

Assignment of the output ports of an RTU Basic Module to the output register bits:

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Inp	D7	D6	D5	D4	D3	D2	D1	D0	C7	C6	C5	C4	C3	C2	C1	C0

Note: on-off outputs of Port D exist only in the version RTU-710x/DA3.
In other versions, the high bits of Register 300 are not occupied by internal on-off outputs: these are applicable only to on-off outputs of Expansion Modules.

Example: on/off and analog output registers assignment

Two Expansion Modules with 8 on-off inputs each, and another with 4 analog outputs are connected to an RTU Basic Module. For this configuration, the output registers are assigned as follows:

- The low bits of Register 300 contain the 8 on-off output states of the RTU Basic Module.
- The high bits of Register 300 contain the on-off output states of the first Expansion Module with 8 on-off outputs.
- The low bits of Register 301 contain the on-off output states of the second on-off output Expansion Module.
- Since no more on-off outputs exist in this configuration, the high bits of Register 301 are unused.
- The registers for 4 analog outputs of the analog output Expansion Module start with Register 302..

Caution!

In RTUs using the Brodersen Compatible MODBUS RTU protocol, the assignment of registers differs from the standard version!

7.3 Mapping Registers

A total of 32 registers (Registers 600 through 631) are available for creating a compacted mirror of arbitrary scattered registers (e.g. in the range of registers of the RTU-710 so that they can be read in a single access).

The registers mirrored here are specified in Configuration Registers 1000 through 1031. Register 1000 corresponds to Register 600, Register 1001 to Register 601, and so on.

For example, if the value 1 is written into Register 1000 and value 300 into Register 1001, then a read operation on Register 600 reads the contents of Register 1 (on-off inputs), a read operation on Register 601 reads the contents of Register 300 (on-off outputs), and a write operation on Register 601 automatically causes the same data to be written to Register 300.

7.3.1 Write Mask For Mapping Registers (Registers 598 and 599)

Normally, each register is defined immediately after a separate write access with the appropriate value. The main advantage of Mapping Registers is the fact that many scattered registers can be mirrored in a single contiguous block of registers, so that all the addressable range of registers of the RTU-710 can be read and written in a single access.

It is possible that an application requires writing to only a few individual registers in the mapping range, leaving the others as they were. For this, the Write Mask becomes useful.

The Write Mask is located at Registers 598 and 599, and therefore covers 32 bits. Each bit of the Write Mask is assigned to a Mapping Register. Bit 0 of the Write Mask Register 599 is the least significant bit, and is assigned to Mapping Register 600. Bit 15 of Register 598 is the most significant bit, and is assigned to Mapping Register 631.

If only some of the Mapping Registers are to be written, then the Masking Registers (Registers 598 and 598) should be accordingly written, in the same access operation in which the Mapping Registers are written. For each Mapping Register that is to be written, its corresponding bit in the Masking Register is written with a value = 1. All Mapping Registers whose corresponding bits in the Masking Register have a value = 0 are ignored during this write operation. If the Write Mask is not defined, then all Mapping Registers (without exception) will be rewritten.

Example:

Mapping Registers 600, 610, and 628 are to be written; all other Mapping Registers to remain unchanged. To avoid having to execute three write cycles for this, the write operation is executed using the Write Mask. The write operation covers registers in the range 598 through 628. The value 0x0401 is written to Register 599 (setting Bit 0 and Bit 10 each to value = 1 write-enables Registers 600 and 610). The value 0x1000 is written to Register 598 (setting Bit 12 to value = 1 write-enables Register 628). Although the write operation covers the entire range of Registers 598 through 628, only Registers 600, 610 and 628 are actually rewritten.

7.4 RTU Configuration Registers

The configuration and special registers start from address 900, and hold the set-up parameters of an RTU station. The position of the register determines whether it is “read”, or “write” register, or a register that is pre-written only by the manufacturer. Some of the registers are saved in non-volatile memory, secured against power interruptions.

7.4.1 Configuration Register: Radio Address

The address of the radio transmission layer is located here. A radio network is given a unique address. This prevents networks using the same frequency within radio range of each other from interfering with one another.

7.4.2 Timeout Monitoring

All outputs of an RTU Basic Module and connected Expansion Modules are maintained in their current states between successive data transfers. To avoid problems with outputs remaining constant unintentionally due to disturbances in radio transmission, two intervals are monitored: time elapsed since receipt of the last message frame: (“t” Timeout) and number of data blocks received since the last message frame carrying the address of that station (“x” Timeout).

7.4.3 Configuration Register: Time Based (“t”) Timeout Monitoring

The RTU-710 constantly monitors the radio message frames that are transmitted by it. If the RTU does not receive any polling message frame from the master station within a predetermined time interval ("n" seconds), all outputs are reset to off condition. The limiting time interval can be altered by setting an appropriate value in this (“t” timeout) register. Setting this register’s value to zero effectively disables the “t” timeout function.

If all outputs are switched off as a result of a timeout event, then Bit 3 of the Status Register is set to value = 1, in order to indicate this timeout occurrence to the master RTU upon its query. This bit is reset to value = 0 upon the next write operation to the Status Register.

The t-timeout interval is set to 5 seconds at the factory, before delivery.

7.4.4 Configuration Register: Data Blocks (“x”) Timeout Monitoring

In a radio network that consists of many stations (stations), it is possible that a particular station may not be addressed by the master station for a length of time. The data block (“x”) timeout defines the number of polling message frames within which the RTU station must be addressed at least once. If the station is not addressed in this number of consecutively received data blocks, its outputs are automatically reset to off condition. The factory set value for this is 512 message frames.

If all outputs are switched off as a result of a timeout event, then Bit 3 of the Status Register is set to value = 1, in order to indicate this timeout occurrence to the master RTU upon its query. This bit is reset to value = 0 upon the next write operation to the Status Register.

This function can be disabled by writing the value " 0 " into this register.

7.4.5 Configuration Register: RTU ID

This register enables a master station to identify RTU stations that are active in a radio network, and to verify that the correct RTU model is installed at a slave station. The ID codes of RTU-710 Series versions are:

- 0010 h: RTU-710/DA2
- 0011 h: RTU-710/DA1
- 0012 h: RTU-710/DA3

7.4.6 Configuration Register: Software Version

The contents of this register identify the software version used in an RTU. A value of 0115h means software level version 1.15. This value is also displayed on the LEDs (as a BCD bit pattern) when the RTU is switched on.

7.4.7 Configuration Register: Radio Channel

This register allows the radio channels to be selected through software.

If the Specific Radio Channel configuration register has the value 0xFFFF (factory set before delivery, except in time-slot radio communication mode) the radio channel (frequency) setting is to be done using the RTUs DIP-switches, accessible from the outside. Every time these DIP-switch settings are changed, this register is overwritten with the new value.

If no DIP-switches are available for frequency setting, the frequency value set in the configuration register “Specific Radio Channel” is used when the RTU is switched on.

7.4.8 Configuration Register: Specific Radio Channel

If an RTU is configured in such a way that any one of several frequencies in a band can be used but cannot be set via DIP-switches, then the frequency channel must be selected through this register. If the frequency can be set via DIP switches, then the value "0xFFFF" must be written into this register.

7.4.9 Configuration Register: Transmitter Output Power

This register contains the transmitter output power value, in the range 0-100%. This value is not linear! Register value of 100 corresponds to 500 mW in a medium power RTU, and 6 watts in a high power RTU. The transmitter power can be limited by an internal setting depending on local statutory restrictions.

If the Transmitter Output Power configuration register has the value 0xFFFF (delivery status) the transmitter output power level is set using the RTUs DIP-switches, accessible from the outside. Every time these DIP-switch settings are changed, this register is overwritten with the new value.

If no DIP-switches exist for setting the radio frequency, the RTU uses the value existing in the Specific Radio Channel configuration register when it is switched on.

7.4.10 Configuration Register: Specific Transmitter Output Power

A change in the contents of the Transmitter Output Power Register has an immediate effect on the current transmitter output power. This value is however lost when an RTU is reset or if the power supply is interrupted. The value of the Transmitter Output Power Register is copied from Specific Transmitter Output Power Register whenever an RTU is reset or restarted after a power supply interruption. If the transmitter output power is to be kept at a constant value at all times, both registers must be set accordingly. If the transmitter output power is to be adjusted via the DIP-switches, a value of "00" must be written into the Specific Transmitter Output Power Register.

7.4.11 Configuration Register: Field Strength of Received Signal

The field strength of the received radio signal at the time of receiving the last message frame is recorded in this register as a percentage value (0-100%). Specific field strength levels, corresponding percentage values, and the coded LED display patterns are listed in the following table.

Field Strength	Value in %	LED Display	Comments
0.5µV	17%	3 red	Low signal strength
1µV	28%	Yellow	Good signal
5µV	51%	1 green	Very good signal
10µV	61%	2 green	
30µV	75%	3 green	
150µV	98%	4 green	

7.4.12 Configuration Register: RTU Address

The logical address of the RTU is set in this register. The value of this register also reflected in register 0. If the address can be set via a DIP-switch, the DIP-switch setting takes precedence.

7.4.13 Configuration Register: Counter/Timer Setting

Each of the 16 on-off inputs of a Basic Module can be have either a counter or a timer function. This register determines these functions for each of the on-off inputs. If register bit is "0", the corresponding input has a timer function. If the bit is "1", the input has a counter function.

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Inp	A7	A6	A5	A4	A3	A2	A1	A0	B15	B14	B13	B12	B11	B10	B9	B8

7.4.14 Configuration Register: Pulse Signal Output

If pulse signals are to be transmitted over a point-to-point RTU-710 system, then output C0 of the master RTU has to be configured for this purpose. When this is done, the RTU ignores the bit corresponding to output C0 in Register 300 (On-Off Outputs). Register 960 is used for setting the pulse signal output, its mode of operation (count or frequency priority mode), and the minimum measuring interval.

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Minimum measuring interval (time) (Factory setting: 20 seconds)												VW	AA	IM	IE

Measuring interval:
The value of Bits 8.....15 determines the minimum time (in seconds) of the measuring interval. The pulse signal output value (count or frequency) is updated during the radio (message frame) transmission immediately following the current measuring interval. Factory setting: 20 seconds.

AA:
Analog output of pulse frequency:
If the value of this bit = 1, then the measured frequency of the input pulse signal at the slave RTU is given as an analog output via the first available analog output channel of the master RTU. The maximum frequency of 10 Hz corresponds to the analog signal output value of 20 mA. The analog output signal can be adjusted for gain (span) and zero offset, to meet specific application requirements.

IM:
Pulse signal count or frequency priority:
If the value of this bit = 1, the pulse signal will be transmitted with count priority. If this bit = 0, the pulse signal will be transmitted with frequency priority.

IE:
If the value of this bit = 1, then output C0 of the master RTU is operated as a pulse signal output. In this mode, C0 is no longer controlled through Output Register 300.

VW:
If the value of this bit = 1, the flowmeter mode is activated. In this mode pulse signals at inputs A0 and A1 of the slave RTU are detected and added together.

7.4.15 Configuration register: gain adjustment for analog output of signal frequency

In this register a multiplier factor can be set for the analog output of measured signal frequency. The value of this setting is the gain factor multiplied by 100. e.g., for a gain factor of 1.5, a value of 150 must be written into this register.

For this register, a setting value of 0 is equivalent to the value 100: i.e., a gain factor of 1.

Register values in the range 1 through 99 correspond to gain factors of 0.01 through 0.99.

The maximum possible value for this register is 10000, corresponding to a multiplier factor of 100.

For more details about this, refer to Section 6.3 "Pulse Signal Transmission".

7.4.16 Configuration register: offset adjustment for analog output of signal frequency

In addition to the gain (span) adjustment of this analog output signal, its zero offset can also be adjusted, via this Offset Adjustment Register.

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Op				12-bit offset value											

Op: Determines whether the offset value is added (Op = 0) or subtracted (Op = 1).

After computation of the measured pulse signal frequency and application of the gain factor multiplier, and offset value that is written into this register is added or subtracted to arrive at the final value of the analog output signal. The offset value is represented by Bits 0....11, and Bit 15 determines whether this value is added (Bit 15 = 0) or subtracted (Bit 15 = 1).

The value that is generated after these adjustment computations is the 12-bit value that is the internal digital equivalent of the analog output signal representing the measured pulse signal frequency. This digital value can be in the range 0 - 4095. If the final result of these computations is a value less than 0, the analog output is set to zero. If the final computed digital value is greater than 4095, its value is set to 4095.

For more details about this, refer to Section 6.3 "Pulse Signal Transmission".

7.4.17 Register Assignment: RTU-710H/DA1 (Without Expansion Modules)

The table below is an example of the register addresses of an RTU-710/DA1. The configuration registers are not listed here.

Register	Function	Comments
0	Slave address	MODBUS address set via DIP-switches, through which the master station can access the RTU.
1	Status	Status byte
2	On-off inputs	16 on-off inputs of the Basic Module
3-6	Analog inputs	4 analog inputs of the Basic Module
7-22	Counter/timer	16 counters / timers (inputs ports A, B)
23-38	Min/Max/Avg	Current min-, max-, average and redundancy values of the first 4 analog inputs
39-54	Min/Max/Avg	Previous min-, max-, average and redundancy values of the first 4 analog inputs
300	On-off outputs	8 on/off outputs of the Basic Module (high bits)

7.4.18 Register Assignment: RTU-710H/DA2 (Without Expansion Modules)

The table below is an example of the register addresses of an RTU-710/DA2. The configuration registers are not listed here.

Register	Function	Comments
0	Slave Address	MODBUS address set via DIP-switches, through which the master station can access the RTU.
1	Status	Status-Byte
2	On-off inputs	16 on-off inputs of the Basic Module
3-18	Counter/timer	16 counters / timers (inputs ports A, B)
300	On-off outputs	8 on/off outputs of the Basic Module (low bits)

7.4.19 Assignment Of Registers: RTU-710H/DA3 (Without Expansion Modules)

The table below is an example of the register addresses of an RTU-710/DA1. The configuration registers are not listed here.

Register	Function	Comments
0	Slave Address	MODBUS address set via DIP-switches, through which the master station can access the RTU.
1	Status	Status-Byte
2	On-off inputs	16 on-off inputs of the Basic Module
3-18	Counter/timer	16 counters / timers (inputs ports A, B)
300	On-off outputs	16 on/off outputs of the Basic Module

8 Operating Modes

The RTU-710 can be configured for point-to-point (P2P) or point-to-multiple-point (P2MP) radio networking. Either one of these two modes can be selected by DIP-switch settings.

8.1 Point-to-Point Radio Link

This mode allows a number of on-off and/or analog signals to be transmitted via a wireless channel. The inputs at one end are reproduced as corresponding outputs on the other, and vice versa. If the RTU is used without an Expansion Module, Input Port A of one station corresponds to Output Port C of the opposite station.

In a point-to-point system, a pulse signal input at the slave RTU can be reproduced as a pulse signal output at the master RTU. This function is described in detail in section 5.

8.1.1 Addressing in Point-to-Point Links

To establish a P2P link, one RTU is designated as the master station, by setting the appropriate DIP-switch. The second RTU is used in its normal mode as a slave station. Communication between the two is based on the MoP protocol. If more than one P2P radio links are operating simultaneously within radio range of each other, the following addressing rules should be observed:

- Up to 15 different master station addresses in the format nnh can be coded by the DIP-switch
  (e.g.: nnh = 11h, 22h, 33h, ... Eeh)
- The address FFh is reserved and can not be used as a master station
- A master station with the address nnh communicates with a slave station with the address nnh+1 (Example: a master station with the address 33h will communicate with a slave station having the address 34h)

Explanation of address assignments:
To differentiate between master and slave stations, in each radio message frame the hexadecimal counting block Fnh (n = 1 to n = E) as well as the code 00h are reserved for the central station. If an RTU is set up as a master, the low bits of the address coding DIP-switch are used for the master station address.

Example:

DIP-switch	= 04h	→	Central station code	=	F4h
DIP-switch position	= 66h	→	Central station code	=	F6h

For slave station addresses, the full 8 bits of the address coding DIP-switches are used, with the next consecutive address being interpreted as a slave station address.

Example:

DIP-switch	= 04h	→	Slave station 05h is accessed
DIP-switch	= 77h	→	Slave station 78h is accessed

Up to 14 point-to-point radio links on the same radio frequency can be operated within radio range of each other, by using distinct addresses.

Caution!

By using a distinctive address setting, the master station is prevented from accepting messages from stations that are not part of its network. This does not however, eliminate the possibilities of interference and disturbances in communication if other radio transmitters within range are operating simultaneously on the same frequency.

8.1.2 Operation

The master station continuously polls the slave station. If it receives a valid response from the slave station, an on-going exchange of data begins between the two stations. The states of all on-off inputs and values of all analog inputs at one station are reproduced as corresponding outputs at the other. Only that part of the data that is valid for the hardware configuration at the receiving end is acted upon.
If, for example, an RTU master station has 8 analog inputs, and the opposite slave station has only 4 analog outputs, the measured values of only the first 4 analog inputs of the master RTU are transmitted. Expansion Modules can be connected via the Local Bus to the Basic Module in any arbitrary sequence.
In a P2P system, the internally set timeout limits are continuously monitored. If one of the RTUs does not receive a validly addressed message frame from the other RTU within the predetermined “t” timeout interval, the outputs of the first RTU are automatically reset to the default “off” states. The timeout limit period can be set to a user-determined value, or disabled, by setting a suitable value in the corresponding register.
At the master RTU station, if radio communication with slave RTU station is interrupted, the “System OK” LED starts blinking.

8.2 Point-to-Multiple-Points Networks

One master station can operate with up to 4 slave stations in a self-sufficient RTU network, without a supervisory computer or PLC. The on-off inputs of the master RTU are transferred in parallel to all slave RTUs on the same network. The number of on-off I/O’s can be increased by adding 1 to 16 Expansion Modules. The 8 on-off outputs of the master station Basic Module (16 on-off outputs for the RTU-710/DA3) are allocated to on-off inputs of the slave stations, depending on the number of slave stations on the network, according to user requirements.

8.2.1 Addressing in Point-to-Multiple-Points Networks

In a point-to-multiple-point network, each RTU is individually set up as master or slave through the DIP-switch provided for this purpose. Another DIP-switch is used to set up the RTU for either standard MODBUS-RTU or MoP communication protocol. Several networks can be operated within radio range of each other, by selecting distinct station addresses, according to the following rules:

- Up to 15 different master station addresses can be DIP-switch coded in the format Address = nnh (e.g., 11h, 22h, 33h... EEh).
- The address FFh is reserved: it cannot be used as a master station address.
- A master station with address “nnh” will communicate with slave stations with addresses “nnh+1”, “nnh+2”,…..(e.g., a master station with the address 33H will communicate with slave stations with addresses 34h, 35h,….)

Explanation of address assignment:
In order to differentiate message frames transmitted by master stations from those transmitted by slave stations, the range of hexadecimal numbers Fnh (n = 1 through E) and the specific code 00h are reserved for master stations. To set up an RTU as a master station, the low bits of the address coding DIP-switches are used for its address.

Example:

DIP-switch	= 04h	→	Central station code	=	F4h
DIP-switch position	= 66h	→	Central station code	=	F6h

For setting the address of a slave station, all 8 bits of the address coding DIP-switches are used, and the succeeding code number is interpreted as a slave station address.

Example:

DIP-switch	= 04h	→	Slave station 05h is accessed
DIP-switch	= 77h	→	Slave station 78h is accessed

Up to 14 point-to-point radio links on the same radio frequency can be operated within radio range of each other, by using distinct addresses.

Caution!

By using a distinctive address setting, the master station is prevented from accepting messages from stations that are not part of its network. This does not however, eliminate the possibilities of interference and disturbances in communication if other radio transmitters within range are operating simultaneously on the same frequency.

8.2.2 Operation

When a master RTU is switched on, it starts polling the slave RTUs. If any of the slave stations fail to acknowledge the polling, the “OK” LED at the master RTU will blink with equal on and off times. As long as the master RTU correctly receives acknowledgements from all slave stations, its “OK” LED remains continuously on.

In a radio network with one master and 2 slaves, the first four inputs of the first slave RTU are reproduced as outputs 0-3 of the master RTU. The first four inputs of the second slave RTU are reproduced as outputs 4-7 of the master RTU.
In a radio network with 3 or 4 slave RTUs, only the first 2 inputs of each slave RTU are reproduced as outputs at the master RTU.

When an RTU-710/DA3 is used as the master, a different number of on-off inputs of each slave RTU are reproduced as outputs at the master, because in this case 16 on-off outputs are available in the master RTU (instead of 8). For example, in a network of RTU-710 stations consisting of one master and 3 slaves, five on-off inputs of each slave RTU are reproduced as outputs at the master RTU.

If a slave station drops out, two attempts are made by the master station to establish contact with that slave station. If the master does not succeed in doing so in these two attempts, the slave is tagged as not reachable, and the “System OK” LED will start blinking.
Thereafter, each slave station that is tagged as not reachable is only briefly monitored in each polling cycle, for its presence/absence on the radio network. This is so that the performance of the entire system is not impaired. The active outputs of the master RTU that are assigned to this slave station are reset to off condition, after the predetermined “t” timeout interval has elapsed. If a dormant slave starts responding again, it is automatically included in the polling roster by the master station.

8.3 "Pipeline" Mode Of Operation

In a "pipeline" system of RTU-710 stations, the RTUs are operated in a logical chain, in order of their addresses. RTUs in the system have consecutive addresses. In a state of rest (all on-off inputs in the off state) an RTU does not transmit message frames.

As soon as even one of its first 15 on-off inputs (A0.....B14) of an RTU turns on, that RTU becomes active, assumes the role of master, and starts transmitting message frames. These are sent to the RTU with next consecutive address. The direction of transmission addressing (i.e., whether to next lower or next higher address) is determined by the state of the on-off input B15. If input B15 is off, the message frames are dispatched in ascending order (each RTU sends message frames to the next one with a higher address). If input B15 is on, the message frames are sent to the next RTU with a lower address.

The "Pipeline" mode of system operations requires the RTU-710 Modules used in the system to be specially programmed by the manufacturer, before delivery.

8.3.1 Changing From "Pipeline" Operating Mode

The following description generally relates to an RTU-710 that starts in "Pipeline" mode. An RTU-710 in this operating mode can be either a master or slave. As soon as even one of its on-off inputs turns on, it acts as a master RTU and starts transmitting message frames to the RTU with the next address.

In this operating mode on-off inputs are transferred from the master RTU to the slave RTUs. Transmission of analog signals and return of message frames from the slave RTUs to the master is not possible.

As described earlier, an RTU whose on-off inputs are all in the off state will not transmit message frames to either the RTU having the next higher or to that with the next lower address. In this way, a chained network is implemented with a master RTU at each end. The conversion is effected by means of the 16th on-off input (B15). When the first message frame is transmitted, the corresponding outputs of the master RTU are also switched on.

If on-off input B15 is off, the RTU sends the message frame to RTU with the next higher address: e.g., if the transmitting RTU has the address 1, it will send the message frame to the RTU having address 2.

If on-off input B15 is on, the RTU sends the message frame to RTU with the next lower address: e.g., if the transmitting RTU has the address 10, it will send the message frame to the RTU having address 9.

The state of input B15 determines the addressing direction of the transmitted message frames, but the activation of this input will not cause the start of data transmission (as would the activation of any of the inputs A0 to B14). The input B15 can be wired so that it is always in the "on" state so that the RTU does not have to continuously transmit message frames. However, the state the input will be reflected by the output D15 if one or more type -/DA3 RTUs exist in the chain.

If a slave RTU receives a message frame addressed to it, it will set its outputs according to the data contained in that message frame, and then re-transmit the message frame to the next slave RTU. The next RTU similarly determines the direction in which it addresses the message frame, depending on the state of input B15 of the master RTU. If this input is off, the message frame is re-transmitted to the RTU with the next higher address. If this input is on, the message frame is sent to the next lower address. The chain ends when the RTU with the next address no longer exists: the data block is therefore voided.

If an RTU detects an invalid data block, it will not re-transmit that data block onward. Therefore, it is desirable that the inputs at the master RTU remain in one state long enough for repeat transmissions of the same message frame. In transmission mode a master RTU sends a message frame every 2 seconds. In this time a message frame would have been relayed through the first 10 RTUs in a chain. The minimum persistence time for inputs can be enforced conveniently by use of the PicoLogo option.

The slave RTU sets its output according to data received from the master RTU, and holds these outputs in their respective states for 10 seconds (sustain without time slot limitation) or 5 minutes (sustain with time slot limitation). If by the end of the sustain time a new valid message frame is not received, all outputs will be switched off. This time period can be changed whenever needed, by changing the settings of RTUs. If an RTU in the chain receives a message frame sent by another RTU acting as master, then the receiving RTU cannot during this time act as a master RTU. This then becomes possible only after the outputs of this RTU are switched off at the end of this time period.

8.4 Interrogation Of "Kamstrup Multical" Counters Via M-Bus (V4.30 Onward)

A special version of the RTU-710 is available that is capable of reading the counters of "Kamstrup Multical" instruments through the serial interface, using the M-Bus protocol. The standard read operation is used. Ten successive counter readings are written to the registers of the RTU-710, starting with Register 101. The counter returns ten 7-digit values for every read cycle. These values are converted to BCD and then stored to conserve register space and transmission time. Two registers (4 bytes) are needed for each value. The first value therefore occupies Registers 101 and 102, the second value Registers 103 and 104, and so on.

For example, if the first value is 1326743, this would be represented in the registers as follows:

Register 101: 0x0132
Register 102: 0x6743

The Multical is interrogated by the RTU-710 every 25 seconds. Register 100 represents the status of the last interrogation:

Register 1001 (Status):

- 0x000: No interrogation done up to now
- 0x001: Last interrogation OK; valid values stored in Registers 101 - 120
- 0xFFF: Last interrogation faulty; no valid values stored in Registers 101 - 120

The Multical is interfaced to the RTU-710 through a standard RS-232 cable. Since this interface is PC compatible it must be a null-modem cable (wires 2-3 and 4-6 have to be crossed), with 9-pin male D-Sub connectors at both ends. Communication bit rates are 300 bits/sec from the RTU to the Multical and 1200 bits/sec from the Multical to the RTU-710. The serial data format is 7 data bits, even parity, 2 stop bits.

The M-Bus serial communication protocol requires the RTU-710 to be specially programmed by the manufacturer, before delivery.

9 Message Frame Structure

This chapter describes how the registers of an RTU-710 can be accessed through a remote radio modem (e.g., model TRM-700H/T1X or TRM-700H/M). Using this facility, a network of up to 240 RTU-710 Wireless I/O Modules can be controlled from a PLC, PC, or SCADA system.

9.1 MoP Protocol

The MoP protocol (MODBUS over Piciorgros) is basically similar to the MODBUS-RTU protocol, but MoP has some enhancements that optimize it for radio communications. These enhancements allow complete data exchange (reading and writing of registers) with the slave stations in a single radio transmission cycle (one data block from the master to the slave station, plus one return data block from the same slave station to the master station). By comparison, the standard MODBUS-RTU protocol requires 4 message frames to achieve the same result: 2 message frames for writing to the slave station registers plus 2 message frames for reading the slave station registers.

The MoP message frame consists of a header followed by a data block. The header is consists of a function code (60h) to identify the protocol, the receiver station address, and up to 2 repeater station addresses.

Using radio repeaters is possible only with the MoP protocol. The standard MODBUS protocol is not designed for such functions. Any slave station in a network can simultaneously function as a repeater for other stations. On the basis of the information in the header, the slave stations that are addressed as repeaters immediately re-transmit the data block they have received.

The MoP protocol is selected through the operating mode (see description of DIP-switches). If no DIP-switches are available for setting the type of operation, the MoP protocol is always activated.

9.2 MoP2 Protocol

The RTU-710 supports the MoP2 protocol. In contrast to the MoP protocol, MoP2 additionally includes checksum error control.

In other respects, the MoP2 protocol is completely identical to MoP. The function code for this is 0x61 (response code: 0xE1), with the standard Modbus CRC characters (2 bytes) inserted at the end of each message frame. If the CRC characters indicate an error, then the message frame is rejected.

When using MoP2 over RTU-710 stations in a radio network that includes relaying, every node in the system must be MoP2 compatible.

RTU-710 polling data block transmitted by a master station using the MoP protocol:

60	(ZB)	A1	A2	A3	A4	IR_H	IR_L	IR_X

OR_H	OR_L	OR_X	$D1_H$	$D1_L$	....	Dn_H	Dn_L

60: Function code: identifies a polling data block with MoP protocol
ZB: This control byte is generated by the TRM-710H/M automatically if it is in the "ZZ" mode. If it is operating in any other mode, the control byte must be sent to it from the control system as "FFh".
A1…A4: Radio addresses
IRH/IRL: Address of first input register that is to be read
IRX: Number of input registers which are to be read
ORH/ORL: Address of the first output register that is to be written
ORX: Number of the output registers that are to be written
D..H/D..L: Data for the output register. 2 data bytes must be transmitted for each output register that is to be written

RTU-710 acknowledgement data block:

E0	(ZB)	A1	A2	A3	A4	IR_H	IR_L	IR_X

$D1_H$	$D1_L$	....	Dn_H	Dn_L

E0: Function code: identifies an acknowledgement data block with MoP protocol
ZB: This control byte will be automatically filtered by the TRM-700H/M master station operating in the "ZZ" mode, and will not be passed on to the control system. With all other operating modes of the master station, this byte is transferred as the value "FFh"
A1...A4: Radio addresses for acknowledgement data blocks
IRH / IRL: Address of the first input register that was read
IRX: Number of input registers which were read out
D..H / D..L: Data for the input register. 2 data bytes are transmitted for each input register that has been read

9.2.1 Accessing RTU-710H Registers Using The MoP Protocol

By accessing the appropriate registers, all inputs, outputs, counters, timers, or controls of an RTU-710 can be determined (separately or together), and at the same time the state of any of any of the outputs can be changed.

Basically, there are 3 different types of registers:

- Input registers
- Output registers
- Control registers

Input registers give out the value of the inputs, counters, timers, etc., and are therefore registers from which values can be read out. They begin with the address 0. Output registers correspond to the on/off and analog outputs of an RTU and can be written with the respective values. They start with the address 300 = 012Ch. Control registers are intended for various control functions such as setting the transmitting power, reading the field strength, etc. They begin with the address 900 = 0384h. Some control registers can be read and written, others can only be read.

All registers have a width of 16 bits. If fewer bits are used for a particular function (analog inputs), only the lower bits are used.

The sequence of the inputs and outputs in the registers is always as follows:

- On-off inputs or outputs
- Analog inputs or outputs
- 16 counter/timer registers (sequence: port A0, A1-A7, B0, B1-B7)
- Minimum, maximum, and average values (only for the first 4 analog inputs)

Example 1: Data communication using the MoP Protocol

Data block sent from a master station to a slave station:

- The data block is to be routed via Stations 07 and 08 (functioning as repeater stations) to Station 04.
- The status of all the on-off inputs and the measured values of analog inputs 1 – 3 are to be transmitted back (Registers 0002 to 0005 to be read; counter register = 4)
- On-off outputs 1, 2, and 3 of the RTU-710 slave station with address 04 are to switched on (value 07h is to be written to the register 0300 = 012Ch)
- Output 1 of the analog output module is to be set to 10 mA (value 0800h is to be written to the register 0301 = 012Dh)

Polling data block:

60	(ZB)	07	08	04	00	00	02	04

01	2C	02	00	07	08	00

60	Function code: identifies a polling data block with MoP protocol
ZB:	This control byte is generated by the TRM-710H/M automatically if it is in the "ZZ" mode. If it is operating in any other mode, the control byte must be sent to it from the control system as "FFh".
07 08 04 00	Routing addresses: repeater station 1, repeater station 2, destination slave station (address 04), master station (address 00)
00 02	Address of the first register that is to be read
04	Number of 16-bit registers that are to be read
01 2C	Address of the on-off output registers of the RTU-710 Basic Module (012C hexadecimal corresponds to 0300 decimal)
02	Number of 16-bit data words to be transmitted
00 07	The first data word, written to address 0300. This is the output register of the RTU Basic Module, that is used to activate outputs 1, 2, and 3 in this example.
08 00	The second register word, written to the address 0301

Acknowledgement data block from the slave station to the master station:

- Acknowledgement message frame from Slave Station 4; on-off inputs 4 and 5 are activated (0018h)
- Analog input 1 supplies a value of 0620h, analog input 2 a value of 0A71h, analog input 3 a value of 0147h

Acknowledgement data block:

E0	(ZB)	00	07	08	04	00	02	04

00	18	06	20	0A	71	01	47

E0	MoP protocol identifier for polling response data block
ZB:	This control byte will be automatically filtered by the TRM-700H/M master station operating in the "ZZ" mode, and will not be passed on to the control system. With all other operating modes of the master station, this byte is transferred as the value "FFh"
00 07 08 04	Destination addresses: repeater station 1, repeater station 2, transmitting (responding slave) station
00 02	Addresses of registers to be written
04	Number of registers to be written
00 18	On-off input register: inputs 4 and 5 are activated
06 20	Measured value: analog input 1
0A 71	Measured value: analog input 2
01 47	Measured value: analog input 3

Explanation:

The sequence of characters in the polling message frame (which includes “FF” in second place) is transmitted by a PLC, SCADA PC, or DCS through a serial data interface, via a locally connected radio modem (more information available at www.piciorgros.com). Therefore this sequence of characters represents only the logical part of the data block. If the communication between the radio modem and PLC / SCADA PC / DCS uses another protocol (e.g., Siemens 3964R), the sequence of characters should be treated as the logical content of that communication protocol.
In this example, the destination RTU that is accessed through repeater stations 07 and 08, responds with an acknowledgement message frame and at the same time sends the required data back to the master station..

Example 2: Data Communication Using the MoP Protocol

- The RTU ID and the software version number of the station with address 4 are to be read from the control registers
- At the same time, the status has to be reset (writing from 0000h to register 0001h)

The transfer takes place with a TRM-700H/M operating in the “ZZ” mode. Therefore, the "ZB" control byte is not included in the transmitted data block.

60	04	00	00	00	03	A4	02

00	01	01	00	00

- Acknowledgement message frame from Slave Station 4, RTU ID number (1002h), and firmware version 1.00 (0100h) are sent.

E0	00	04	00	00	03	A4	02

10	02	01	00

9.3 MODBUS Slave Mode Operation

9.3.1 The MODBUS-RTU Protocol

When operated in the MODBUS-RTU mode, an RTU-710 station can be accessed using MODBUS code 3 (register read) and code 16 (register write). The register structure of MODBUS-RTU is basically similar to that of the MoP protocol. Register 0 corresponds to the MODBUS register 40001 (however in the MODBUS protocol it is addressed as “0”). The RTU-710 returns a MODBUS acknowledgement after every data block it receives. In contrast to the MoP protocol, the standard MODBUS protocol requires two complete data block transfers in order to read inputs and write outputs. The mode of operation is selected via the appropriate DIP-switches (see the section of this Manual that describes DIP-switch designations and functions).

9.3.2 MODBUS-RTU Protocol, Brodersen Compatible

In the MODBUS-RTU and MoP operating modes, all on-off inputs and outputs are always precisely defined through the registers. The positions of all I/O channels can be easily determined by reading the contents of the control registers.

Exmple: An RTU station consists of an RTU-710/DA2 (Basic Module) connected to two Expansion Modules each with 8 relay outputs (RO1 and RO2). The RTU-710/DA2 Basic Module has 8 on-off outputs (INT) of its own. This station therefore has a total of 24 on-off outputs. The representation of the outputs in the registers is as follows:

40301		**40302**		**40303**	
H	**L**	**H**	**L**	**H**	**L**
RO1 Port A	**INT Port A**	**---**	**RO2 Port A**	**---**	**---**

In Brodersen compatible RTUs, a complete register is assigned for each Basic and Expansion Module. If the unit has only 8 on-off outputs, only the low half of the 16-bit register is used (the high part remains unoccupied). This feature defines the Brodersen compatible MODBUS-RTU mode. In this mode the positions of I/O channels cannot be directly determined. Therefore this mode is recommended exclusively for use in Brodersen systems. Taking the same RTU station configuration of the example above, the registers assignment for a Brodersen compatible RTU station would be as follows:

40301		**40302**		**40303**	
H	**L**	**H**	**L**	**H**	**L**
---	**INT Port A**	**---**	**RO1 Port A**	**---**	**RO2 Port A**

9.4 Compatibility With FMC-V24/DA1 And FMC-V24/DA2

Starting with firmware version 3.10, the RTU-710 supports the standard interrogation message frames for FMC-V24/DA1 And FMC-V24/DA2 Modules, allowing RTU-710 Modules to be used in networks configured with FMC-V24/DA1 And FMC-V24/DA2 Modules.

The supported codes are:

- 0x21: V24/DA1 single-cycle polling
- 0x23: V24/DA1 masked single-cycle polling
- 0x41: V24/DA2 single-cycle polling
- 0x43: V24/DA2 masked single-cycle polling
- 0x28: Reset of status bytes

The group polling codes are not supported.

It should be noted that by using these codes only that part of the RTU-710 hardware is usable that corresponds with the appropriate FMC-V24/DAx hardware. In these cases on-off outputs are generally limited to 8, since the message frame contains only one byte for output control. In -/DA1 message frames only 8 on-off and 1 analog input are supported. The other 8 on-off inputs can be read using the -/DA2 function codes.

These function codes generally support only one event counter and two timers. The Status Register then represents only a byte value (Bits 0....7).

If an RTU-710/DA2 is interrogated using the FMC-V24/DA1 function code, the analog input value is returned as 0.

The use of these function codes is <u>not</u> recommended for new developments / new installations, since they will significantly restrict the functionality of a system. Therefore the structure of these message frames is not described here. This information is available in the technical documentation of the FMC-V24/DA1 and/or FMC-V24/DA2.

10 Standard DIP-Switches Assignment

10.1 RTU Settings Through DIP-Switches

All relevant RTU settings can be done through its DIP-switches: serial interface settings, transmitting (RF) power, Layer 1 protocol, operating radio frequency. For this, a 4-level programming approach is used.

When the RTU is not in Programming Mode, DIP-switches 1-7 determine the RTU's station address. DIP-switch 8 is used to put the RTU into either Programming or Operating Mode.

DIP-Switches							
1	2	3	4	5	6	7	8
A0	A1	A2	A3	A4	A5	A6	P

Address Settings							
1	***2***	***3***	***4***	***5***	***6***	***7***	***DIP-Switches***
A0	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**Address**
0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	1
0	1	0	0	0	0	0	2
1	1	0	0	0	0	0	3
0	0	1	0	0	0	0	4
1	0	1	0	0	0	0	5
...	...	...	...	...	...	...	...
0	1	1	1	1	1	1	126
1	1	1	1	1	1	1	127

Assignment of radio frequencies to radio links in different frequency bands is listed in the tables in section 10.6. RTUs featuring adjustable frequency have the frequency band marked at the bottom of the unit.

Only the lowest 7 bits of the address value can be altered through the DIP-switches. If an address value greater than 127 is to be set then the highest (8th) bit can be set using the Programming Software. The lower 7 bits can thereafter be changed via the DIP-switches.

10.2 Entering Programming Mode

To enter into programming mode, first switch off power to the RTU. Next, move DIP-switches 1-7 all to the "OFF" (0) position, and DIP-switch 8 to the "ON" (1) position.

DIP-Switches							
1	2	3	4	5	6	7	8
0	0	0	0	0	0	0	1

Now switch on power to the RTU. The "OK" LED should flash with a slow tempo.

In programming mode, DIP-switches 6-7 select the programming level and DIP-switches 1-5 select the setting parameters. DIP-switch 8 (as mentioned earlier) is used to enter / exit the programming mode.

10.3 RF Power Output Setting

The RTU-710 has 16 selectable RF power output levels. To set the desired RF power output level, first put the RTU-710 into programming mode as described above. RF power output levels are generally divided into High Power (up to 6 watts transmitting power) and Medium Power (up to 500 mW transmitting power).

DIP-Switches							
1	2	3	4	5	6	7	8
P0	P1	P2	P3	-	0	0	1

Effective Radiated Power (ERP) With 0dB, 3dB, 7dB and 10dB AntennasHigh Power RTU (RF Power Output Up To 6W)							
1	*2*	*3*	*4*	*DIP-Switches*			
P0	**P1**	**P2**	**P3**	**0dB**	**3dB**	**7dB**	**10dB**
0	0	0	0	100 mW	200mW	500mW	1W
1	0	0	0	250 mW	500mW	1.25W	2.5W
0	1	0	0	500 mW	1W	2.5W	5W
1	1	0	0	750 mW	1.5W	3.75W	7.5W
0	0	1	0	1W	2W	5W	10W
1	0	1	0	1.25W	2.5W	6.25W	12.5W
0	1	1	0	1.5W	3W	7.5W	15W
1	1	1	0	2W	4W	10W	20W
0	0	0	1	2.5W	5W	12.5W	25W
1	0	0	1	3W	6W	15W	30W
0	1	0	1	3.5W	7W	17.5W	35W
1	1	0	1	4W	8W	20W	40W
0	0	1	1	4.5W	9W	22.5W	45W
1	0	1	1	5W	10W	25W	50W
0	1	1	1	5.5W	11W	27.5W	55W
1	1	1	1	6W	12W	30W	60W

Effective Radiated Power (ERP) With 0dB, 3dB, 7dB and 10dB AntennasMedium Power RTU (RF Power Output Up To 500mW)							
1	***2***	***3***	***4***	***DIP-Switches***			
P0	**P1**	**P2**	**P3**	**0dB**	**3dB**	**7dB**	**10dB**
0	0	0	0	10mW	20mW	50mW	100mW
1	0	0	0	100mW	200mW	500mW	1W
0	1	0	0	250mW	500mW	1.25W	2.5W
1	1	0	0	500mW	1W	2.5W	5W

Note: RF power output must not under any circumstances be allowed to exceed the maximum RF power level specifically allowed for the location. Remember that line losses due to antenna cables and connectors may be balanced out by antenna gain.

After putting the RTU into programming mode, DIP-switches 1-4 are used to set the RF power output level. After that is done, DIP-switch 8 is moved to the "OFF" (0) position, thereby causing the RTU to exit programming mode. The "OK" LED will now flash at double tempo, which indicates that the setting was successfully executed.

Now another setting can be done (by moving DIP-Switch 8 to the "ON" (1) position), or the programming can be terminated..

10.4 Radio Channel Setting

The radio frequency can be selected at this programming level, provided this is permissible within the terms of the local radio operating license / permission. The selection of radio channels is done using the DIP-switches according to the tables immediately below. Radio frequencies corresponding to radio channels are listed in the tables in section 10.6:

DIP-Switches							
1	2	3	4	5	6	7	8
F0	F1	F2	F3	F4	1	0	1

Radio Channel Settings					
1	***2***	***3***	***4***	***5***	***DIP-Switches***
F0	**F1**	**F2**	**F3**	**F4**	**Radio Channel**
0	0	0	0	0	0
1	0	0	0	0	1
0	1	0	0	0	2
1	1	0	0	0	3
0	0	1	0	0	4
1	0	1	0	0	5
0	1	1	1	1	30
1	1	1	1	1	31

After putting the RTU into programming mode, DIP-switches 1-5 are used to select the radio channel. After that is done, DIP-switch 8 is moved to the "OFF" (0) position, thereby causing the RTU to exit programming mode. The "OK" LED will now flash at double tempo, which indicates that the setting was successfully executed.

Now another setting can be done (by moving DIP-Switch 8 to the "ON" (1) position), or programming terminated.

Radio channels numbered higher than 31 can be selected using the PC-based Programming Software.

10.5 Operating Mode Setting

The operating mode of the RTU is set using the DIP-switches, at Programming Level 3, as follows:

DIP-Switches							
1	2	3	4	5	6	7	8
M0	M1	M2			0	1	1

Operating Mode Settings			
M0	M1	M2	Operating Mode
0	0	0	Slave: MoP protocol or point-to-point system
0	0	1	Slave, MODBUS-RTU protocol, Brodersen compatible
0	1	0	(Not allowed)
0	1	1	Slave, MODBUS-RTU protocol
1	0	0	Master, point-to-point system
1	1	0	Master, master + 2 slaves system
1	0	1	Master, master + 3 slaves system
1	1	1	Master, master + 4 slaves system

After putting the RTU into programming mode, DIP-switches 1-5 are used to select the operating mode. After that is done, DIP-switch 8 is moved to the "OFF" (0) position, thereby causing the RTU to exit programming mode. The "OK" LED will now flash at double tempo, which indicates that the setting was successfully executed.

Now another setting can be done (by moving DIP-Switch 8 to the "ON" (1) position), or programming terminated.

10.6 Frequency Tables

Assignment of radio frequencies to radio links in different frequency bands is listed in the tables below. RTUs featuring adjustable frequency have the frequency band marked at the bottom of the unit.

ISM Band Identification: ISM	
Radio Channel	**Frequency (MHz)**
0	433.100
1	433.125
2	433.150
3	433.175
4	433.200
5	433.225
6	433.250
7	433.275
8	433.300
9	433.325
10	433.350
11	433.375
12	433.400
13	433.425
14	433.450
15	433.475
16	433.500
17	433.525
18	433.550
19	433.575
20	433.600
21	433.625
22	433.650
23	433.675
24	433.700
25	433.725
26	433.750
27	433.775
28	433.800
29	433.825
30	433.850
31	433.875

ISM-Band (Continued) Identification: ISM	
Radio Channel	**Frequency**
32	433.900
33	433.925
34	433.950
35	433.975
36	434.000
37	434.025
38	434.050
39	434.075
40	434.100
41	434.125
42	434.150
43	434.175
44	434.200
45	434.225
46	434.250
47	434.275
48	434.300
49	434.325
50	434.350
51	434.375
52	434.400
53	434.425
54	434.450
55	434.475
56	434.500
57	434.525
58	434.550
59	434.575
60	434.600
61	434.625
62	434.650
63	434.675

Private Data RadioIdentification: DND	
Radio Channel	**Frequency (MHz)**
0	447.9750
1	447.9875
2	448.0000
3	448.1250
4	448.1375
...	...
10	459.5300
11	459.5500
12	459.5700
13	459.5900

Great BritainIdentification: GB	
Radio Channel	**Frequency (MHz)**
0	458.5000
1	458.5125
2	458.5250
3	458.5375
4	458.5500
5	458.5625
6	458.5750
7	458.5875
8	458.6000
9	458.6125
10	458.6250
11	458.6375
12	458.6500
13	458.6625
14	458.6750
15	458.6875
16	458.7000
17	458.7125
18	458.7250
19	458.7375
20	458.7500
21	458.7625
22	458.7750
23	458.7875
24	458.8000
25	458.8125
26	458.8500
27	458.8625
28	458.8750
29	458.8875
30	458.9125
31	458.9250

Malaysia Identification: MY	
Radio Channel	**Frequency (MHz)**
0	450.6250
1	451.3750
2	452.1250
3	452.8750
4	453.6250
5	454.3750
6	455.1250
7	455.8750
8	456.6250
9	457.3750
10	458.1250
11	458.8750
12	459.6250
13	460.3750
14	461.1250
15	461.9750

Afghanistan Identification: AFG	
Radio Channel	**Frequency**
0	440.0000
1	440.0500
2	440.1000
3	440.1500
4	440.2000
5	440.2500
6	440.3000
7	440.3500
8	440.4000
9	440.4500
10	440.5000
11	440.5500
12	440.6000
13	440.6500
14	440.7000
15	440.7500

Korea Identification: ROK	
Radio Channel	**Frequency (MHz)**
0	441.7000
1	441.7875
2	441.8750
3	442.0500
4	442.2250

Austria High-Power Identification: A	
Funkkanal	**Frequenz (MHz)**
0	440.5250
1	440.5500
2	440.6250
3	440.7750
4	440.8250

11 RTU-710H Specifications

General description:	Radio remote I/O module combining the functions of on-off and analog inputs / outputs with a built-in radio modem
I/O (Basic Module):	16 on-off inputs, isolated, floating reference potential 8 on-off outputs, solid-state, isolated 4 analog inputs (Model RTU-710H/DA1 only)
Special functions:	Radio repeater chain: 4 stations: transmitting station, repeater station 1, repeater station 2, destination station Counters: up to 16 counters, 16 bits each Timers: up to 16 timers, 16 bits each Min./max./average: for the first 4 analog inputs
Radio frequency bands:	433 - 434 MHz , 420 - 470 MHz
Channel assignments	Continuously variable over full frequency range
RF output power:	Medium power: 10 mW - 500mW High power: 100mW - 6W
Power supply:	10 to 28 V DC
Enclosure:	Coated aluminum body with plastic ends; per DIN 43880; DIN rail mounting
Dimensions:	Approx. 162 x 80 x 62 mm (excluding BNC connector and terminal blocks)
Operating temperature:	-20 to +70 °C