Introduction

Modbus is a commonly used protocol used for communicating between industrial devices.

A Modbus Master can communicate with up to 247 Slaves, each with a unique Slave Id from 1 to 247. The Master is responsible for sending commands to the Slaves, which act on the command and reply.

In the RAPIX Lighting Control System, a Zone Controller can act as a Modbus Slave.

A full description of Modbus is beyond the scope of this document. Refer to the official Modbus specification at http://www.modbus.org/.

This document describes of controlling and monitoring a RAPIX Lighting Control System using Modbus.

RAPIX Support for Modbus

Modbus Options

Modbus has four object types, two of which are supported by the RAPIX Zone Controller:

Object type	Access	Size	Supported?
Coil	Read-write	1 bit	YES
Holding register	Read-write	16 bits	YES
Discrete input	Read-only	1 bit	NO
Input register	Read-only	16 bits	NO

The following Modbus functions related to reading and writing the values of Coils and Holding Registers are supported:

Function Code	Function
1	Read Multiple Coils
3	Read Multiple Holding Registers
5	Write Single Coil
6	Write Single Holding Register
15	Write Multiple Coils
16	Write Multiple Holding Registers

The following options are supported:

Transport	TCP/IP
Holding Register	16 bit, unsigned integer. Big-endian (most significant byte first)
Number of connections to a Modbus Master	1 or 2 Zone Controllers can each accept a single connection from a Modbus Master.

Addresses

The RAPIX Lighting Control System uses a one-to-one mapping between a Modbus object number and the RAPIX Zone Id. Therefore, for example, a Modbus object number 7 will map to RAPIX Zone id 7.

Addressing Conventions

Modbus has various conventions for numbering Modbus objects so that, for example, Coil 7 will not be confused with Holding Register 7. The most common number convention is:

- Coil *numbers* start with 0 and span from 00001 to 09999
- Holding Register *numbers* start with 4 and span from 40001 to 49999
- Both of the *number* ranges listed above map to *addresses* 0 to 9998.
- For this convention:
  the *address* of a coil is the coil *number* minus 1
  the *address* of a Holding Register is the *number* minus 40001

Some examples of using this convention are shown below:

Modbus Object	Modbus Address	RAPIX Zone Id
Coil number 0000<u>5</u>	4	<u>5</u>
Coil number 0<u>1234</u>	1233	<u>1234</u>
Holding Register number 4000<u>5</u>	4	<u>5</u>
Holding Register number 4<u>1234</u>	1233	<u>1234</u>

The Modbus *address* is the value used in the Modbus data frames. This value is not visible to the user, and is not generally of interest.

The setup of RAPIX Zone Controllers allows the selection of the address offsets to suit any numbering convention.

Note that some systems do not follow the convention of subtracting 1 from the *number* to get the *address*.

To determine which addressing convention is used by a Modbus Master either:

1. Refer to its documentation.
2. Use the Modbus Master to control a particular Zone. If a different Zone is actually changed, then the addressing option is most likely set incorrectly.
3. Use a protocol analyser to view the Modbus Messages. Refer to the chapter on Wireshark for an example of this.

Modbus to RAPIX Mapping

Various aspects of a RAPIX system can be controlled or monitored through the Modbus interface. The default settings are:

Modbus Object Number	Maps to	Coils	Registers	Write	Read
1 - 999	Zone 1 to 999 level	×	✓	✓	✓
	Zone 1 to 999 on/off state	✓	×	✓	✓
1000	Zone Fade Time	×	✓	✓	✓
2001 – 2999	Zone 1 to Zone 999 error status	×	✓	×	✓
3001 – 3999	Scene 1 to Scene 999	✓	✓	✓	✓
4000 - 4255	Operating Property 0 to 255	×	✓	✓	✓
5000 - 7550	Flag Groups 0 to 255, Flags 0 - 9	✓	✓	✓	✓

If there are more than 999 Zones or Scenes, then the Modbus Object Numbers will need to be changed accordingly.

Zone Levels

When a Modbus Coil is used to control or monitor a RAPIX Zone, the Coil state (on/off) maps to the Zone state (on/off).

When a Modbus Holding Register is used to control or monitor a RAPIX Zone, the Holding Register value (0 - 65535) maps to the Zone level (0 - 254).

The RAPIX Lighting Control System provides several options for how the Holding Register level mapping can be done to suit the requirements of the Modbus Master.

Modbus Scale	Purpose	Scaling
0 – 1	On/off control	0 = off 1 = on
0 – 100	Percentage control	0 = off 1 – 100 = 1% – 100%
0 – 254	DALI Level control	0 = off 1 – 254 = DALI Level 1 to 254
0 – 255	8-bit control	0 = off 1 – 255 = 0.4% to 100%
0 – 65535	16-bit control	0 = off 1 – 65535 = 0.4% to 100%

When the zone levels are read from a Holding Register, there are two options for the value returned:

- Target Level: the level requested for the Zone
- Current Level: the current average level of all the members of the zone.

Is it recommended that the Target Level be used, because reading the Holding Register will return the same value that was written to it. When using the Current Level, the value read from a Holding Register will often be different from the value written to it. This will occur if:

a. The Zone is fading to the new level (see below)
b. The target level is outside of the range of some of the Zone devices. For example, the Zone may be set to 100%, but some devices may be restricted to a maximum of 90%. The Zone average will then be something in between 90% and 100%.

The Modbus Object Number for Zone levels needs to be configured when reading the level of a zone. By default:

- The "Modbus Number for Zone 1 Level" setting is 1.
- Writing register **23** will set the level of Zone **23**.
- Reading register **23** will get the scaled level of Zone **23**.
- Writing coil **23** will set the on/off state of Zone **23**.
- Reading coil **23** will get the on/off state of Zone **23**.

Zone Fade Times

When a RAPIX Zone is set to a new level, a fade time can be used. This is the time taken for the level to transition from the current level to the new level. Fade times of 0 (instant) and 1 to 65535 seconds (18 hours) can be selected.

To set the fade time, the value (in seconds) is written to a special Holding Register (the address is selectable). Following this, all Zone level changes will use this fade time. The fade time defaults to 0 (instant) on start-up.

Zone Error Status

RAPIX Zone Controllers can report the error status of Zones through Modbus Holding Registers. The error status value is a bitfield as shown in the table below:

Bit-field Value*	Name	Meaning
0x00	OK	Everything in the Zone is OK
0x01	LEVEL UNKNOWN	The level of some or all devices in the zone is unknown. This is not necessarily an error.
0x02	LAMP FAILURE	One or more devices has a lamp failure
0x04	DEVICE_FAILURE	One or more devices has an internal failure
0x08	DEVICE MISSING	One or more devices in the Zone are not responding (but the DALI Line is OK)
0x10	DALI LINE FAILURE	One or more DALI Lines (which are part of the Zone) have a communication failure
0x20	ZONE CONTROLLER COMMS FAILURE	One or more Zone Controllers (which are part of the Zone) is not communicating
0x40	EM FAILURE	One or more Emergency Devices has a failure
Others	undefined	Do not use

**** Note: 0x indicates a hexadecimal value***

The simplest way to use the Error Status value is:

1. If the value is 0, all is OK
2. If the least significant bit is set, then the Zone Level is unknown / uncertain (this is not necessarily an error)
3. If any of the other bits are set, there is a failure

Examples:

Error Status = 17 = 0x11 = 0x10 + 0x01 (DALI Line Failure and Level Unknown)

Error Status = 70 = 0x46 = 0x40 + 0x04 + 0x02 (EM Failure, Device Failure and Lamp Failure)

The Modbus Object Number for Zone status needs to be configured when reading the error status of a zone. By default:

- The “Modbus Number for Zone 1 Status” setting is 2001.
- Reading register 20**23** will give the error state of Zone **23**.
- Reading register 2000 (i.e. "Zone 0") will give the error state of the whole system.

If the “Modbus Number for Zone 1 Status” is set to 0, reading of the Zone Error Status is disabled.

Scenes

A Modbus Coil or Holding Register can be used to set a RAPIX Scene or to read the state of a RAPIX Scene. The Modbus Object Number for Scenes needs to be configured for using RAPIX Scenes. By default:

- The "Modbus Number for Scene 1" setting is 3001.
- Writing coil or register 30**23** will set the state of RAPIX Scene **23**:
  - If the value written = 1, the RAPIX Scene will be set.
  - If the value written = 0, the RAPIX Scene will be turned off.
- Reading coil or register 30**23** will get the state of RAPIX Scene **23**:
  - If the RAPIX Scene is set, the value read = 1.
  - If the RAPIX Scene is not set, the value read = 0.

If the "Modbus Number for Scene 1" is set to 0, use of RAPIX Scenes is disabled.

Operating properties

A Modbus Holding Register can be used to set or read the value of a RAPIX Operating Property.
The Modbus Object Number for Operating Properties needs to be configured for using RAPIX Operating Properties. By default:

- The "Modbus Number for Op. Prop. 0" setting is 4000.
- Writing register 40**23** will set the value of RAPIX Operating Property **23**.
- Reading register 40**23** will get the value of RAPIX Operating Property **23**.

If the "Modbus Number for Op. Prop. 0" is set to 0, use of RAPIX Operating Properties is disabled.

Flags

A Modbus Coil or Holding Register can be used to set a RAPIX Flag or to read the state of a RAPIX Flag. The Modbus Object Number for Flags needs to be configured for using RAPIX Flags. By default:

- The "Modbus Number for Flag Group 0" setting is 5000.
- The "Flags per Group" setting is 10.
- The relationship between the Modbus number and the flags is:
  - 500**0** = Flag Group 0, Flag **0**
  - 500**1** = Flag Group 0, Flag **1**
  - …
  - 500**9** = Flag Group 0, Flag **9**

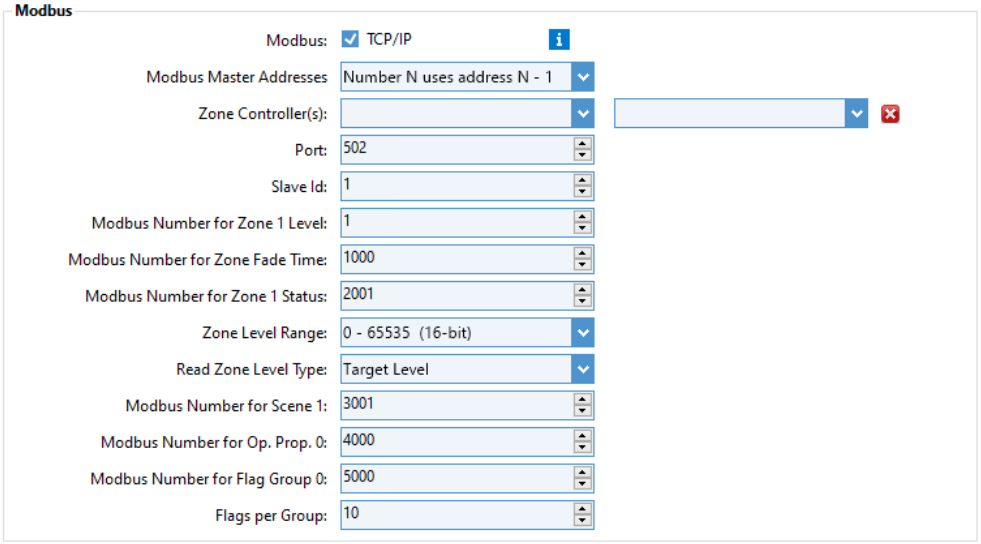
  (10 Flags per Group)
  - 50**1**0 = Flag Group **1**, Flag 0
  - …
  - 50**1**9 = Flag Group **1**, Flag 9
  - Etc.
- Writing a coil or register will set the state of a RAPIX Flag:
  - If the value written = 1, the RAPIX Flag will be set.
  - If the value written = 0, the RAPIX Flag will be cleared.
- Reading a coil or register will get the state of a RAPIX Flag:
  - If the RAPIX Flag is set, the value read = 1.
  - If the RAPIX Flag is clear, the value read = 0.

If the "Modbus Number for Flag 0" is set to 0, use of RAPIX Flags is disabled.

Configuring the Modbus settings using RAPIX Integrator

To configure the Modbus settings for the RAPIX Lighting Control System:

- Use RAPIX Integrator Software
- Select the Site tab:



The Modbus settings are described in the table below and are discussed in detail in the previous sections:

Setting	Purpose	Default Value
Modbus TCP/IP	Enables the Modbus interface on the selected Zone Controller	Disabled
Modbus Master Addresses	Most commonly, a Modbus Master will use *address* N – 1 for Modbus *Object Number* N. See section on Addressing Conventions.	N - 1
Zone Controller	The Zone Controller(s) that will have the Modbus interface enabled. **Ozuno recommends the Zone Controller with the lowest IP address is <u>not</u> used, as this will be the Master Zone Controller and will therefore be busier than the others.**	-
Port	The TCP/IP Port	502
Slave Id	The Modbus Slave Id	1
Modbus Number for Zone 1 Level	The Modbus Object Number to use to control or monitor the level of Zone 1. The next number will be for Zone 2 etc.	1
Modbus Number for Zone Fade Time	The Modbus Object Number used for setting the Zone fade time (for all Zones)	1000
Modbus Number for Zone 1 Status	The Modbus Object Number to use to monitor the error status of Zone 1. The next number will be for Zone 2 etc.	2001
Zone Level Range	The range that the Modbus master will use for the Zone Level	65535
Read Zone Level Type	Whether to read the Zone target level or current level	Target Level
Modbus Number for Scene 1	The Modbus Object Number to use to control or monitor the state of Scene 1. The next number will be for Scene 2 etc.	3001

Setting	Purpose	Default Value
Modbus Number for Op Prop 0	The Modbus Object Number to use to control or monitor the value of Operating Property 0. The next number will be for Operating Property 1 etc.	4000
Modbus Number for Flag Group 0	The Modbus Object Number to use to control or monitor the value of Flag Group 0, Flag 0. The next number will be for Flag Group 0, Flag 1 etc.	5000
Flags Per Group	The number of flags included in each Group	10

Run-time Execution

After the configuration has been set using RAPIX Integrator software, it is saved to the Zone Controllers.

After the configuration has been transferred, the Zone Controller that was configured as the Modbus slave will accept Modbus over TCP requests.

After that transfer, there is no need for RAPIX Integrator to remain open, connected to Zone Controllers, remain on site, and so on.

Use with Third-Party Systems

Configuration

To interface a Modbus system to the RAPIX Lighting Control System, use this configuration:

1. Use the Zone Controller IP Address and Port as set in RAPIX Integrator
2. Use 16-bit unsigned, big-endian format for Holding Registers
3. Configure the Modbus system and/or the Modbus settings in RAPIX Integrator so that the following are compatible:
    a. Numbering scheme (i.e. Address offset value);
    b. Level range; and
    c. Slave Id.

Polling

Modbus Masters poll Modbus Slave devices (such as the RAPIX Zone Controller) to read the values of coils and registers.

The number of Modbus objects being read, and the rate of the polling should be minimised to reduce the processing load on a RAPIX Zone Controller.

The RAPIX Zone Controller display can be used to show the CPU usage.

Reduce the Modus Master polling rate if the RAPIX Zone Controller CPU load increases by more than 20%.

Project Report

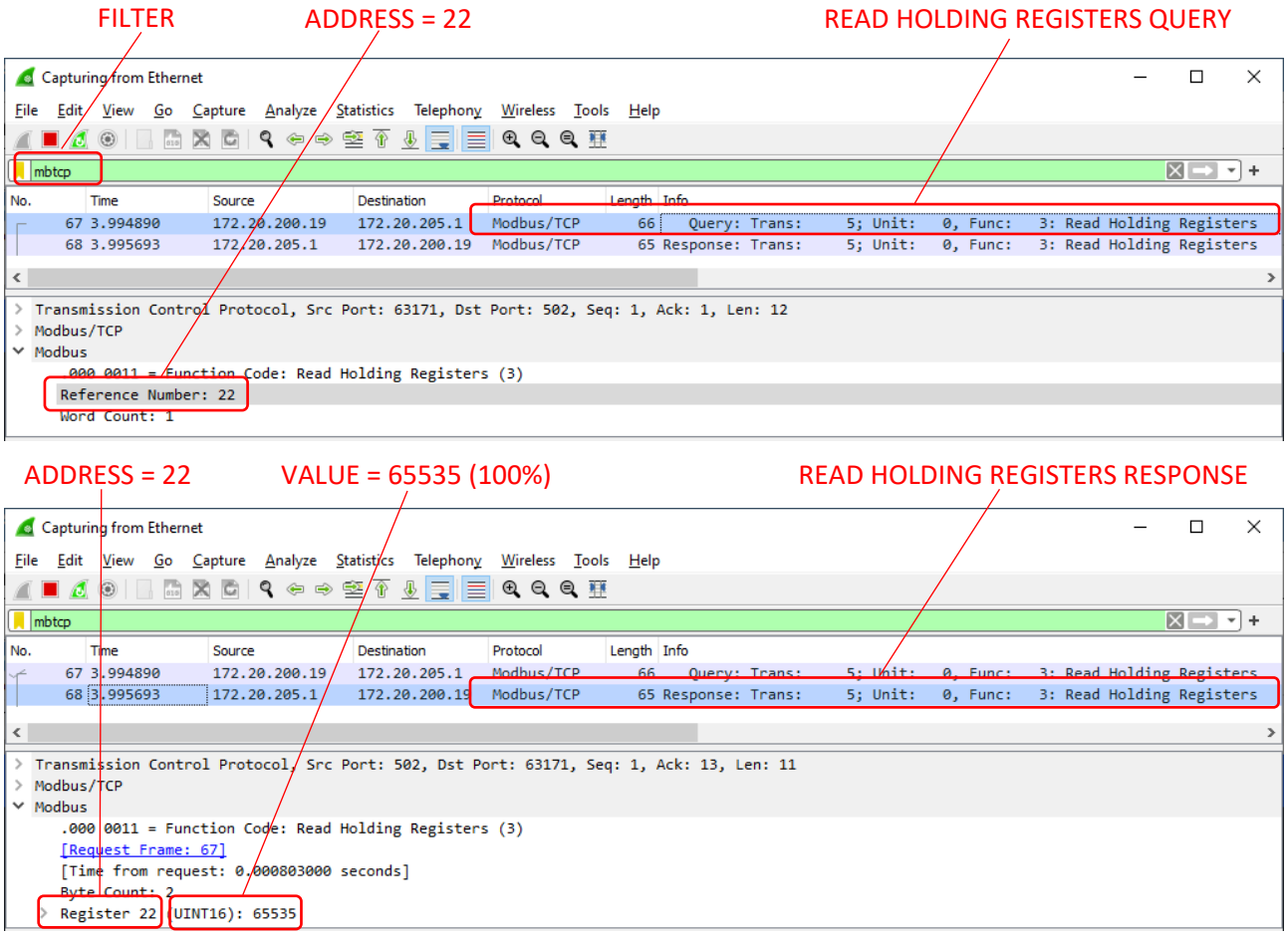
The Project Report (available from the Tools Menu) generates a section summarising the Modbus settings:

Feature	Details
Modbus Master	Modbus Object Number **N** maps to address **N - 1** (default behaviour)
Zone Controller 1	Floor 1 ZC (172.20.205.1)
Zone Controller 2	Floor 2 ZC (172.20.205.2)
Port	502
Slave Id	0
Zone State	Coil number **1** gets or sets the state (on/off) of zone **1**, etc.
Zone Level	Holding Register number **1** gets or sets the level of zone **1**, etc.
Zone Fade Time	Holding Register number **999** sets the fade time for all Zones
Zone Status	Holding Register number **1001** gets the status (e.g. errors) of Zone **1**, etc.
Scaling	Holding Register value 65535 = Zone level 100%
Scenes	Coil or Holding Register number **2001** gets or sets the state of Scene **1**, etc.
Operating Properties	Holding Register number **3000** gets or sets the value of Operating Property **0**, etc.
Flags	Coil or Holding Register number **4000** gets or sets the state of Flag Group **0**, Flag 0. Number **4010** is Flag Group **1**, Flag 0, etc.

Wireshark

The Wireshark software (https://www.wireshark.org/) can be used to view the details of Modbus messages going in and out of your computer. By using the “mbtcp” filter, only the Modbus messages will be displayed.

The screen shots below show the query and response when reading Holding Register 23. Note that the address used in this case was 22, showing that the Modbus Master was using the typical offset of 1.



Change History

Rev	Date	Updated By	Comment
1	7 Nov 2019	DS	First Release
2	11 Nov 2019	DS	Added new features
3	15 Jan 2020	DS	Added Zone Error Status
4	23 Sep 2020	DS	Corrected description of offsets
5	3 Jul 2023	DS	Simplified explanation of address mapping. Added details for use with RAPIX Scenes, Flags and Operating Properties. Added details of Project Report and use of Wireshark.

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