R090 Modbus TCP / DALI converter

Summary **R090 is a serial converter which acts as a Modbus TCP server (accepts Modbus TCP commands) and controls a DALI (Digital Addressable Light Interface) bus with up to 64 DALI devices. R090 acts as a multi master of the DALI bus (according EN 60929 ed. 4:2011 Annex E, static priority 4, setting time 16 ms, retry timeout 300 ms), and provides the power supply for the bus. It also incorporates a web interface for manual entering of DALI commands inclusive bus configuration and diagnostic commands. This converter is full substitute for previous type M090.**

Applications

- **integration of DALI light controllers to a Modbus TCP compatible SCADA or PLC**
- **configuring and controlling of a DALI bus over a comfortable web interface, even on a remote basis**

Function

R090 acts as a multi master of the DALI bus (according EN 60929 ed. 4:2011 Annex E, static priority 4, setting time 16 ms, retry timeout 300 ms), and provides the power supply for the bus, see below. The Modbus and web commands are translated into DALI protocol telegrams and sent to the DALI devices. The responses from the light controllers are translated back to Modbus registers and available at the corresponding addresses, see tables below.

Design notes

The DALI bus supports up to 64 light controller addresses, up to 16 scenes, and up to 16 groups. Wire length and diameter must always be respected! For the complete overview of the DALI bus specification, see e.g. http://www.dali-ag.org/ (DALI manual). The DALI bus uses 22.5 V operation voltage.

The bus devices are connected over a 2-pole connector, regardless of polarity. The Ethernet is connected over RJ45 connector with PoE (Power over Ethernet).

When specifying the DALI bus load, the amount and types of the DALI components must be selected so as not to exceed the guaranteed DALI bus current of the power supply. Using the **single master** topology, up to 64 control devices may be installed. A **multimaster** bus load shall not exceed the maximum total current for all devices (incl. input devices and application controllers) of 125 mA.

If the bus is loaded, the warm dissipation have to be guaranteed. The heat is product of frequent communication with high number of converters. Please do not exceed maximal permitted working temperature of 45 °C, otherwise the proper function is not guaranteed and the converter could be damaged!

Technical data

Power supply	24V ±20 % DC/AC Or PoE (Power over Ethernet, 802.af class2)
Consumption	1 VA (no DALI load) max. 6 VA (full load, 64 DALI slaves)
Communication	
Ethernet	1x Ethernet 10/100BaseT; galvanically insulated, insulating voltage 1 kV RJ45, 2 LED (link, data) integrated in the connector
DALI	standard EN 60929 ed. 4:2011 Annex E, 1200 bps device R090 is according this standard power supply and multimaster (collision avoidance/detection, priority 4 setting time 16 ms, retry timeout 300 ms) Galvanic separation DALI bus is separated up to 1000 V Short circuit protection of DALI power supply electronic with automatic reset, short-circuit current I_k= 250 mA Overload sustainability of the DALI power supply - sustainable to unlimited bus short-circuit. guaranteed current according to EN 62386-101: 125 mA
4x LED	RUN, PWR, TxD, RxD
Housing	Polycarbonate box (certification UL94V0); 4U
Dimensions	See below
Terminals	Screw terminals M3, maximum wire cross-section 2,5 mm^2
Protection degree	IP20 (EN 60529)
Operating environment	

Ambient conditions	-5 – 45 °C; 5 – 95 % relative humidity; non-condensing gases and chemically non-aggressive conditions (according EN 60721-3-3 climatic class 3K3)
Storage conditions	-5 – 45 °C; 5 – 95 % relative humidity; non-condensing gases and chemically non-aggressive conditions (according EN 60721-3-1 climatic class 1K3)
Standards conformity	EMC EN 61000-6-2 ed.3:2005, EN 55022 ed.3:2010 EN 60950-1 ed.2:2006 + A11:2009 + A12:2011 + A1:2010 + A2:2014 + Opr.1:2012 EN 50581:2012
EU legislation	Council Directive 2014/35/EC, The Low Voltage Directive (LVD) Council Directive 2014/30/EC, Electromagnetic Compatibility (EMC) Directive Council Directive 2011/65/EC, RoHS2 Directive

Power supply

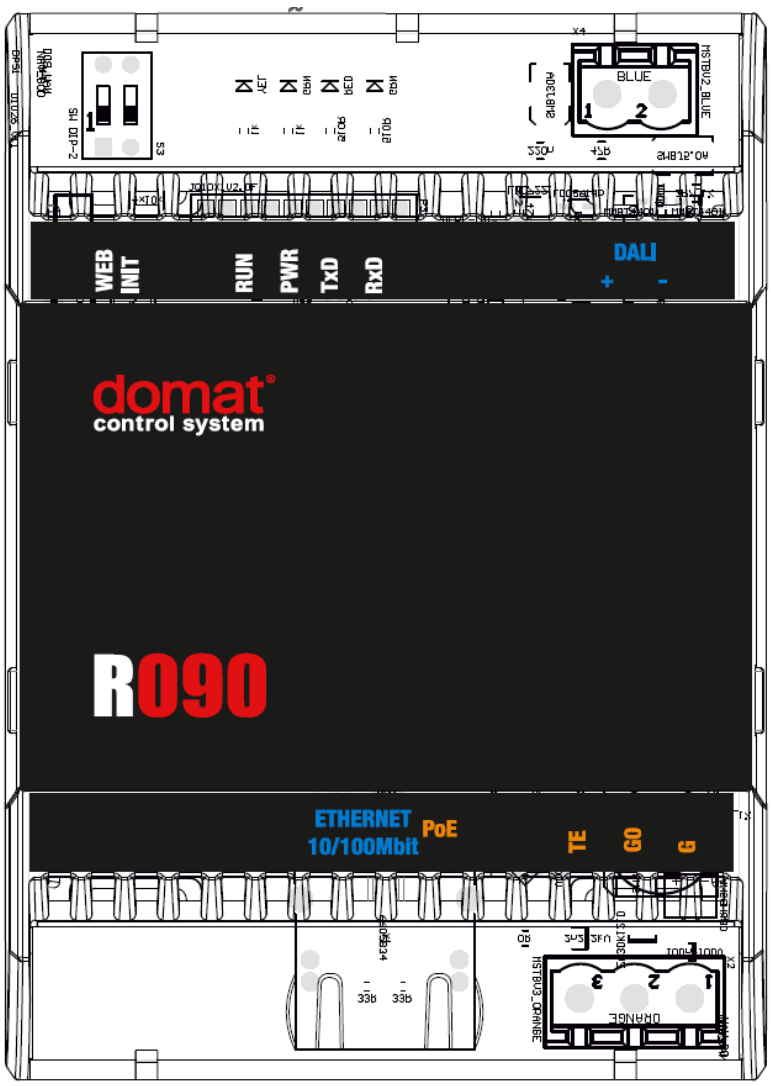
Alternative power supply (G/G0 terminals vs. PoE):

1. If the G/G0 power is applied first, the R090 is powered from this G/G0 external source. At power dropout the power is switched over to PoE with a short dropout (device reset).

2. If the PoE power is applied first, the R090 is powered from the PoE. The switchover to G/G0 follows only if the G/G0 voltage is 27 V DC (19 V AC) and above.

3. If both G/G0 and PoE are applied at the same time, the R090 is powered from G/GO terminals. The device will not be damaged.

Schema



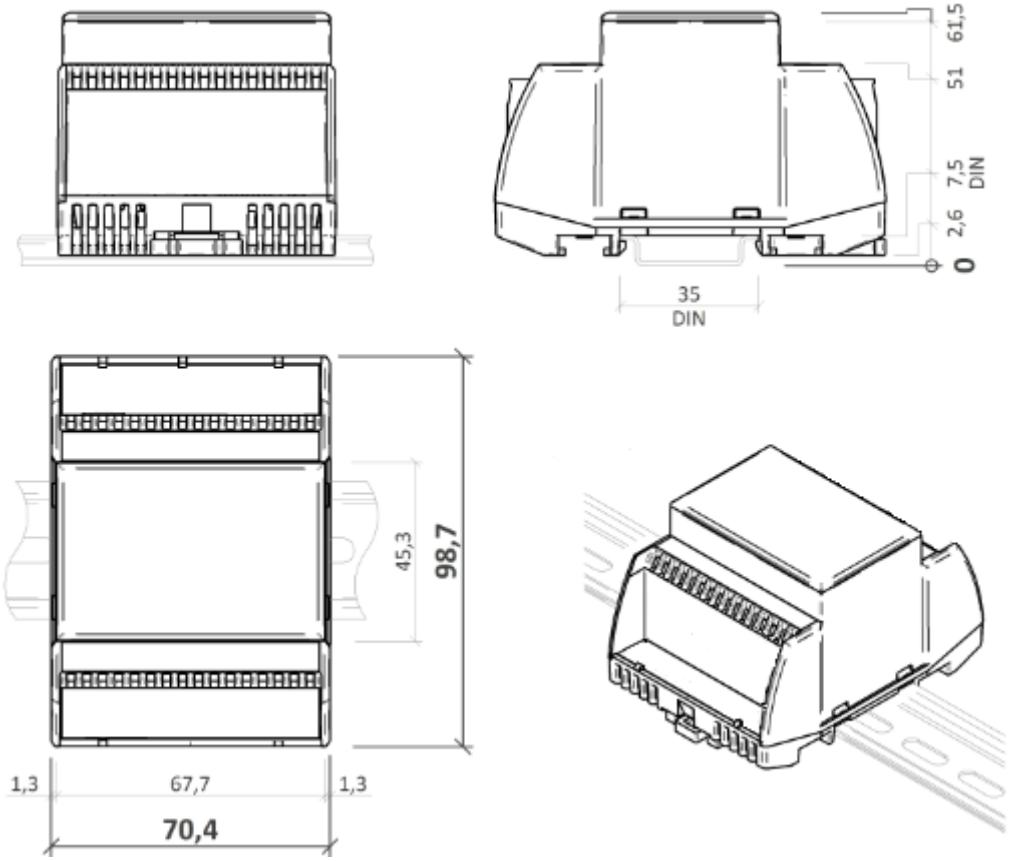
Terminals and connectors:	
DALI	DALI bus, positive and negative
Ethernet, PoE	Network interface, PoE
G	power
G0	power
TE	optional connection for shielding

LED indication:	
RUN	yellow LED – system cycle (OK: LED flashes periodically 1 s ON, 1 s OFF; ERROR: LED flashes in other pattern, LED is still ON or OFF)
PWR	green LED – power (ON: power OK; OFF: no power applied, weak or damaged power supply, …)
RxD	green LED – receiving data at DALI interface (flashing: receiving data; OFF: no data traffic)
TxD	red LED – transmitting data at DALI interface (flashing: transmitting data; OFF: no data traffic)
LINK/DATA	Ethernet activity

DIP switches:

WEB	DIP1 if ON at power-up, web access is denied
INIT	DIP2 if ON at power-up, configuration parameters are brought to defaults

Dimensions



Dimensions are in *mm*.

Settings

The network properties are set over the R090's web interface. The default network settings are:

IP address	192.168.1.99
Network mask	255.255.255.0
Default gateway	192.168.1.1

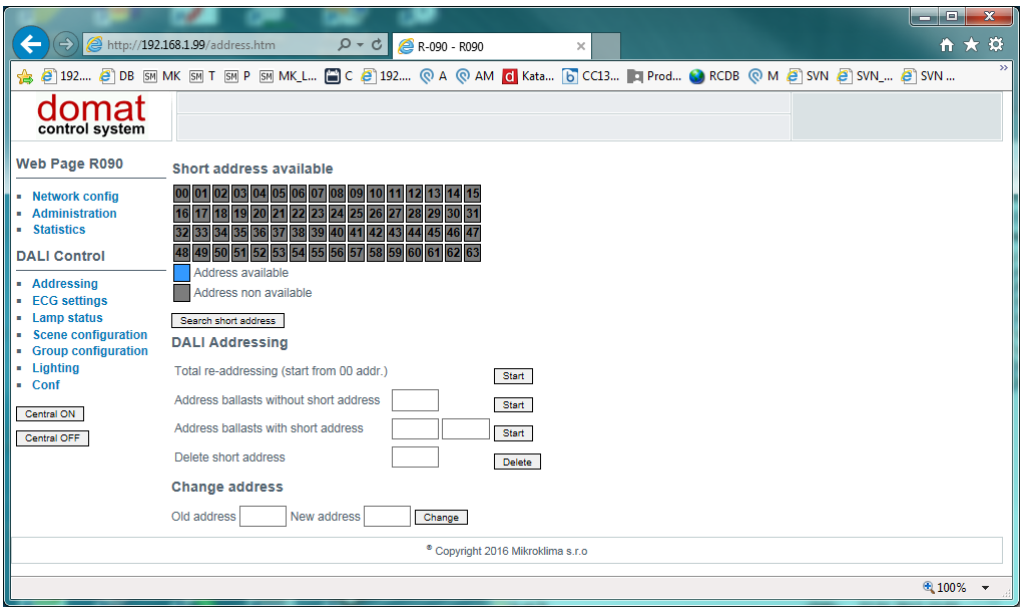
All settings are stored in EEPROM.

Bringing the device to default settings:

1. Power off the R090.
2. Set the DIP switch 1 (INIT) to ON.
3. Apply power.
4. Locate the device on its default IP address and configure it as necessary.
5. Remove power.
6. Set the INIT switch to OFF.
7. Apply power again.
8. The R090 has the new settings.

Web interface

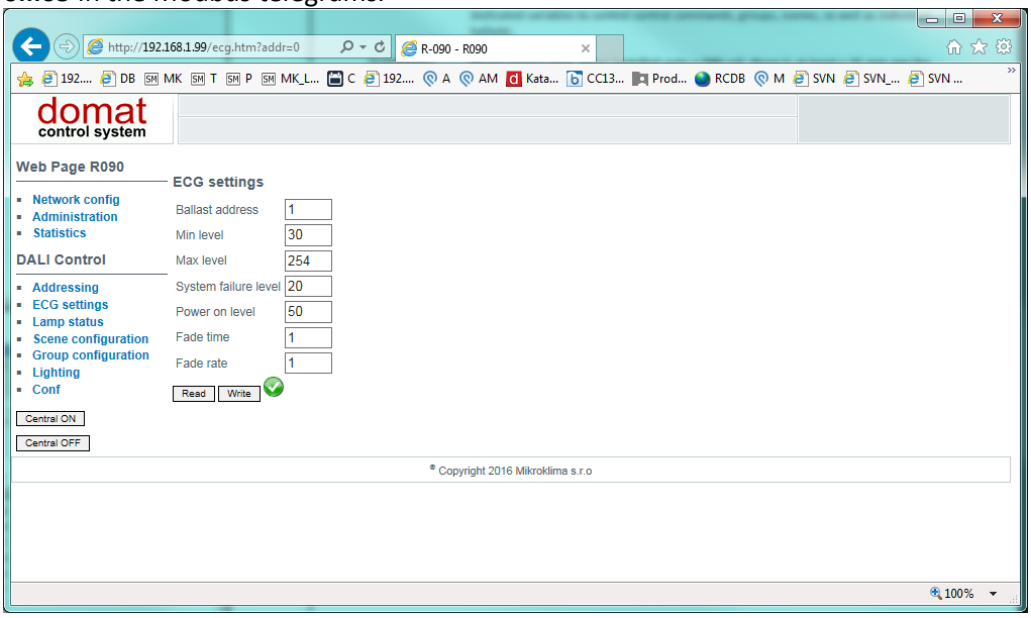
Over the web interface it is possible to set the R090 up (*Network config*), upload new firmware if necessary (*Administration*), and diagnose the interface (*Statistics*). The DALI Control menu is used to test if the DALI part is operating properly, to address the ballasts (*Addressing*), set the individual ballast parameters (*ECG settings*), see the states of the lamps at a glance (*Lamp status*), configure scenes and groups, issue group commands (*Ligthing*), and enable registers for simple control (*Conf*).



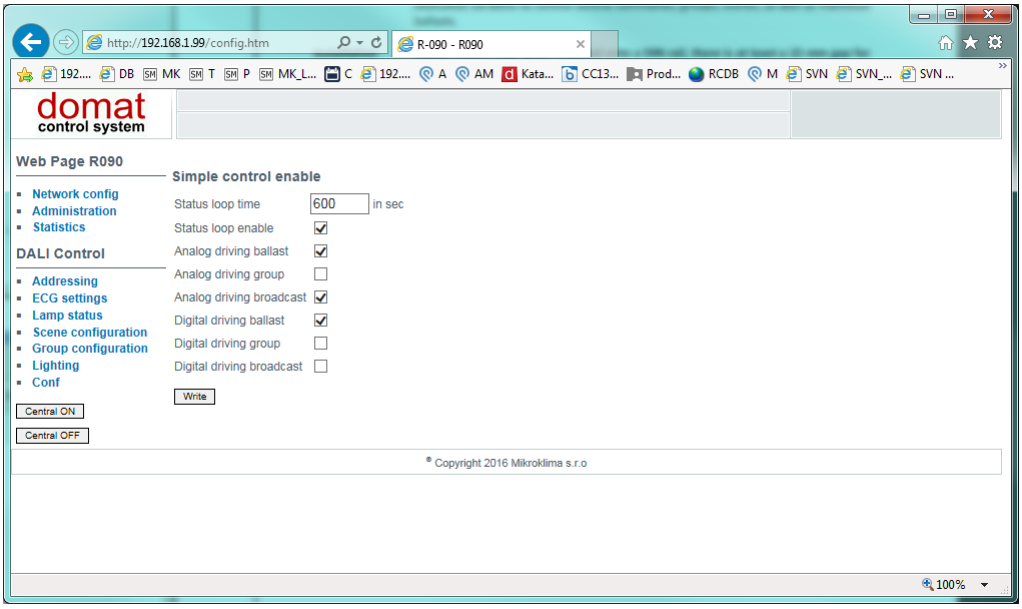
Addressing

When updating the firmware, update of the internal web pages may be necessary. The files are part of the firmware release package. For upload, use a ftp client with username/password: root / root99.

Please note that the numbering of the ballasts is:
0...63 at the web interface
0...63 in the Modbus telegrams.



Menu ECG Settings



Conf – Simple control enable menu

The web interface is useful when commissioning the system: the DALI bus may be checked separately from the PLC program. As soon as the groups are configured and it is possible to control the DALI ballasts over the web interface, it is time to commission the PLC part.

In the SoftPLC, there is a special driver for R090 so that the integration is easy – it is not necessary to map the Modbus registers via a generic Modbus driver, there are dedicated variables to control central commands, groups, scenes, as well as individual ballasts.

In the Merbon IDE, there are a Modbus devices for direct commands through writing to Modbus registers.

Installation

Please ensure that, when installed onto a DIN rail, there is at least a 15 mm gap for air circulation at both vertical device sides, which is necessary for proper cooling of the device.

Modbus TCP communication

The supported Modbus functions are:

03 Read Holding Registers – read words
16 Force Multiple Registers – write words

The memory is divided into sections, and only registers which functionally stick together, like 95 to 158, 160 to 175, etc. are able to be written in a single command. In other words, the F16 command can not cross borders, like writing to registers 157 to 162 in one command.

The address space is accessible wordwise (16 bit words). See table below.

Tab. 1: Modbus table

Name	Address	Type	Description	Note
modul LSB	1 LSB	R	module ID lower byte	0x0090 hex
modul MSB	1 MSB	R	module ID upper byte	
firmware LSB	2 LSB	R	firmware version lower byte	
firmware MSB	2 MSB	R	firmware version upper byte	
	3 LSB	R	reserved	
status MSB	3 MSB	R	module status upper byte **bit 0** - 0 normal mode - 1 init mode **bit 1** - 0 **bit 2 -** 0 **bit 3 -** 0 **bit 4** - 0 **bit 5** - 1 **bit 6** - 0 **bit 7** - 1	
Send twice mask	4 LSB	R RAM	**bit 0** = block 0 **bit 1** = block 1 **bit 2** = block 2 **bit 3** = block 3 **bit 4** = block 4 **bit 5** = block 5 **bit 6** = block 6 **bit 7** = block 7	**bit_x** = 1 -> send Dali command from **block x** twice within 100ms; suits for all commands except of commands 32-128, 258 and 259, which are sent twice automatically set/reset of bit is done only by user
reserved	4 MSB	R RAM		
command mask	5 LSB	R,W RAM	**bit 0** = block 0 **bit 1** = block 1 **bit 2** = block 2 **bit 3** = block 3 **bit 4** = block 4 **bit 5** = block 5 **bit 6** = block 6 **bit 7** = block 7	By setting the bit, executing of the corresponding block is enabled. The module executes the enabled blocks one after another from **bit 7** to **bit 0**

command executed	5 MSB	R RAM		The set bit indicates the executed block, **bit 0** = **block 0** etc.
DALI command block 0	6 LSB	R,W RAM		DALI command for block 0 according to the tables
DALI address block 0	6 MSB	R,W RAM		DALI address for block 0
D0 block 0	7 LSB	R,W RAM	if the request is performed by a single DALI command which contains answer, the answer is in this block	additional data 0 for block 0 -> tables
D1 block 0	7 MSB	R,W RAM	If the request is performed by a single DALI command, then: **0x00** – no reply returned **0x55** – valid DALI reply returned, and stored in register **7LSB** **0x02 –** bus error, bus permanently short-circuited **0x03** – DALI reply returned but damaged (unrecognized)	***Note 1*** additional data 1 for block 0 -> tables
D2 block 0	8 LSB	R,W RAM		additional data 2 for block 0 -> tables
	8 MSB		reserved	
DALI command block 1	9 LSB	R,W RAM		
DALI address block 1	9 MSB	R,W RAM		
D0 block 1	10 LSB	R,W RAM		
D1 block 1	10 MSB	R,W RAM		
D2 block 1	11 LSB	R,W RAM		
	11 MSB		reserved	
DALI command block 2	12 LSB	R,W RAM		
DALI address block 2	12 MSB	R,W RAM		
D0 block 2	13 LSB	R,W RAM		
D1 block 2	13 MSB	R,W RAM		
D2 block 2	14 LSB	R,W RAM		

	14 MSB		reserved	
DALI command block 3	15 LSB	R,W RAM		
DALI address block 3	15 MSB	R,W RAM		
D0 block 3	16 LSB	R,W RAM		
D1 block 3	16 MSB	R,W RAM		
D2 block 3	17 LSB	R,W RAM		
	17 MSB			
DALI command block 4	18 LSB	R,W RAM		
DALI address block 4	18 MSB	R,W RAM		
D0 block 4	19 LSB	R,W RAM		
D1 block 4	19 MSB	R,W RAM		
D2 block 4	20 LSB	R,W RAM		
	20 MSB		reserved	
DALI command block 5	21 LSB	R,W RAM		
DALI address block 5	21 MSB	R,W RAM		
D0 block 5	22 LSB	R,W RAM		
D1 block 5	22 MSB	R,W RAM		
D2 block 5	23 LSB	R,W RAM		
	23 MSB		reserved	
DALI command block 6	24 LSB	R,W RAM		
DALI address block 6	24 MSB	R,W RAM		
D0 block 6	25 LSB	R,W RAM		
D1 block 6	25 MSB	R,W RAM		
D2 block 6	26 LSB	R,W RAM		
	26 MSB		reserved	
DALI command block 7	27 LSB	R,W RAM		
DALI address block 7	27 MSB	R,W RAM		
D0 block 7	28 LSB	R,W RAM		

D1 block 7	28 MSB	R,W RAM		
D2 block 7	29 LSB	R,W RAM		
	29 MSB		reserved	
enable functions for simple control	30 LSB, MSB	R,W EEPROM default 0x7F hex (all enabled)		bit0 – enable round for error states and status readout bit1 – enable analogue intensity control - ballasts bit2 – enable analogue intensity control - groups bit3 – enable analogue intensity control - broadcast bit4 – enable bit (on/off) control - ballasts bit5 – enable bit (on/off) control – groups bit6 – enable bit (on/off) control broadcast (central on/off)
status of ballast 0	31 LSB	R RAM	bit 0 - Status of ballast; "0" = OK bit 1 -Lamp failure; "0" = OK bit 2 - Lamp arc power on; "0" = OFF bit 3 - Query: Limit Error; "0" = Last requested arc power level is between MIN..MAX LEVEL or OFF bit 4 - Fade ready; "0" = fade is ready; "1" = fade is running bit 5 - Query: "RESET STATE"? "0" = "No" bit 6 - Query: Missing short address? "0" = "No" bit 7 - Query: "POWER FAILURE"? "0" = "No"; "RESET" or an arc power control command has been received since last power-on. The "STATUS INFORMATION" shall be available in the RAM of the ballast and shall be updated regularly by the ballast according to the actual situation. The responses are same as command 144 responses from standard DALI table.	See DALI standard.
status of ballast 0	31 MSB	R RAM	bit 0: - 0 - ballast communication is OK - 1 - ballast is not communicate	

status of ballast 1	32 LSB	R RAM	See status of ballast 0.	
status of ballast 1	32 MSB	R RAM	See status of ballast 0.	
…	…	…	…	…
status of ballast 63	94 LSB	R RAM	See status of ballast 0.	
status of ballast 63	94 MSB	R RAM	See status of ballast 0.	
ballast 0 intensity	95 LSB, MSB	R,W RAM	Analogue intensity value for ballast 0 (0-254). It is written during writing. Function must be enabled in register 30 bit 1.	***Note 2***
ballast 1 intensity	96 LSB, MSB	R,W RAM		
ballast 2 intensity	97 LSB, MSB	R,W RAM		
…	…	….		
ballast 63 intensity	158 LSB, MSB	R,W RAM		
error and status readout round trip	159 LSB, MSB	R,W EEPROM default 60 sec	Value is in sec. (0 – 65535). If the value is 0, status and error is not read.	
group intensity 0	160 LSB,MSB	R,W RAM	Analogue value of group 0 intensity (0-254). It is written during writing. Function must be enabled in register 30 bit 2.	
group intensity 1	161 LSB,MSB	R,W RAM		
group intensity 2	162 LSB,MSB	R,W RAM		
…	…	…		
group intensity 15	175 LSB,MSB	R,W RAM		
analogue broadcast value	176 LSB,MSB	R,W RAM	Analogue value of all ballasts intensity (0-254) – central command	
bit control of ballasts 0-15	177 LSB,MSB	R,W RAM	– switch off – switch on It is written during writing. Function must be enabled in register 30 bit 4.	bit 0 –ballast 0 bit 1 – ballast 1 bit 2 – ballast 2

bit control of ballasts 16-31	178 LSB,MSB	R,W RAM		
bit control of ballasts 32-47	179 LSB,MSB	R,W RAM		
bit control of ballasts 48-63	180 LSB,MSB	R,W RAM		
bit control of groups 0-15	181 LSB,MSB	R,W RAM	0 – switch off 1 – switch on It is written during writing. Function must be enabled in register 30 bit 5.	***Note 3*** bit 0 – group 0 bit 1 – group 1 bit 2 – group 2 etc.
bit broadcast control	182 LSB,MSB	R,W RAM	It is written during writing. Function must be enabled in register 30 bit 6.	bit 0 – 0 = central OFF, 1 = central ON

Notes

Note 1: Possible reasons of error messages:
0x00 No reply: Bad R090 hardware, wiring problems, ...

0x02 Bus error: Appears when the bus is short-circuited. If there is no traffic on the bus, the microcontroller checks the bus every second. If a short-circuit is detected, the red LED goes on and the bus power is switched off. After 1 s the bus power is switched on again and the check is repeated. If there is no short-circuit, the converter goes to normal. If the problem persists, the check is performed again after 1 s. The problem may also be in the damaged analogue output circuits of the converter, which the processor can not distinguish from a real bus short-circuit.

0x03 Unrecognized reply: It may happen that at installations where there bus contains 50 – 60 ballasts more ballasts reply at the same time, or if there is a signal interference.

Note 2: For all analogue values, the maximum settable value depends on the particular ballast type. Some ballasts allow e.g. to set analogue value in range of 80 to 250 only. If the current value is 80 and a command to set to 254 is sent, the new value of 254 is displayed in the Modbus map and sent to the ballast, but the ballast does not accept this value and keeps its previous setting of 80.

Note 3: Even if a single bit is changed only, the register to control all 16 groups is always set as a whole (Modbus function F16). If, for example, a ballast is assigned to groups 14 and 15, both groups are off, and there is a command issued to set group 14 to on and group 15 to off, the ballast just blinks shortly and goes to off.

Tab. 2: Standard DALI commands

Nr.	DALI command (bin)	DALI address	D0	D1	D2	Function
Commands 0 – 31: Indirect arc power control commands						
0	0000 0000	YAAA AAA 1	0	0	0	OFF - Extinguish the lamp immediately without fading.
1	0000 0001	YAAA AAA 1	0	0	0	UP – Dim up for 200 ms (execution time) using the selected 'FADE RATE', if this command is received again while it is been executed, the execution time shall be retriggered. This command shall only affect ballasts with burning lamps. No lamp shall be ignited with this command. No change if the arc power output is already at the "MAX LEVEL".
2	0000 0010	YAAA AAA 1	0	0	0	DOWN – Dim down for 200 ms (execution time) using the selected 'FADE RATE', if this command is received again while it is been executed, the execution time shall be retriggered Lamp shall not be switched off via this command. No change if the arc power output is already at the "MIN LEVEL".
3	0000 0011	YAAA AAA 1	0	0	0	STEP UP - Set the actual arc power level one step higher immediately without fading. This command shall only affect ballasts with burning lamps. No lamp shall be ignited with this command. No change if the arc power output is already at the "MAX LEVEL".
4	0000 0100	YAAA AAA 1	0	0	0	STEP DOWN - Set the actual arc power level one step lower immediately without fading. Lamp shall not be switched off via this command. No change if the arc power output is already at the "MIN LEVEL".
5	0000 0101	YAAA AAA 1	0	0	0	RECALL MAX LEVEL - Set the actual arc power level to the "MAX LEVEL" without fading. If the lamp is off it shall be ignited with this command.
6	0000 0110	YAAA AAA 1	0	0	0	RECALL MIN LEVEL - Set the actual arc power level to the "MIN LEVEL" without fading. If the lamp is off it shall be ignited with this command.
7	0000 0111	YAAA AAA 1	0	0	0	STEP DOWN AND OFF - Set the actual arc power level one step lower immediately without fading.

						If the actual arc power level is already at the "MIN LEVEL", the lamp shall be switched off by this command.
8	0000 1000	YAAA AAA 1	0	0	0	ON AND STEP UP - Set the actual arc power level one step higher immediately without fading. If the lamp is switched off, the lamp shall be ignited with this command and shall be set to the "MIN LEVEL".
9-15	0000 1XXX					reserved
16-31	0001 XXXX	YAAA AAA 1	0	0	0	GO TO SCENE - the actual arc power level to the value stored for scene XXXX using the actual fade time. If the lamp is off, it shall be ignited with this command. If the value stored for scene XXXX is zero and the lamp is lit then the lamp shall be switched off by this command after the fade time.
Commands 32 – 128: Configuration commands These commands are automatically sent twice within 100ms.						
32	0010 0000	YAAA AAA 1	0	0	0	RESET – After the second reception of the command, the variables in the persistent memory shall be changed to their reset values. It is not guaranteed that any commands are received properly within the next 300 ms by a ballast acting on this command.
33	0010 0001	YAAA AAA 1	0	0	0	STORE ACTUAL LEVEL IN THE DTR Store actual arc power level in the DTR without changing the current light intensity. If the ballast is in the process of fading it is the instantaneous level, not the target level that is stored.
34-41	0010 XXXX					reserved
42	0010 1010	YAAA AAA 1	0	0	0	STORE THE DTR AS MAX LEVEL - Save the value in "Data Transfer Register" as new "MAX LEVEL".
43	0010 1011	YAAA AAA 1	0	0	0	STORE THE DTR AS MIN LEVEL - Save the value in "Data Transfer Register" as new "MIN LEVEL". If this value is lower as the "PHYSICAL MIN. LEVEL" of the ballast, then store the "PHYSICAL MIN. LEVEL" as new "MIN LEVEL".
44	0010 1100	YAAA AAA 1	0	0	0	STORE THE DTR AS A SYSTEM FAILURE LEVEL - Save the value in "Data Transfer Register" as new "SYSTEM FAILURE LEVEL".
45	0010 1101	YAAA AAA 1	0	0	0	STORE THE DTR AS POWER ON LEVEL - Save the value in "Data Transfer Register" as new "POWER ON LEVEL".

46	0010 1110	YAAA AAA 1	0	0	0	STORE THE DTR AS FADE TIME - Save the value in "Data Transfer Register" as new "FADE TIME". FADE TME range is 0-15, where 0 means no FADE. The fade time specifies the time for changing the arc power level from the actual level to the requested level. In case of lamp off, the preheat and ignition time is not included in the fade time.
47	0010 1111	YAAA AAA 1	0	0	0	STORE DTR AS FADE RATE - Save the value in "Data Transfer Register" as new "FADE RATE". FADE RATE range is 1-15, where 1 means fastest dimming and 15 slowest dimming.
48-63	0011 XXXX					reserved
64-79	0100 XXXX	YAAA AAA 1	0	0	0	STORE DTR AS SCENE - Save the value in Data Transfer Register as a new level of the scene 0-15 - XXXX.
80-95	0101 XXXX	YAAA AAA 1	0	0	0	REMOVE FROM SCENE - Remove the ballast from scene 0-15 - XXXX. Removing the ballast from scene XXXX means storing 1111 in scene register XXXX.
96-111	0110 XXXX	YAAA AAA 1	0	0	0	ADD TO GROUP - Add the ballast to group 0-15 - XXXX.
112-127	0111 XXXX	YAAA AAA 1	0	0	0	REMOVE FROM GROUP - Remove the ballast from group 0-15 - XXXX. Removing the ballast from group XXXX means storing "0" in the group register.
128	1000 0000	YAAA AAA 1	0	0	0	STORE DTR AS SHORT ADDRESS - Save the value in the DTR as new short address. The structure of the DTR shall be: XXXX XXXX = 0AAA AAA1 or 1111 1111 shall remove the short address.
129-143	1000 XXXX					reserved
Commands 144 – 155: Query commands						
144	1001 0000	YAAA AAA 1	0	0	0	QUERY STATUS – Answer is the following „STATUS INFORMATION“ byte: **bit 0** - Status of ballast; 0 = OK **bit 1** – Lamp failure; 0 = OK **bit 2** – Lamp arc power on; 0 = OK **bit 3 -** Query: Limit Error; "0" = Last requested arc power level is between MIN..MAX LEVEL or OFF **bit 4** – Fade ready; "0" = fade is ready; "1" = fade is running **bit 5** – Query: "RESET STATE"? "0" = "No"

						bit 6 – Query: Missing short address? "0" = "No" **bit 7** – Query: "POWER FAILURE"? "0" = "No"; "RESET" or an arc power control command has been received after last power-on.
145	1001 0001	YAAA AAA 1	0	0	0	QUERY BALLAST - Ask if there is a ballast with the given address that is able to communicate. Answer shall be "Yes" or "No".
146	1001 0010	YAAA AAA 1	0	0	0	QUERY LAMP FAILUTRE - Ask if there is a lamp problem at the given address. Answer shall be "Yes" or "No".
147	1001 0011	YAAA AAA 1	0	0	0	QUERY LAMP POWER ON - Ask if there is a lamp operating at the given address. Answer shall be "Yes" or "No".
148	1001 0100	YAAA AAA 1	0	0	0	QUERY LIMIT ERROR - Ask if the last requested arc power level at the given address could not be met, because it is above the MAX LEVEL or below the MIN LEVEL. Answer shall be "Yes" or "No".
149	1001 0101	YAAA AAA 1	0	0	0	QUERY RESET STATE - Ask if the ballast is in "RESET STATE". Answer shall be "Yes" or "No".
150	1001 0110	YAAA AAA 1	0	0	0	QUERY MISSING SHORT ADDRESS - Ask if the ballast has no short address. Answer shall be "Yes" or "No". The answer shall be "Yes" if the ballast has no short address.
151	1001 0111	YAAA AAA 1	0	0	0	QUERY VERSION NUMBER - Ask for the version number of the IEC standard document met by the software and the hardware of the present ballast. The "VERSION NUMBER" shall be stored in a ROM. Answer shall be the 'VERSION NUMBER' as an 8 bit number 'XXXX 0000'. The first 4 bits (XXXX) represent the version number of this standard.
152	1001 1000	YAAA AAA 1	0	0	0	QUERY CONTENT DTR Answer shall be the content of the DTR as an 8 bit number.
153	1001 1001	YAAA AAA 1	0	0	0	QUERY DEVICE TYPE - Answer shall be an 8 bit number (x = 0 to 255). The standard device type shall return the answer 0 (this device type shall not react on the application extended commands 224 to 255). For the list of device types see command 272.
154	1001 1010	YAAA AAA 1	0	0	0	QUERY PHYSICAL MINIMUM LEVEL - Answer shall be the "PHYSICAL MIN. LEVEL" as an 8 bit number. The "PHYSICAL MIN. LEVEL" shall be stored in a ROM.
155	1001 1011	YAAA AAA 1	0	0	0	QUERY POWER FAILURE - Answer shall be "YES" if the ballast has not received a "RESET" or one of the following arc power control commands since the last power-on: "DIRECT ARC POWER CONTROL", "OFF", "RECALL MAX LEVEL", "RECALL MIN LEVEL",

						"STEP DOWN AND OFF", "ON AND STEP UP", "GO TO SCENE"
156-159	1001 11XX					reserved
Commands 160 – 165: Queries related to arc power parameter settings						
160	1010 0000	YAAA AAA 1	0	0	0	QUERY ACTUAL LEVEL - Answer shall be this level as an 8 bit number. During preheating and if a lamp error occurs the answer shall be "MASK".
161	1010 0001	YAAA AAA 1	0	0	0	QUERY MAX LEVEL - Answer shall be this level as an 8 bit number.
162	1010 0010	YAAA AAA 1	0	0	0	QUERY MIN LEVEL - Answer shall be this level as an 8 bit number.
163	1010 0011	YAAA AAA 1	0	0	0	QUERY POWER ON LEVEL - Answer shall be this level as an 8 bit number.
164	1010 0100	YAAA AAA 1	0	0	0	QUERY SYSTEM FAILURE LEVEL - Answer shall be this level as an 8 bit number.
165	1010 0101	YAAA AAA 1	0	0	0	QUERY FADE TIME / FADE RATE - Answer shall be XXXX YYYY where XXXX corresponds with the number of command 46 and where YYYY corresponds with the number of command 47.
166-175	1010 XXXX					reserved
Commands 176– 196: Queries related to system parameter settings						
176-191	1011 XXXX	YAAA AAA 1	0	0	0	QUERY SCENE LEVEL Answer shall be the arc power level of scene 0-15 - XXXX as an 8 bit number.
192	1100 0000	YAAA AAA 1	0	0	0	QUERY GROUPS 0-7 - One bit for each group in back channel data byte. Bit 0 = group 0. Bit1 = group 1 … "0" = not belonging to group. "1" = belonging to group.
193	1100 0001	YAAA AAA 1	0	0	0	QUERY GROUPS 8-15 - One bit for each group in back channel data byte. Bit 0 = group 8. Bit 1 = group 9 … "0" = not belonging to group. "1" = belonging to group.
194	1100 0010	YAAA AAA 1	0	0	0	QUERY RANDOM ADDRESS (H) - The 8 high bits of the random address
195	1100 0011	YAAA AAA 1	0	0	0	QUERY RANDOM ADDRESS (M) - The 8 mid bits of the random address.
196	1100 0100	YAAA AAA 1	0	0	0	QUERY RANDOM ADDRESS (L) - The 8 low bits of the random address.

197-223	110X XXXX					reserved
224-255	11XX XXXX	YAAA AAA 1	0	0	0	QUERY APPLICATION EXTENDED COMMANDS
256	1010 0001	0000 0000	0	0	0	TERMINATE – All special mode processes shall be terminated.
257	1010 0011	XXXX XXXX	0	0	0	DATA TRANSFER REGISTER (DTR) - Store 8 bit value XXXX XXXX to DTR.

Tab. 3: Address types

Short address	0-63	0AAAAAA1
Group address	0-15	100AAAA1
Broadcast		11111111
Direct control	0-63	0AAAAAA0
Direct control of one ballast	0-63	1AAAAAA0
Direct control of group	0-15	100AAAA0

Tab. 4: Advanced DALI commands

Nr.	DALI command	DALI address	D0	D1	D2	Function
258	1010 0101	XXXX XXXX				INITIALISE – This command shall be received a second time in the next 100 ms. No other commands addressing the same ballast shall be received between these two commands, otherwise these commands and command 258 shall be ignored. The command shall start or re-trigger a timer for 15 minutes; the addressing commands 259 to 270 shall only be processed within this period. All other commands shall still be processed during this period. This time period shall be aborted with the "TERMINATE" command. This command is sent automatically twice within 100ms. 0000 0000 – All ballasts shall react 0AAA AAA1 – Ballasts with the address AAA AAA shall react 1111 1111 – Ballasts without short address shall react
259	1010 01111	0000 0000				RANDOMISE – This command shall be received a second time in the next 100 ms. No other commands addressing the same ballast shall be received between these two commands, otherwise these commands and command 259 shall be ignored. The ballast shall generate a new random address on the request of this command. The new random address shall be available within a time period of 100 ms. This command is sent automatically twice within 100ms.
260	1010 1001	0000 0000				COMPARE – The ballast shall compare it's random address with the combined search address stored in SEARCHADDRH, SEARCHADDRM and SEARCHADDRL. If it’s random address is smaller or equal to the combined search address stored in SEARCHADDRH, SEARCHADDRM and SEARCHADDRL and the ballast is not withdrawn then the ballast shall generate a query ”YES”.
261	1010 1011	0000 0000				WITHDRAW – The ballast with it’s random address that is equal to the combined search address stored in SEARCHADDRH, SEARCHADDRM and SEARCHADDRL shall no longer respond to the compare command. This ballast shall not be excluded from the initialization process.
262	1010 1101	0000 0000				reserved

263	1010 1111	0000 0000				reserved
264	1011 0001	HHHH HHHH				SEARCHADDRH
265	1011 0011	MMMM MMMM				SEARCHADDRM
266	1011 0101	LLLL LLLL				SEARCHADDRL
Final address is HHHHHHHHHMMMMMMMMLLLLLLLL						
267	1011 0111	0AAA AAA1				PROGRAM SHORT ADDRESS – The ballast shall store the received 6 bit address as its short address if it is selected.
268	1011 1001	0AAA AAA1				VERIFY SHORT ADDRESS - The ballast shall give an answer ”YES” if the received short address is equal to it’s own short address.
269	1011 1011	0000 0000				QUERY SHORT ADDRESS – The ballast shall send the short address if the random address is the same as the search address or the ballast is physically selected. The structure of the answer shall have the format 0AAA AAA1. If no short address is stored the answer shall be "MASK"
270	1011 1101	0000 0000				PHYSICAL SELECTION – If a ballast receives this command, it shall cancel its physical selection and shall set the ballast to "Physical Selection Mode". In this mode the comparison of SEARCH and RANDOM ADDRESS shall be disabled.
271	1011 1111					reserved
272	1100 0001	XXXX XXXX				ENABLE DEVICE TYPE X - X = 0 to 255. This command shall be sent before an application extended command (224 – 255). This command can be processed without the use of the INITIALISE command. This command shall not be used for device type 0, because the application extended commands 224-255 are not used for this device type. X=0 – device for fluorescent lamps X=1 – device for emergency lighting X=2 – device for HID lamps X=3 device for low voltage halogen lamps X=4 – device for dimming of incandescent lamps X=5 - device for conversion of digital signals according E.4 into d.c. signals according E.2 X=6 – LED X=7-255 - reserved
273	1100 0011					reserved
274	1100 0101					reserved

275	1100 0111					reserved
276	1100 1001				0x13	reserved
277	1101 0001				0x14	reserved
278	1101 0101				0x15	reserved
279	1101 0111				0x16	reserved

Tab. 5: Responses to advanced DALI commands

Nr.	DALI command	DALI address	D0	D1	D2	Function
260	1010 1001	0000 0000	Response	-	-	COMPARE – The ballast shall compare it's random address with the combined search address stored in SEARCHADDRH, SEARCHADDRM and SEARCHADDRL. If it's random address is smaller or equal to the combined search address stored in SEARCHADDRH, SEARCHADDRM and SEARCHADDRL and the ballast is not withdrawn then the ballast shall generate a query "YES".
268	1011 1001	0AAA AAA1	Response			VERIFY SHORT ADDRESS - The ballast shall give an answer "YES" if the received short address is equal to it's own short address.
269	1011 1011	0000 0000	Response			QUERY SHORT ADDRESS – The ballast shall send the short address if the random address is the same as the search address or the ballast is physically selected. The structure of the answer shall have the format 0AAA AAA1. If no short address is stored the answer shall be "MASK"

R090 converter special functions

R090 converter contains 22 preprogammed functions, that are not embodied in DALI stanrard. These functions trigger sequence of other commands.

Functions are controlled by registers, that are normally used to control DALI functions.

The following table shows example of using these functions by registers labeled as „block 0“ (reg. 6, 7, 8).

To use these functions you can use any of other „blocks“ so „block 1“ would be registers 9, 10, 11, for „block 2“ registers 12, 13, 14, etc.

Triggering of these functions is done by switching bits in register 5 – command mask.

Tab. 4: R090 converter special functions

No.	6 LSB	6 MSB	7 LSB	7 MSB	8 LSB	Function
1	-	YAAA AAA1	0100 XXXX	Value [0-254]	0000 0001	Store value as new parameter of scene XXXX (group address can be used as well)
2	-	0AAA AAA1	0110 XXXX 0111 XXXX	-	0000 0010	0110 XXXX = Add ballast to group XXXX 0111 XXXX = Remove ballast from group XXXX
3	-	YAAA AAA1	-	Value [0-15]	0000 0011	Store value as „FADE TIME“ (group address can be used as well)
4	-	YAAA AAA1	-	Value [1-15]	0000 0100	Store value as „FADE RATE“ (group address can be used as well)
5	-	YAAA AAA1	-	Value [0-254]	0000 0101	Store value as „MAX LEVEL“ (group address can be used as well)
6	-	YAAA AAA1	-	Value [0-254]	0000 0110	Store value as „MIN LEVEL“ (group address can be used as well)
7	-	YAAA AAA1	-	Value [0-255]	0000 0111	Store value as „SYSTEM FAILURE LEVEL“ (group address can be used as well)
8	-	YAAA AAA1	-	Value [0-254]	0000 1000	Store value as „POWER ON LEVEL“ (group address can be used as well)
9	-				0000 1001	Completely new addressing
10	-		Address to start with	0AAA AAA1	0000 1010	New addressing of all ballasts with given address
11	-		Address to start with		0000 1011	New addressing of ballasts without short address

12	-	0AAA AAA1	-	-	0000 1100	Deletes given short address of ballast
13	-	0AAA AAA1 (current address)	-	0AAA AAA1 (new address)	0000 1101	Changes current address to new address
14	-	YAAA AAA1	number of winks [1-255]	wink time [1-255]	0000 1110	winks the addressed ballast; wink values must not be 0! (group address can be used as well)
15	-				0000 1111	Short addresses request [0-31]
16	-				0001 0000	Short addresses request [32-63]
17	-				0001 0001	Ballast status request [0-31]
18	-				0001 0010	Ballast status request [32-63]
19	-				0001 0011	"Lamp failure" request [0-31]
20	-				0001 0100	"Lamp failure" request [32-63]
21	-				0001 0101	"Lamp power on" request [0-31]
22	-				0001 0110	"Lamp power on" request [32-63]

Tab. 5: Answers for R090 converter special functions

No.	6 LSB	6 MSB	7 LSB	7 MSB	8 LSB	Function
1	-	-	-	-		
2	-	-	-	-	-	
3	-	-	-	-	-	
4	-	-	-	-	-	
5	-	-	-	-	-	
6	-	-	-	-	-	
7	-	-	-	-	-	
8	-	-	-	-	-	
9	-	-	Number of addressed ballasts [0-63]	-	-	Completely new addressing
10	-	-	Number of addressed ballasts [0-63]	-	-	New addressing of all ballasts with given address
11	-	-	Number of addressed ballasts [0-63]	-	-	New addressing of all ballasts without short address
12	-	-	-	-	-	
13	-	-	-	-	-	
14	-	-	-	-	-	

15	Addresses 0-7	Addresses 8-15	Addresses 16-22	Addresses 23-31	-	1 – Yes 0 - No
16	Addresses 32-39	Addresses 40-47	Addresses 48-55	Addresses 56-63	-	1 – Yes 0 - No
17	Addresses 0-7	Addresses 8-15	Addresses 16-22	Addresses 23-31	-	1 - Error 0 - OK
18	Addresses 32-39	Addresses 40-47	Addresses 48-55	Addresses 56-63	-	1 - Error 0 - OK
19	Addresses 0-7	Addresses 8-15	Addresses 16-22	Addresses 23-31	-	1 - Error 0 - OK
20	Addresses 32-39	Addresses 40-47	Addresses 48-55	Addresses 56-63	-	1 - Error 0 - OK
21	Addresses 0-7	Addresses 8-15	Addresses 16-22	Addresses 23-31	-	1 - On 0 - Off
22	Addresses 32-39	Addresses 40-47	Addresses 48-55	Addresses 56-63	-	1 - On 0 - Off

Light level control

It is possible to control the light level using two different ways. DALI recognizes direct and indirect light level control.

Indirect light level control

The command consists of 2 bytes.

Byte 1 DALI address (short address / group address / broadcast)
Byte 2 Standard or Extended DALI command – see tables above.

Direct light level control

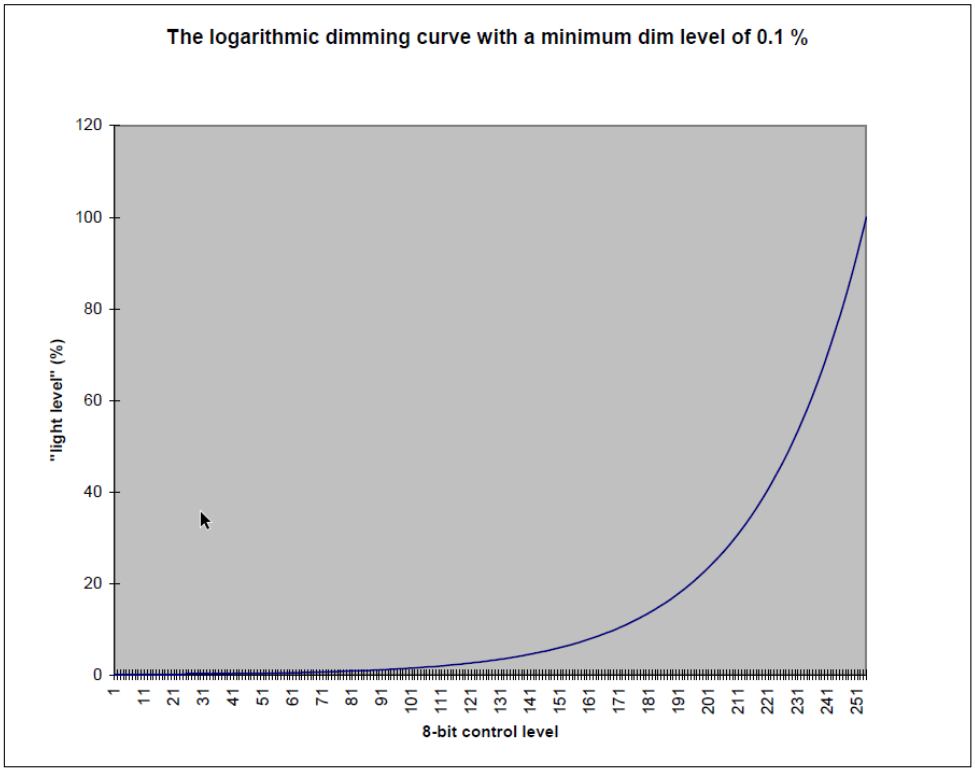
The command consists of 2 bytes.

Byte 1 DALI address; this is the DALI ballast short address, with the first bit of 0.
Byte 2 Light level: a number in the range of 0...254.

This is a way, how to control the light level directly without using of groups, scenes etc.

Scene controll can use also percentage values. It is calculated using formula:

$$X(n) = 10^{\frac{n-1}{253/3}-1}, \left|\frac{X(n)-X(n+1)}{X(n)}\right| = const. = 2.8\%$$



Example of Modbus TCP command

There are 8 "blocks" - (0 to 7) – which represent positions for the DALI commands. To execute a command

- the block(s) must be filled with the data representing the command(s)
- bit(s) in Register 5 LSB which corresponds to the block to be executed must be set.

After executing of the command, the info bit in register 5 MSB is set so that the Modbus master can read that the execution was OK.

If a command is generating a response, the response is stored in the D0..D2 registers of the particular block.

More blocks may be filled at the same time and executed all together by writing a corresponding bit pattern into register 5 LSB.

Example:

Tx: 00 07 00 00 00 0D 01 10 00 05 00 03 06 0B 05 00 00 00 00

A Modbus TCP example telegram for **ballast Adr 6: set to max (DALI function 5)**. It is written in command block 0 (Modbus register 6, which is Modbus address 5).

00 07 00 00 00 0D 01	Details see Modbus TCP frame structure
10	Modbus F16, write multiple registers
00 05	Modbus address to be written to, address 5 = register 6
00 03	Number of 16bit registers to be written
06	Number of bytes to follow
0B 05 00 00 00 00	The data is 0B 05 for command block 0, other command blocks 1 and 2 are empty (00 00 00 00) - (this is how the client software, with which the example was done, is communicating: it writes three blocks at a time; other clients may only send the first couple of bytes).

The most important data is **0B 05**.
05: LSB = DALI command, see Tab 2 No.5
0B: MSB = 0000 1011 - the structure of a standard DALI command - see Tab 2:

Y AAA AAA 1, where
Y = 0 for Short address (see Tab 3), and
AAA AAA = 000 101 = 5 = DALI address of the ballast.

In a similar way more command blocks may be filled, and then activated at the same time.

Another Modbus TCP telegram has to activate (execute) this command:

Address 6: execute block 0 (write 1 into Modbus register 5, or Modbus address 4)

00 08 00 00 00 09 01	Details see Modbus TCP frame structure
10	Modbus F16, write multiple registers
00 04	Modbus address to be written to, address 4 = register 5
00 01	Number of 16bit registers to be written
02	Number of bytes to follow
00 01	1 at Bit 0 means **Execute command block 1**. At this time the commands from Block D0 are sent to the DALI bus.

Registers for simple control and status monitoring

To make Modbus communication easier, it is possible to read out statuses and control the ballasts also **using a simple Modbus read / write commands to dedicated Modbus registers 30 to 182**. These commands are converted to DALI commands in the converter, and sent to the DALI bus (unlike the standard commands, where the Modbus client actually has to compile the DALI telegrams and send them over Modbus). The Modbus client then may assign a separate register or bit to each ballast which makes the Modbus client engineering easier.

It is necessary to enable the required functions in Register 30 (see table above) for two reasons:

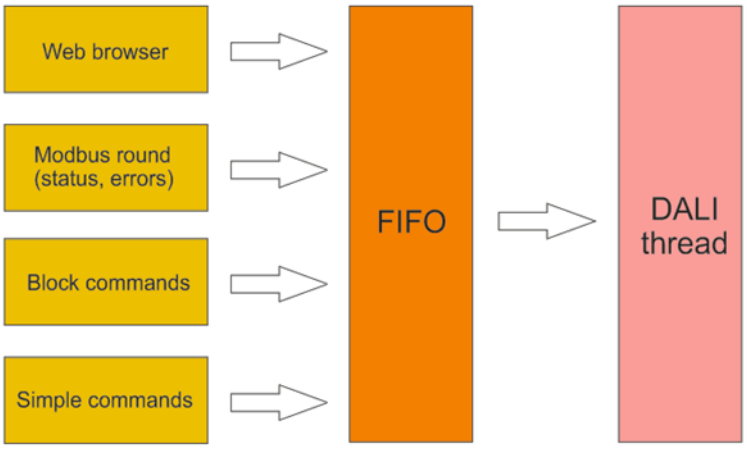
- this communication may bring extra load to the DALI bus, it is advisable to set e.g. the status update interval to the longest acceptable time

- only enabled command types are sent to the DALI bus – security reason.

If these functions are not used, they should be disabled in register 30.

Note that if more commands to control a single DALI ballast are set over different registers, the last one is active. Make sure that the Modbus client does not send weird commands over different registers which could spoil the DALI functionality.

To use the simple control commands in a proper way, it is necessary to understand the principle of command processing within the R090. There is an internal FIFO queue of 96 commands. The commands are read over the Modbus TCP interface or web pages, and put into the queue. On the queue output, the commands are translated into DALI telegrams, and sent to the DALI interface. **There is no feedback between the DALI command execution and the respective Simple command.** The Modbus server response to confirm a Simple command receipt only means that the command has been received by the R090, not that the command has been queued or executed at the DALI bus.
There are no exceptions, priorities, nor any other internal logics in the queue. As the DALI bus communication speed is 1200 bps while the Modbus TCP commands travel at a speed of Ethernet, in case that the Simple commands are sent in a fast sequence, it may happen that the queue gets full.



If the queue is full, all incoming Modbus Simple commands are discarded. At the *Statistics* web page, there is a **Dali failure counter** item which counts the discarded commands. If this value is increasing steadily, it means that the Simple commands queue is permanently full and the Modbus communication should be less frequent.

Always select only the relevant simple command types at the *Conf* page. It is advised to disable the types of commands which are not used.

Firmware update

The last firmware version is available on web link:
http://domat-int.com/en/downloads/software Section Firmware for Domat devices.

Applicable for firmware v1.0.0 and newer:

- Open the web page of the R090, go to *Administration*, and upload the new firmware file (*R090_fw_x_x_x.bin*)
- power off / on the R090
- connect to the R090 over FTP (name / password: root / root99)
- delete all web pages which are in the R090
- copy the new web pages from your PC to the R090
- disconnect the FTP server
- power off / on the R090

Applicable for firmware older than v1.0.0 (RC - release candidate versions)

- Open the web page of the R090, go to *Administration*, and upload the new firmware file (*R090_fw_x_x_x.bin*)
- set the INIT switch at R090 to ON
- power off / on the R090
- the IP address of R090 is 192.168.1.99 now
- go to the R090 web pages, *Conf*
- click the *Write* button
- connect to the R090 over FTP (name / password: root / root99)
- delete all web pages which are in the R090
- copy the new web pages from your PC to the R090
- disconnect the FTP server
- set the INIT switch to OFF
- power off / on the R090
- set the new IP address of the module, and all other settings.

Changes in versions

11/2016 – The first datasheet version.
12/2016 – Updated information about DALI commands, Modbus table and firmware update information.
01/2017 – Design notes merged with Bus design notes and all moved above the Technical data table.
01/2017 – New table “R090 converter special functions” added, minor updates to DALI functions tables.
01/2017 – New information about commands that have to be sent twice within 100ms