

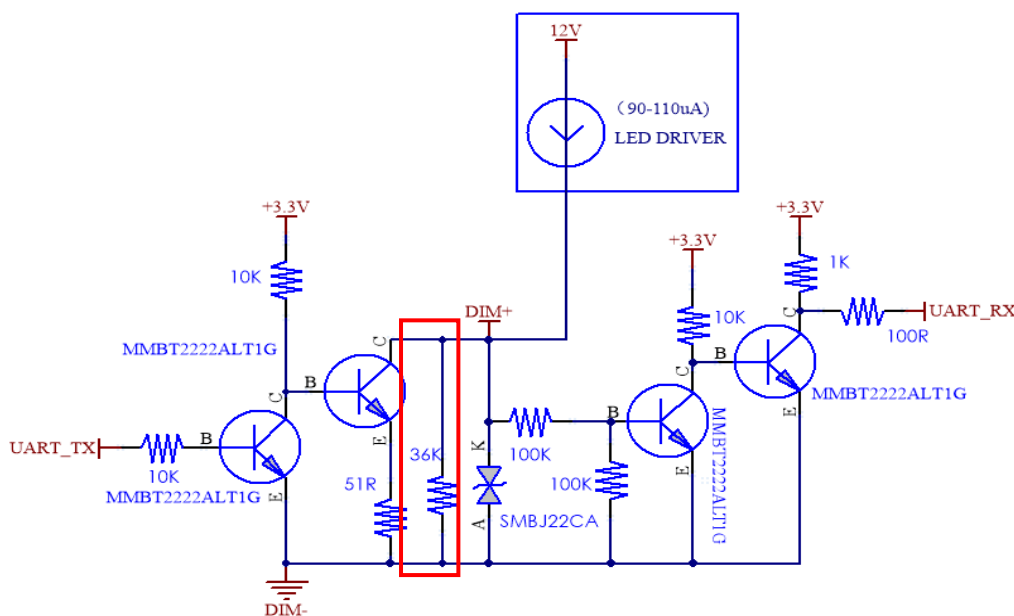
# Multiple Output Channels Digital Dimming V1.0

## Communication Protocol

### I. Hardware Interface Design

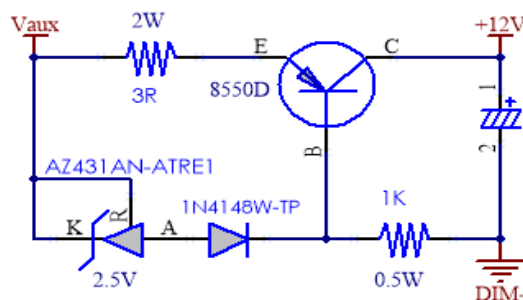
- Digital Dimming utilizes a Master-Slave single line UART communication bus
- To communicate with the driver via UART\_TX and UART\_RX, a conversion circuit is needed
- DIM+ is internally pulled high by the 12V auxiliary supply, which regulates a 90-110uA constant current supply on the DIM+ line.
- To ensure the reliability of communication, a 36kΩ resistor is required, paralleled between DIM+ and GND.

Reference design shown below:



- For NB-IOT, GPRS, and 4G systems, a current limiting circuit to the controller is required with the current limited to 850mA.

Reference design shown below:



## II. Data and Frame Definition

- A standard UART interface is utilized
- Each byte data is consisted of 1 start bit, 8 data bits and 1 stop bit
- The Baud rate is 9600
- The Interval between data frames is a minimum of 120ms with a recommendation of over 150ms. (Including intervals between send-frame and send-frame, send-frame and receive-frame)

## III. Software Protocol Definition

- A Data frame includes head, command, offset address, data length, data, checksum, and two ends.
- Checksum = command + offset address + data length + data

### Available Commands:

- **Select Output Channel**
  - Select corresponding output channel for operation
- **Set Max Current**
  - Allows user to set output current as a percentage of the maximum current
- **Read Output Current**
  - Returns actual current in DC mA
- **Read Output Voltage**
  - Returns actual voltage in Vdc
- **Set Digital Dimming Level**
  - Set Digital Dimming brightness level, setting value between 0-200
  - Dim percentage=Setting Value/200
- **Read Digital Dimming Level**
  - Read Digital Dimming brightness level, returns value between 0-200
  - Dim percentage=Return Value/200
- **Read LED Output Power**
  - Read Active Power for Driver LED Output in Watts
- **Set Standard Power Transferring Percentage**
  - Allow power transferring from CH2/CH3/CH4 to CH1 when CH2/CH3/CH4 are off

- **Set Dynamic Power Transferring Percentage**
  - Allow to set a target output power, and the total power will be setting value
  - Allow power transferring from CH2/CH3/CH4 to CH1 when CH2/CH3/CH4 are not in full power
- **Read Total Lamp-On Time**
  - Read Total Lamp-On Time in hours.
  - Lamp on time is defined as the time that the driver has been powered and not in a dim-to-off state.
- **Read Internal Temperature**
  - Reads return value(Rtv) of driver internal NTC, see Appendix 1 for corresponding Rtv value and temperature values
- **Read Driver Operating Time**
  - Reads driver operating time, or time that the driver has been powered, without consideration to the dim level
- **Read Driver Power Failure Mode**
  - Detects short or open circuit on driver output
- **Read Model Information**
  - Returns driver model and rated power level
- **Read Current Ratio**
  - Returns the programmed output current as a percentage of the maximum output current
- **Set Driver Dimming Mode**
  - Allows user to change the driver dimming mode
- **Reset**
  - Power cycles the driver. This is required if the dimming mode is changed when the driver is connected to AC Power.

### Information Update Rate:

Without considering UART timing, the driver updates variables approximately every 150ms. If the dimming command or set max current command are used It can take up to 2 seconds for the current and voltage readings to move to their final state. If read before 2 seconds, an intermittent state will be reflected.

### Compatible Drivers:

Digital Dimming Vm1.0 is available on all EUM, ESM and NSM multiple output channel drivers ending in Mx.

## IV. Command List

Checksum = Command + Offset Address + Data Length + Data Bit

Header	Command	Offset Address	Data Length	Data	Checksum	End	End	Definition	Note	
0x3A	0x31	0x00	0x00	0x00-0x64		0x0D	0x0A	Set Maximum Current as Percentage	*	
	0x32	0x00	0x01	If right, return 0x55, if wrong, no return				Response to command 0x31		
	0x3A	0x00	0x01	0x01	0x02	0x3D			Read Output Current	*
			0x01	0x01	0x02	0x3E			Read Output Voltage	*
		0x05	0x01	0x01	0x01	0x41			Read Digital Dimming Brightness	* *
			0x06	0x01	0x02	0x43			Read LED Output Power (W)	*
		0x07	0x01	0x01	0x43			Read Digital Dimming Brightness Level of Start-up	*	
		0x10	0x01	0x03	0x4E			Read Total Lamp On-Time (h)		
		0x12	0x01	0x01	0x4E			Read Driver Internal Temperature (NTC) (°C)		
		0x14	0x01	0x03	0x52			Read Total Driver Operating Time (h)		
		0x15	0x01	0x01	0x51			Read Digital LED Power Failure Mode bit0=1: short circuit, bit1 = 1: open circuit	*	
		0xA0	0x01	0x02	0xDD			Read Setting Target Output Power		
	0xEE	0x01	0x01-0x07				Read Digital Dimming Brightness Level for Selected Output Channel			
	0xEF	0x01	0x01	0x2B			Read Selected Output Channel			

Header	Command	Offset Address	Data Length	Data	Checksum	End	End	Definition	Note
0x3A	0x3C	0x00	0x01	0x00 - 0xC8		0x0D	0x0A	Set Digital Dimming Brightness Level	*
	0x3C	0xA0	0x02	See Definition				Set target Output Power	
	0x3C	0xFF	0x01	0x01-0x08				Select Operating Output Channel 0x01: Channel 1 0x02: Channel 2 0x04: Channel 3 0x08: Channel 4	
	0x3C	0xEE	0x02, 0x03, 0x04	See Definition				Select Operating Output Channel(s) and Set Digital Dimming Brightness Level Together	
	0x3C	0x80	0x01	0x00-0xC8, 0xFF				Set Digital Dimming Brightness Level of Start-up. 0x00-0xC8: Dimming level 0xFF: Disable this function	*
	0x35	0x0B	0x01	0x05	0x46			Read Model Information	
	0x35	0x20	0x01	0x01	0x57			Read Setting Current of Channel 1	
	0x35	0x14	0x01	0x01	0x4B			Read Setting Current of Channel 2	
	0x35	0x17	0x01	0x01	0x4E			Read Setting Current of Channel 3	
	0x35	0xE8	0x01	0x01	0x22			Read Setting Current of Channel 4	
	0x35	0x1E	0x01	0x01	0x55			Read Power Transferring Percentage from Channel 2 to Channel 1	
	0x35	0x1B	0x01	0x01	0x52			Read Power Transferring Percentage from Channel 3 to Channel 1	
	0x35	0xE9	0x01	0x01	0x20			Read Power Transferring Percentage from Channel 4 to Channel 1	
	0x36		0x05					Return Corresponding Information in 0x35 above	
	0x37	0x1A	0x01	0x00,0x01				Set Power Transferring Modes: 0x00: Standard 0x01: Dynamic	
	0x37	0x34	0x01	See Definition				Set Dimming Mode	
	0x37	0x1E	0x01	0x00-0x64				Set Power Transferring Percentage from Channel 2 to Channel 1	
	0x37	0x1B	0x01	0x00-0x64				Set Power Transferring Percentage from Channel 3 to Channel 1	

	0x37	0xE9	0x01	0x00-0x64				Set Power Transferring Percentage from Channel 4 to Channel 1	
	0x38		0x01	0x55 (If successful)				Response for Command Setting in 0x37 above	
	0x39	0x00	0x01	0x00	0x3A			After Setting the Mode, The Reset must be sent to take effect	

**Notes:**

- ✧ The function commands marked with \* above operated after selecting corresponding Channel(s)
- ✧ More details and setting please refer to Command Definition part below.

## V. Command Definition

- **Command 0x31– Set Constant Power Max. Current**

Set constant power maximum current to fit for LED applications.

This data exists in the EEPROM and is not recommended for frequent use

To dim the driver, please use the 0x3C dimming command.

Example: Set constant power maximum current to 70% of current output (70=0x46)

Head	Command	Offset Address	Data Length	Data bit	Checksum	End	End
0x3A	0x31	0x00	0x01	0x46	0x78	0x0D	0x0A

- **Command 0x32 – Response of Command 0x31**

If data received successfully, reply is 0x55. If not, there is no reply.

Head	Command	Offset Address	Data Length	Data bit	Checksum	End	End
0x3A	0x32	0x00	0x01	0x55	0x88	0x0D	0x0A

- **Command 0x3C - Digital Dimming Command**

- **Set Digital Dimming Brightness Level**

Data from 0-200 corresponds to 0-100% dimming level.

To dim driver off, send command 0. If driver does not support Dim-to-Off, 0 is the minimum dimming level.

If the minimum dimming level is 10%, then all levels between 0-20 are 10%.

All values over 200 are 100% dimming level.

Example: dimming to 50% (50%\*200=100=0x64)

Head	Command	Offset Address	Data Length	Data bit	Checksum	End	End
0x3A	0x3C	0x00	0x01	0x64	0xA1	0x0D	0x0A

- **Select Operating Output Channel**

The different output channels can be controlled separately for operation and implement function commands.

0x01: Channel 1

0x02: Channel 2

0x04: Channel 3

0x08: Channel 4

Example: Select channel 2 for operation (0x02)

Head	Command	Offset Address	Data Length	Data bit	Checksum	End	End
0x3A	0x3C	0xFF	0x01	0x02	0x3E	0x0D	0x0A

- **Set Target Output Power**

In dynamic power transferring mode, the target output power can be set and the total output power will be limited to the setting value under dynamic operation

Example: Set target output power is 1000W (0x03 E8)

Head	Command	Offset Address	Data Length	Data bit	Checksum	End	End
0x3A	0x3C	0xA0	0x02	0x03 0xE8	0xA1	0x0D	0x0A

- **Select Operating Output Channel**

The different output channels can be controlled separately for operation and implement function commands.

- **Select Operating Output Channel(s) and Set Dimming Level**

This command allows to select single channel or multiple channels(s) for operation and set dimming level together

0xXX XX XX XX:

0x	Select Channel(s)	Dim for first channel	Dim for second channel	Dim for third channel	Dim for fourth channel
	01: CH1	CH1	/	/	/
	02: CH2	CH2	/	/	/
	04: CH3	CH3	/	/	/
	08: CH4	CH4	/	/	/
	03: CH1, CH2	CH1	CH2	/	/
	05: CH1, CH3	CH1	CH3	/	/
	09: CH1, CH4	CH1	CH4	/	/
	06: CH2, CH3	CH2	CH3	/	/
	10: CH2, CH4	CH2	CH4	/	/
	12: CH3, CH4	CH3	CH4	/	/
	07: CH1,CH2,CH3	CH1	CH2	CH3	/
	11: CH1,CH2,CH4	CH1	CH2	CH4	/
	13: CH1,CH3,CH4	CH1	CH2	CH4	/
	14: CH2,CH3,CH4	CH2	CH3	CH4	/
	15: CH1,CH2, CH3, CH4	CH1	CH2	CH3	CH4

Data Length Setting: Selected numbers of output channel(s) + 1

0x02: One output channel selected

0x03: Two output channels selected

0x04: Three output channels selected

0x05: Four output channels selected

Example: Select CH1 and CH3 for operation, set 50% dimming for CH1 and 80% dimming for CH3.

Head	Command	Offset Address	Data Length	Data bit	Checksum	End	End
0x3A	0x3C	0xEE	0x03	0x05 64 A0	0X36	0x0D	0x0A

- **Set Dimming Level of Start-up**

When driver starts-up and will reach to the setting dimming level by this command.

This setting also related to power transferring function, and can dim off the channel at start-up time.

Example: Set 50% dimming level when driver started-up

Head	Command	Offset Address	Data Length	Data bit	Checksum	End	End
0x3A	0x3C	0x80	0x01	0x64	0x21	0x0D	0x0A



- **Command 0x3D - Response from Digital Dimming Command 0x3C**

If data received successfully, reply is 0x55; if not, no reply.

- **Command 0x3A - Query Command**

The query command requests driver data registers pertaining to driver health and diagnostic information.

- **Read Current:**

Actual current value= Return current value (mA)

Head	Command	Offset Address	Data Length	Data bit	Checksum	End	End
0x3A	0x3A	0x00	0x01	0x02	0x3D	0x0D	0x0A

- **Read Voltage:**

Actual voltage value = Return voltage value (Vdc)

Head	Command	Offset Address	Data Length	Data bit	Checksum	End	End
0x3A	0x3A	0x01	0x01	0x02	0x3E	0x0D	0x0A

- **Read Dimming Level:**

Actual Dimming Level, 0-200

Diming Level = Dimming Percentage \* 200

Head	Command	Offset Address	Data Length	Data bit	Checksum	End	End
0x3A	0x3A	0x05	0x01	0x01	0x41	0x0D	0x0A

- **Read LED Output Power**

Actual Active Power for Driver Output, in Watts

Head	Command	Offset Address	Data Length	Data bit	Checksum	End	End
0x3A	0x3A	0x06	0x01	0x02	0x43	0x0D	0x0A

- **Read Dimming Level of Start-up**

Actual Dimming Level, 0-200

Diming Level = Dimming Percentage \* 200

Head	Command	Offset Address	Data Length	Data bit	Checksum	End	End
0x3A	0x3A	0x07	0x01	0x01	0x43	0x0D	0x0A

- **Read Total Lamp-On Time**

Actual Lamp-on Time = Return Time Value, in Hours

Head	Command	Offset Address	Data Length	Data bit	Checksum	End	End
0x3A	0x3A	0x10	0x01	0x03	0x4E	0x0D	0x0A

- **Read Internal Temperature**

Rtv value of internal driver NTC. See Appendix 1 for correlation between Rtv value and temperature values in °C.

Head	Command	Offset Address	Data Length	Data bit	Checksum	End	End
0x3A	0x3A	0x12	0x01	0x01	0x4E	0x0D	0x0A

- **Read Total Driver Operating Time**

Total driver operating time, in hours. Total driver operating time is defined as time that the driver has been energized, without regard to the status of the driver output.

Head	Command	Offset Address	Data Length	Data bit	Checksum	End	End
0x3A	0x3A	0x14	0x01	0x03	0x52	0x0D	0x0A

- **Read Failure Mode**

Reads driver failure mode.

For short circuit, reply is 0x01

For open circuit, reply is 0x02

If driver is not in failure mode, reply is 0x00

Head	Command	Offset Address	Data Length	Data bit	Checksum	End	End
0x3A	0x3A	0x15	0x01	0x01	0x51	0x0D	0x0A

- **Read Dimming Level for selected output channel**

The different channels can be set with different dimming level independently, then can use this command to read out these data.

Example: Read dimming level for CH1 and CH2.

Head	Command	Offset Address	Data Length	Data bit	Checksum	End	End
0x3A	0x3A	0xEE	0x01	0x03	0x2C	0x0D	0x0A

- **Read Selected Output Channel(s)**

Check which channels are under operation and query.

Head	Command	Offset Address	Data Length	Data bit	Checksum	End	End
0x3A	0x3A	0xEF	0x01	0x01	0x2B	0x0D	0x0A

- **Command 0x3B - Query 0x3A Command Response**

Example: Receive response from Query Current Value

Head	Command	Offset Address	Data Length	Data bit	Checksum	End	End
0x3A	0x3B	0x00	0x02	0x04, 0x12	0x53	0x0D	0x0A

The data 0x04 0x12 = 0 x0412 = 1042, is the actual current value (mA)

- **Command 0x35 - Read LED driver information**

- **Read Model Information**

Reads the information of the current model, including the rated power and the maximum rated current lomax.

Example: Read LED Driver Information

Head	Command	Offset Address	Data Length	Data bit	Checksum	End	End
0x3A	0x35	0x0B	0x01	0x05	0x46	0x0D	0x0A

Driver will return 3A36 0B 05 **82 5B E8 02 62** 9F 0D 0A

82 5B E8 Expresses ESM-1K0DxxxMx, 02 62 express Max current is 610, lomax is 6.1A.

See data format below:

**Data Format:**

Byte	Bit								Value
	7	6	5	4	3	2	1	0	
0x0B	x	x	x	x	x	x	x	x	Suffix
0x0C	x	x	x	x	x	x	x	x	Prefix
0x0D	x	x	x	x	x	x	x	x	Power Level
0x0E	x	x	x	x	x	x	x	x	Model Current
0x0F	x	x	x	x	x	x	x	x	

Data	Bit								Hex
	7	6	5	4	3	2	1	0	
Suffix (0x0B)									
xxxDxxxMx	1	0	0	0	0	0	1	0	0x82
xxxTxxxMx	1	0	0	0	0	0	0	1	0x81
Prefix									
High 5 bits of 0x0c									
EUM	0	1	0	0	1				
ESM	0	1	0	1	1				

- **Read Output Setting Current of Different Channels**

See different Offset Address definition below for different channels

0x20: Channel 1

0x14: Channel 2

0x17: Channel 3

0xE8: Channel 4

Example:

Head	Command	Offset Address	Data Length	Data bit	Checksum	End	End
0x3A	0x35	0x14	0x01	0x01	0x4B	0x0D	0x0A

LED driver returns 3A 36 14 01 **50** 4B 0D0A

0x50 expresses that the maximum current of the driver is 80% of the maximum rated current for CH2, ie  $loset = l_{max} * \% = 2.1 * 80\% = 1680mA$

- **Read Power Transferring Percentage of Different Channels**

See different Offset Address below for different definition

0x1E: Power transferring from Channel 2 to Channel 1

0x1B: Power transferring from Channel 3 to Channel 1

Example:

Head	Command	Offset Address	Data Length	Data bit	Checksum	End	End
0x3A	0x35	0x1E	0x01	0x01	0x55	0x0D	0x0A

LED driver returns 3A 36 1E 01 **50** 55 0D0A

When CH2 is off, then 80% power of CH2 transferred to CH1 and increase power capacity of CH1.

- **Command 0x37**

- **Set Dimming Mode**

This command sets the dimming mode for a Digital Dimming compatible Inventronics driver. Please note that only one dimming mode can be selected at a time. However, OLC is not considered a dimming mode, and can be used in conjunction with any other dimming mode.

The dimming mode Data Bit encoding is as follows:

Dimming Mode Data Bit			
Bit	Setting	1	0
7	OLC	Enable	Disable
6	Set to 1	1	x
5	Set to 0	x	0
4	Digital Dimming	Enable	Disable
3	0-10v/0-5v	0-5v	0-10v
2	PWM	PWM	0-10v/0-5v
1	Timer	Enable	Disable
0	Set to 1	1	x

Example: Set driver dimming mode to Digital Dimming:

Head	Command	Offset Address	Data Length	Data bit	Checksum	End	End
0x3A	0x37	0x34	0x01	0x51	0xBD	0x0D	0x0A

- **Set Power Transferring Percentage of Different Channels**

See different Offset Address below for different definition

0x1E: Power transferring from Channel 2 to Channel 1

0x1B: Power transferring from Channel 3 to Channel 1

Example:

Head	Command	Offset Address	Data Length	Data bit	Checksum	End	End
0x3A	0x37	0x1E	0x01	0x50	0xA6	0x0D	0x0A

When CH2 is off, then 80% power of CH2 transferred to CH1 and increase power capacity of CH1.

- **Command 0x38 - Response of Command 0x37**

If data received successfully, reply is 0x55. If not, there is no reply.

Example: Dimming mode set successfully.

Head	Command	Offset Address	Data Length	Data bit	Checksum	End	End
0x3A	0x38	0x34	0x01	0x55	0xC2	0x0D	0x0A

- **Command 0x39 – Reset Command**

When driver Powered on, this command must be sent after setting change in 0x37 to take setting effective.

Head	Command	Offset Address	Data Length	Data bit	Checksum	End	End
0x3A	0x39	0x00	0x01	0x00	0x3A	0x0D	0x0A

## Appendix I:

Internal OTP: Rtv value corresponds to temperature

Rtv Value	T °C	Rtv Value	T °C	Rtv Value	T °C	Rtv Value	T °C	Rtv Value	T °C	Rtv Value	T °C
00	0	1C	28	38	56	54	84	70	112	F1	-15
01	1	1D	29	39	57	55	85	71	113	F0	-16
02	2	1E	30	3A	58	56	86	72	114	EF	-17
03	3	1F	31	3B	59	57	87	73	115	EE	-18
04	4	20	32	3C	60	58	88	74	116	ED	-19
05	5	21	33	3D	61	59	89	75	117	EC	-20
06	6	22	34	3E	62	5A	90	76	118	EB	-21
07	7	23	35	3F	63	5B	91	77	119	EA	-22
08	8	24	36	40	64	5C	92	78	120	E9	-23
09	9	25	37	41	65	5D	93	79	121	E8	-24
0A	10	26	38	42	66	5E	94	7A	122	E7	-25
0B	11	27	39	43	67	5F	95	7B	123	E6	-26
0C	12	28	40	44	68	60	96	7C	124	E5	-27
0D	13	29	41	45	69	61	97	7D	125	E4	-28
0E	14	2A	42	46	70	62	98	FF	-1	E3	-29
0F	15	2B	43	47	71	63	99	FE	-2	E2	-30
10	16	2C	44	48	72	64	100	FD	-3	E1	-31
11	17	2D	45	49	73	65	101	FC	-4	E0	-32
12	18	2E	46	4A	74	66	102	FB	-5	DF	-33
13	19	2F	47	4B	75	67	103	FA	-6	DE	-34
14	20	30	48	4C	76	68	104	F9	-7	DD	-35
15	21	31	49	4D	77	69	105	F8	-8	DC	-36
16	22	32	50	4E	78	6A	106	F7	-9	DB	-37
17	23	33	51	4F	79	6B	107	F6	-10	DA	-38
18	24	34	52	50	80	6C	108	F5	-11	D9	-39
19	25	35	53	51	81	6D	109	F4	-12	D8	-40
1A	26	36	54	52	82	6E	110	F3	-13		
1B	27	37	55	53	83	6F	111	F2	-14		

## Revision History

Change Date	Rev.	Description of Change		
		Item	From	To
2024-05-06	A	Document Release	/	/
2024-12-03	B	Commands for Four Output Channels	/	Added
		Commands for Dynamic Power Transfer		Added

## Disclaimer

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