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2017-03-15

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Documentation

Issue 2.5.0

Topic MT protocol LRF command set

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Topic **MT protocol LRF command set**

Description Documentation of the LRF platform command set based on MT connectivity protocol

MT connectivity protocol
Laser Range Finder (LRF) part

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1 Introduction

1.1 General notes

For basic MT connectivity protocol information refer to MT_connectivity_protocol.doc.

The GLM80 and SPAD (PLR15, GLM30, ...) platform uses frames of type “LONG” and “SHORT”.

For “Connect”-LRFs, like GLM100C, RS232 single wire (RTxPin), USB virtual serial interface and Bluetooth connections can be established.

The access level for a Bluetooth and USB connection is generally limited to level 1.

1.2 Synchronization concept for “Connect”-LRFs

The synchronize command is used to synchronize the LRF with a host device like a smartphone, tablet or PC. This command handles all simple (single distance), complex (area, wall area, volume), indirect and continuous measurements.

While a BT connection is established, the synchronization command can be used to set the LRF into AutoSync-mode. In this mode, the LRF sends out each event, e.g. laser on, change of reference or mode. In GetSync mode, the synchronization command can be used periodically to get the current status of the device.

Unlike the master behaviour described in MT_connectivity_protocol.doc, the LRF in AutoSync mode does not expect any response from the host. Therefore, no response should be sent in this case. The LRF also does not repeat any requests.

In case of a “bus conflict” (collision of request from both parties, i.e. typically the host receives a request instead of a response), the host has to manage this conflict by switching to slave mode and processing the incoming request from the LRF. Be aware that the LRF then removes all pending requests. If applicable, the host should send its request again.

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2 Command set

Note: “X“= available/implemented

For SPAD-Platform:
- X: All devices
- A: PLR30C/50C, GLM50C
  - A1: PLR30C
  - A2: PLR50C
  - A3: GLM50C

For GLM80-Platform:
- X: All devices
- B: GLM100C

For GLMCam-Platform:
- X: All devices

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Command	Access level	Description	Request data bytes (LSB first)	Response data bytes (LSB first)	GLM80	SPAD	GLMCam	
		Basic functionality						
64	0	Single/continuous distance measurement	*uint8_t* Parameter Bit[7..6] Reference: 0: Front 1: Tripod 2: Rear 3: Pin Bit[4..3] Measurement rate for fixed measurement time [2)]: 0: 5 Hz 1: 10 Hz 2: 20 Hz 3: 30 Hz	*uint32_t* Distance [50 µm] Note: In case of a measurement error, distance is set to 0.	X	X	X	

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			Bit[2] Measurement time [1]: 0: Automatically adjusted depending on target conditions 1: Fixed Bit[1..0] Measurement mode: 0: Single measurement 1: Continuous measurement 2: Stop continuous measurement Note: For continuous measurements, it is highly recommended to call “Stop continuous measurement” once every 5..10 minutes to adjust working point settings [1] Available for SPAD platform only [2] Available for OEM module only					
65	0	Laser on (pointer mode)	-	-	X	X	X	
66	0	Laser off	-	-	X	X	X	
67	0	VCSEL on	-	-	-	-	-	
68	0	VCSEL off	-	-	-	-	-	

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69	0	Buzzer on	-	-	X	X	X	
70	0	Buzzer off	-	-	X	X	X	
71	0	LCD backlight on	-	-	X	X	X	
72	0	LCD backlight off	-	-	X	X	X	
73	0	Keypad backlight on	-	-	-	-	-	
74	0	Keypad backlight off	-	-	-	-	-	
75	0	Get battery pack SOC	-	*uint8_t* State of charge [%]	X	-	X	
76	0	Check the laser enable pin GLM80 platform: LSRON SPAD platform: LASEROFF	-	*uint8_t* Status 0: Laser is off 1: Laser is enabled	-	X	X	
77	0	Get laser class	-	*uint8_t* Laser class 1: Laser class 1 2: Laser class 2	-	X	-	
78	0	Select laser class Note/usage: Due to laser safety, changing the laser class is a 2 step process: 1) Select desired laser class with command 78. The active laser class is not changed.	*uint8_t* Laser class 1: Laser class 1 2: Laser class 2	-	-	X	-	

		2) Activate the desired laser class with command 79. The parameters of command 78 and 79 must match, otherwise the laser class is not changed and a hardware error is set.						
79	0	Activate laser class	*uint8_t* Laser class 1: Laser class 1 2: Laser class 2	-	-	X	-	
80	0	Synchronize App and LRF Details see section 4.2.2	***a) LRF as slave*** *uint16_t* Parameter Bit[14] Device config Bit[13..11] Angle reference Bit[10..8] Distance reference Bit[6] Auto sync Bit[7+5] Signaling Bit[4..0] Mode ***b) LRF as master*** *size Sync_Container_t* Data	***a) LRF as slave*** *size Sync_Container_t* Data ***b) LRF as master*** no response!	X	-	-	
81	0	Get a range of measurement list entries	*uint8_t* Desired start index *uint8_t* Desired stop index	*uint8_t* Start index *uint8_t* Stop index *n * Sync_Container_t* Data	B	-	-	

		If the list contains less than the requested entries, the behavior is as follows: a) If the requested range is partly within the existing range, the existing entries are sent. b) If the requested range is completely out of the existing range, the last existing entry will be sent (with start index = stop index). Example: Desired start index = desired stop index = 255 returns the last entry Note: Index 0 is the constant. To find out how many entries can be transmitted at one time, use MT command 0 (get communication info, max payload size Tx) and divide by the size of the sync container. Details see section 4.2.3		(n = stop index - start index + 1) * sync container Details see section 4.2.2	-	A3	X	

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		New: Use cmd 85 remote control 58= GetMeasListEntryByIndex returning ExchangeDataContainer						
82	0	Clear a range of measurement list entries Note: Index 0 is the constant	*uint8_t* Start index *uint8_t* Stop index	-	X	X	X	
83	0	Get user settings	-	*size User_Settings_t* (platform dependent) Data Details see section 3.1	X	-	-	
84	0	Set user settings Notes: To avoid unintended changes of user settings, always read the user settings before writing them! After changing laser pointer enable or unit, it is recommended to read and compare these settings (laser pointer enable will be declined if battery is low, units can be changed only if LRF supports imperial units).	*size User_Settings_t* (platform dependent) Data Details see section 3.1	-	X	-	-	

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85	0	Exchange data container More details see section 4.2.4	***a) LRF as slave (= Request by App) or "remote control mode"*** *uint8_t* DevModeSync Bit[7..2] DevMode (= RemoteCtrlCmd) Bit[1] Enable Keypad bypass Bit[0] Enable Auto sync (LRF sends events) *uint8_t* RemoteCtrlData → if unused to be set to 0 ***b) LRF as master (= Event by LRF)*** *ExchangeDataContainer_t* "Enable Auto sync" bit must have been set before by using a)	***a) LRF as slave (Request by App)*** *ExchangeDataContainer_t* ***b) LRF as master (Event by LRF)*** no response!	-	A	X	
86	0	Do Remote Trigger Button "Enable Auto sync" bit must have been set! More details see section 4.2.5	*uint8_t* ButtonNumber	- (requested information indirectly responded as Master request event from LRF→App as soon as available)	-	A3	X	
115	0	Get measurement info	-	*float* SNR *float* SNR* [sqrt(Hz)] *float* VHV [V] *float* DAC: Laser DAC value (12 bit)	-	X	X	

				float Temperature [°C] Note: SNR, SNR* and VHV refer to the latest distance measurement, whereas DAC and Temperature are always new values				
		9 DOF sensor						
176	0	FusionLib control	*uint8_t* Parameter Bit[7] Data acquisition 0: Latest data 1: Data from last dist. measurement	*uint8_t* Sensor status Bit[7..6] Orientation status Bit[5..4] GYRO status Bit[3..2] MAG status Bit[1..0] ACC status Where: 0: Unreliable 1: Accuracy low 2: Accuracy medium 3: Accuracy high	-	-	-	
177	0	Get orientation data	*uint8_t* Parameter Bit[7] Data acquisition 0: Latest data	*4 * float* Data Euler h, p, r, y [°] or Quaternion w, x, y, z [?]	B	-	-	

			1: Data from last dist. measurement Bit[0] Data type 0: Euler 1: Quaternion	*uint8_t* Sensor status (see command 176)				

3 Platform dependent structures

3.1 User settings

GLM80 platform:

Struct User_Settings_t
{
uint8_t Spirit level enable
uint8_t Display rotation enable
uint8_t Speaker enable
uint8_t Laser pointer enable (continuous laser)
uint8_t Backlight mode
uint8_t Angle unit
uint8_t Unit
uint8_t Device configuration (variant, features)
uint8_t MeasListLastUsedIndex
*2 * uint8_t* Reserved
}

Structure below is valid for response of Command 83 (GetSettings) and request of Command 84 (SetSettings).

Byte (as uint8_t)	**Description**
Spirit level enable	0: disabled 1: enabled
Display rotation enable	0: disabled 1: enabled
Speaker enable	0: disabled 1: enabled
Laser point enable (contin. Laser)	0: disabled 1: enabled
Backlight mode	0: auto 1: enabled 2: disabled
Angle unit	16: Degree

	17: Percent 18: Millimeter per Meter 19: Inch per Foot
Distance unit	2: Meter (m) 3: Centimeter (cm) 4: Millimeter (mm) 5: Yard (yd) 6: Foot (ft) 7: Feet Inch Fract 8: Inch (in) 9: Inch Fract
Device configuration	?
MeasListNumberOfEntries	*If measurement list is implemented only:* <number of entries in the measurement list>; index 0 is the constant, entries start at 1. If the device supports no constant, then measurement list starts at index 1.
Reserved	Always set to 0
Reserved	Always set to 0

4 Additional command description

4.1 MT part

4.2 LRF part

4.2.1 Command 64: Single/continuous distance measurement

This command is a standalone command, i.e. it includes everything that is necessary for a distance measurement, like laser on and off.
In continuous measurement mode, new measurements values have to be polled, too. In contrast to the single measurement mode, laser and ASIC are kept operating to speed up measurement execution. In this case, and for GLM80 platform, the reference measurement (flap) is automatically inserted from time to time.

4.2.2 Command 80: Synchronize App and LRF

Sync container structure:

Type	**Description**
uint16_t	Parameter, see below
uint8_t	State of charge (SOC) [%]
int8_t	Temperature [°C]
*4 * float*	Value 1..4 (Measurement values/results)
float	Current angle (spirit level) [°]
uint32_t	Timestamp [seconds since 1970-01-01 0:00:00]
uint8_t	Bit[7..1] Device state/usability errors 0: OK 1: Temperature warning 2: Battery empty warning 3: Connection error 4: Measurement or calculation error 6: Calibration error Bit[0] Laser status 0: Off 1: On
uint8_t	Measurement list index
uint16_t	Compass heading [°]
uint8_t	NDOF sensor status

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The size of the sync container is 33 bytes.
Unused values are set to 0.
In case of a measurement error, distance could be set to 0.

Parameter for LRF as slave and first 2 bytes of sync container:

Bit [14]	**Device config**
0	Metric
1	Imperial

Bit [13..11]	**Angle reference**
0	Back
1	Side
2	Rail

Bit [10..8]	**Distance reference**
0	Front
1	Tripod
2	Rear
3	Pin

Direction App -> LRF

Bit [6]	**AutoSync**
0	Off
1	On LRF continuously sends changes. This bit must be set.

Bit [7+5]	**Signaling**
0, 0	Stop -> Laser on
0, 1	Start -> One shot mode
1, 0	Switch mode -> Laser off, mode init

Direction LRF -> App

Bit [7..5]	**Calculation indicator**
0	Ignore
1	+
2	-
3	+=
4	-=

Bit [4..0]	Mode
1	Single distance
2	Area
3	Volume
4	Angle
5	Rail
6	Min/Max (continuous) distance
7	Indirect height
8	Indirect length
9	Double indirect height
10	Wall area
Direction App -> LRF only	
0	GetSync (read status)
Direction LRF -> App only	
11	Setup
12	Calibration
13	Measurement list

4.2.3 Command 81: Get a range of measurement list entries

Example:

Index	Measurement type	Angle Ref		Dist Ref		Value 1	Value 2	Value 3	Value 4
0	Constant	0	-	2	Rear	2.239m	0.000	0.000	0.000
1	Length	0	-	2	Rear	18.585m	0.000	0.000	0.000
2	Area	0	-	0	-	9.378m^2	2.239m	4.187m	0.000
3	Wall area	0	-	0	-	19.658m^2	2.716m	4.132m	7.237m
4	Volume	0	-	0	-	44.654m^3	2.266m	4.603m	4.279m
5	Indirect height	0	-	1	Tripod	2.621m	6.255m	24.8°	0.000
6	Indirect length	0	-	0	Front	6.095m	6.723m	25.0°	0.000
7	Double indirect height	0	-	0	-	4.572m	5.458m	2.570m	56.5°

8	Angle	0	Back	0	-	13.5°	0.000	0.000	0.000
9	Angle	1	Side	0	-	25.3°	0.000	0.000	0.000
10	Min/Max	0	-	2	Rear	0.763m	0.811m	0.584m	0.000
11	Operation +	0	-	2	Rear	3.926m	0.846m	3.079m	0.000
12	Operation -	0	-	2	Rear	3.727m	4.472m	0.745m	0.000

4.2.4 Command 85: Exchange data container

This command is in principle very similar to command 80. The intention is to minimize data transfer as well as to reduce the complete data load including protocol bytes to max 20 bytes for fitting into a single Bluetooth LE packet.
Additionally an extended remote control functionality is provided with this command.

Hint: For the general command overview see the above table “Command set” command 85!
Pay attention for 2 different situations: a) “LRF as slave” and b) “LRF as master”.
For full RemoteCtrl functionality “Enable Auto Sync” bit must be set!

4.2.4.1 DevModeSync byte interpretation

Bit [7..2]	**DevMode**	Comment
	See table **DevMode** below	

Bit [1]	**Enable Keypad bypass**	Comment
0	Disable	
1	Enable keypad to pass every key event to App and no more device HMI control possible	If the App only wants to set this bit the DevMode has to be set to 0 <NoAction>

Bit [0]	**Enable Auto sync (LRF sends events)**	Comment
0	Disable	
1	Enable	

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4.2.4.2 DevMode bit field

DevMode bit field is used for requests, events and responses and their data interpretation.

RemoteCtrlCmd*1 (App→LRF) DevMode (LRF→App) Bit[7..2]	**App → LRF *1**	**LRF → App**	**Result**	**Component1**	**Component2**
0 <NoAction>	X	X	0.0	0.0	0.0
1 SingleDistance	-	X	Length [m]	0.0	0.0
2 ContinDistance	-	X	Current Length [m]	Length min [m]	Length max [m]
3 Area part 1	-	X	0.0	Length 1 [m]	0.0
4 Area final	-	X	Area [m²]	Length 1 [m]	Length 2 [m]
5 Volume part 1	-	X	0.0	Length 1 [m]	0.0
6 Volume part 2	-	X	0.0	Length 2 [m]	0.0
7 Volume final	-	X	Volume [m³]	Length 3 [m]	0.0
8 SingleAngle	-	X	Angle [°]	0.0	0.0
9 ContinAngle	-	X	Angle [°]	? Angle min [°]	? Angle max [°]
10 IndirectHeight	-	X	Height [m]	Length [m]	Angle [°]
11 IndirectLength	-	X	Length [m]	Height [m]	Angle [°]
12 DoubleIndirectHeight part 1	-	X	0.0	Height 1 [m]	Angle 1 [°]
13 DoubleIndirectHeight final	-	X	Height [m]	Height 2 [m]	Angle total [°]
14 WallArea part 1	-	X	0.0	Height [m]	0.0
15 WallArea consecutive	-	X	Area [m²]	Curr. Length [m]	Sum. Length [m]
16 CalculatedDistancePlus	-	X	Length [m]	Length 1 [m]	Length 2 [m]
17 CalculatedDistanceMinus	-	X	Length [m]	Length 1 [m]	Length 2 [m]
18 CalculatedAreaPlus	-	X	Area [m²]	Area 1 [m²]	Area 2 [m²]
19 CalculatedAreaMinus	-	X	Area [m²]	Area 1 [m²]	Area 2 [m²]
20 CalculatedVolumePlus	-	X	Volume [m³]	Volume 1 [m³]	Volume 2 [m³]
21 CalculatedVolumeMinus	-	X	Volume [m³]	Volume 1 [m³]	Volume 2 [m³]
22 Single Level	-	X	Level Roll [°]	Level Pitch [°]	0.0
23 Contin Level	-	X	Level Roll [°]	Level Pitch [°]	0.0
...					
58 GetMeasListEntryByIndex*2	X	-	-	-	-

59 TemperatureAndSOC	-	X	SOC [%]	Temperature[°C]	<reserved>
60 SetDevAppMode	X	-	-	-	-
60 SetDevAppMode	-	X	Device Mode*3	<reserved>	<reserved>
61 SetAngleReference	X	X	-	-	-
62 SetDistanceReference	X	X	-	-	-
63 ErrorMessage	-	X	ErrorNumber See 4.2.4.5	0	0

*1In remote control mode (=LRF as slave / Request by App) DevMode = RemoteCtrlCmd, rows DevStatus, Result and Components to be ignored. RemoteCtrlData see table below
Whenever an error occurs the device responds or sends as event an Exchange data container command using DevMode = 63 (Error Message).
To trigger a measurement the command 86 (remote trigger button) should be executed using ButtonNumber EN_BUTTON_MEASURE.
*2For implementations with invalid index 0 (constant CST not existing) MT protocol parameter error is responded.
*3Device mode as described in table. Write the integer value directly in the float (e.g. 1.0f for devMode = “1 single distance”). Valid values are 1, 2, 4, 7, 8, 9, 10, 11, 13, 15, 23, 24.

4.2.4.3 RemoteCtrlData byte interpretation

As long as this byte is unused it has to be transmitted as 0x00 for compatibility reasons.

RemoteCtrlCmd (=DevMode request)	**RemoteCtrlData value & description**
58 GetMeasListEntryByIndex	Bit[7..6] request measurement part value, default = 0 = final *1 Bit[5..0] desired index; Hint: index 0 is the constant
60 SetDevAppMode	Use above table’s DevMode (final) to set LRF mode, see 4.2.4.2, e.g. “1 SingleDistance “ / “7 Volume final” to change only to SingleDistance/Volume mode Valid values are: 1, 2, 4, 7, 8, 10, 11, 13, 15, 23, 24 Sending 0 (“no action”) will get the current DevMode. Device will response with exchange data container with device mode “60” and the currently set device mode in field Result.
61 SetAngleReference	0: back 1: side

	2: rail
62 SetDistanceReference	0: front 1: tripod 2: rear 3: pin
All other values of RemoteCtrlCmd	Set to 0

*1In case a measurement consists of multiple single measurements (e.g. Volume consisting of part 1, part 2, final) by default the final measurement ExchangeDataContainer is sent. If desired the App can also request the missing parts by setting Bit[7..6] as 1, 2, ... re-using the same index.

4.2.4.4 ExchangeDataContainer_t structure interpretation

Exchange data event/response container structure = **ExchangeDataContainer_t** (send by LRF):

Type	Byte No	Name	Description
uint8_t	0	DevModeRef	Bit[7..2] DevMode Bit[1..0] Reference Edge Angle: 0=back, 1=side, 2=rail; Distance: 0=front, 1=tripod, 2=rear, 3=pin
uint8_t	1	DevStatus	Bit[7..4] Reserved Bit[3] Config units (0: metric; 1: imperial) Bit[2] Battery Low warning*2 Bit[1] Temperature warning*2 (<Min/Low or >Max/High) Bit[0] Laser status (0: Off; 1: On)
uint16_t	2	UniqueID*3	one ID per complete measurement
float_t	4..7	Result	e.g. Indirect L/H (m) or or Act.L (m) or V (m³)
float_t	8..11	Component1	e.g. Distance (m) or Min.L (m) or l3 (m)
float_t	12..15	Component2	e.g. Angle (°) or Max.L (m)

*2 As long as a device warning is present the corresponding bits are always set in each ExchangeDataContainer. If 'auto sync' is enabled in the device and a warning occurs, an event using DevMode=0 (NoAction) is sent one-time from LRF to the App.
*3 A new UniqueID is defined by each new measurement (e.g. Volume part 1; Volume part 2 is the same UniqueID). For the next measurement the UniqueID is increased (+1) even if the former measurement was not finished. Restarting the device also restarts the UniqueID (it is not stored in MeasList).

4.2.4.5 ErrorNumber (63) interpretation

The ErrorNumber is a 4 byte integer value.

```
enum
{
  EN_ERROR_UNDEFINED = 0, // used for earlier product without clear definitions
  EN_ERROR_SINGLE_DISTANCE_MEASUREMENT = 1, // General Laser Measurement
                                            Error, normally indicated by „Error“ in the device
  EN_ERROR_ANGLE_CALIBRATION = 2,
  ...
};
```

4.2.5 Command 86: Do Remote Trigger Button

Assuming that the Device and App mode are synced, a remote (measure) button starts respectively triggers a measurement on the device. The resulting information is transferred in a following Master-request (event) command 85 from LRF to App, optionally with 'long' delay where applicable. The "Enable auto sync" bit has to be set to 1, otherwise events can't be sent!

```
enum
{
  EN_BUTTON_MEASURE = 0,
  ...
}
```

5 Functionality guide

5.1 Smartphone App synchronization and remote control

While setting up the (Bluetooth) connection the “Enable auto sync” bit (using e.g. cmd 85 with DevMode 0 = NoAction) has to be set to allow master request events from LRF to App.
As a result all HMI changes are signalized from LRF to app and vice versa.
Do remote trigger button – using command 86 with ButtonNumber EN_BUTTON_MEASURE – in the currently selected device mode allows even a mixed control on LRF and App. The result data are transferred from LRF to App – using command 85 – as a master request event initiated from LRF. For example in single distance mode the first button switches on the laser and the second executes the measurement, both events transferred to the App.

5.2 Measurement list handling

For SPAD platforms using ExchangeDataContainer commands.
Command 83 “Get user settings” delivers MeasListLastUsedIndex.
The complete MeasList needs to be received stepwise index by index using command 85 “Exchange data container” with RemoteCtrlCmd 58 “GetMeasListEntryByIndex”. Potential details of each measurement (e.g. Volume part 1) can be requested using “request measurement part value” different to 0.

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6 Frequently used command examples

The following command examples can be used directly in a terminal application.

Description	SPP Pro	Mode	Cmd	Data length	Data bytes	Chksum
Set buzzer on	BuzzerOn	0xC0	0x45	00	-	0xD0
Set buzzer off	BuzzerOff	0xC0	0x46	00	-	0x58
Get communication info		0xC0	0	00	-	0xFC
Get device name	GetDevName	0xC0	05	00	-	0xC2
Get device info		0xC0	6	00	-	0x4A
Single distance meas. (Front edge)		0xC0	64	01	0	0xFA
Laser on	LaserOn	0xC0	65 = 0x41	00	-	0x96
Laser off	LaserOff	0xC0	66 = 0x42	00	-	0x1E
Get battery pack SOC		0xC0	75	00	-	0xEA
Get HW error code		0xC0	13	00	-	0x4E
Set AutoSyncEnable	PLRAsyncEna	0xC0	0x55	02	01 00	0x1A
Set AutoSyncDisable	PLRAsyncDisa	0xC0	0x55	02	00 00	0x62
Set GIS AutoSyncEnable	GISAsyncEna	0xC0	0x5E	02	01 00	0x5C
	Echo 2 by	0xC0	0x3E	02	0x 77 88	0xFE
	Echo 29 by	0xC0	0x3E	0x1D	0x 54 65 73 74 44 61 74 61 42 79 74 65 73 3E 32 30 76 69 61 53 50 50 6F 76 65 72 42 4C 45	0xD6