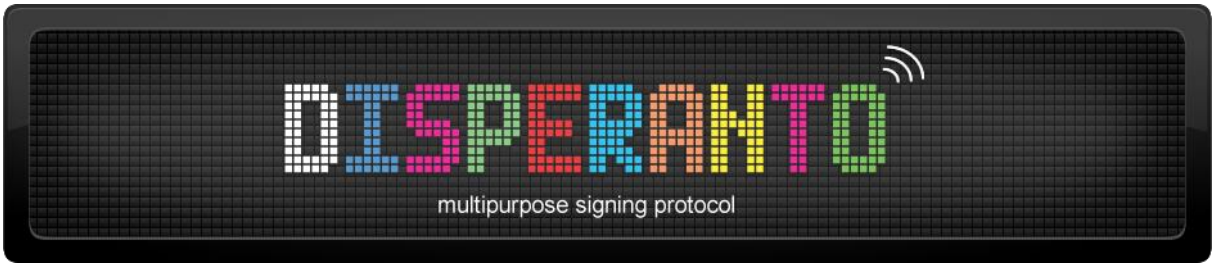

Disperanto

Traffic Display Protocol

October 9, 2024
Document version 3.0.0

DOCUMENT INFORMATION

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Version	Date	Author	Comment
0.1			<not translated>
0.2	2012-03-07	SSN	First English version
0.3	2012-04-13	SSN	Added: • message number • diagnostics message • CRC + example
0.4	2012-07-02	SSN	Clarified some commands and encoding
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2.1	2019-03-14	JOA	Added support for non-matrix text display
3.0.0	2024-10-09	JOA	Replaced CRC code example with faster version

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Identification

This document describes Disperanto (Traffic Display Protocol). This is the interface that controls displays showing route and parking information. Servers use this protocol to send the information to the displays.

1.2 System overview

Disperanto was designed to control traffic displays. It is an application protocol that is used in addition to existing network protocols. The protocol is designed to be applicable to a variety of traffic displays, such as full matrix displays, simple number displays and even rotation panels.

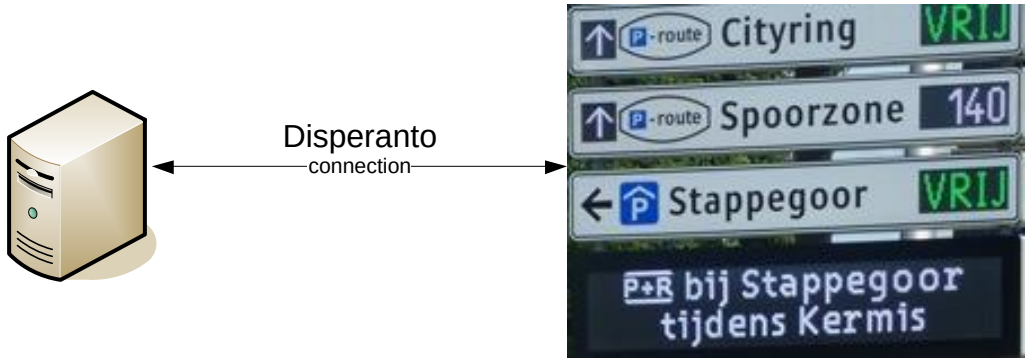

Figure 1: Disperanto is the protocol that connects servers and displays

The protocol is suited for both simple as well as high-resolution multicolor displays. It is efficient, flexible and scalable and can be used on various data connections. It has been optimized for mobile communication networks.

1.3 Document overview

1.3.1 Purpose of the document

The purpose of this document is to describe the protocol in sufficient detail to allow suppliers of traffic displays and of traffic management systems to implement it in software. Displays and management systems of independent suppliers should be interoperable.

1.3.2 Structure of the document

Chapter 2 gives a general description of the protocol and its functionality. Chapter 3 describes the communication layer. Chapter 4 describes the messages that are exchanged between the display controller and the management system.

2. INTRODUCTION DISPERANTO

Disperanto has the following capabilities:

- suitable for various displays: graphical, VVX(G), arrow and rotation panels;
- able to show fixed as well as loadable images;
- efficient transfer of full color images in low and high resolution;
- reliable communication with feedback from display;
- extended status messages from display to server;
- extended properties and capability messages from display to server;
- flexible in use because, as displays only have to support the functions specified in their capabilities;
- efficient communication by mobile infrastructure due to low overhead;
- can be used with communication over TCP/IP, UDP/IP and/or serial lines.

2.1 Data connection

The protocol is designed to be independent of any specific data connection. The carrying data connection can be connection-oriented or not. The connection can be stream- or packet-oriented. The protocol exchanges packets of data with a header and CRC. It is optimized for use on a mobile communication network.

The management system initiates the data connection to the display controller. The display controller will not initiate a connection and does not need to know how to connect to the management system.

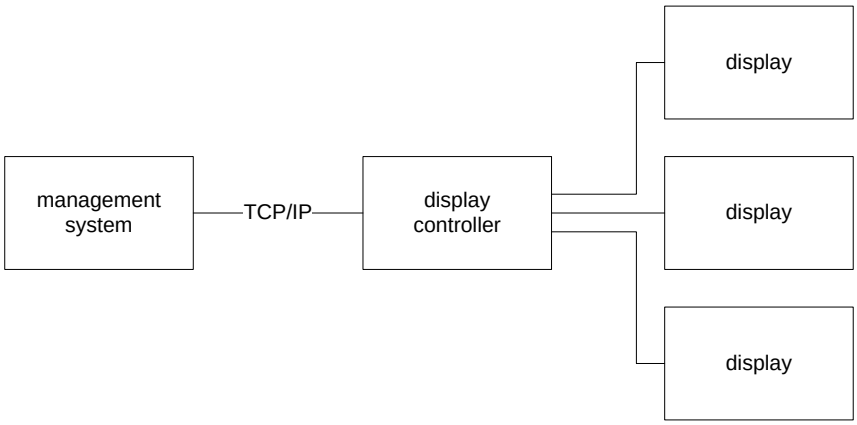

Figure 2: Example of a setup in which a display controller controls several displays.

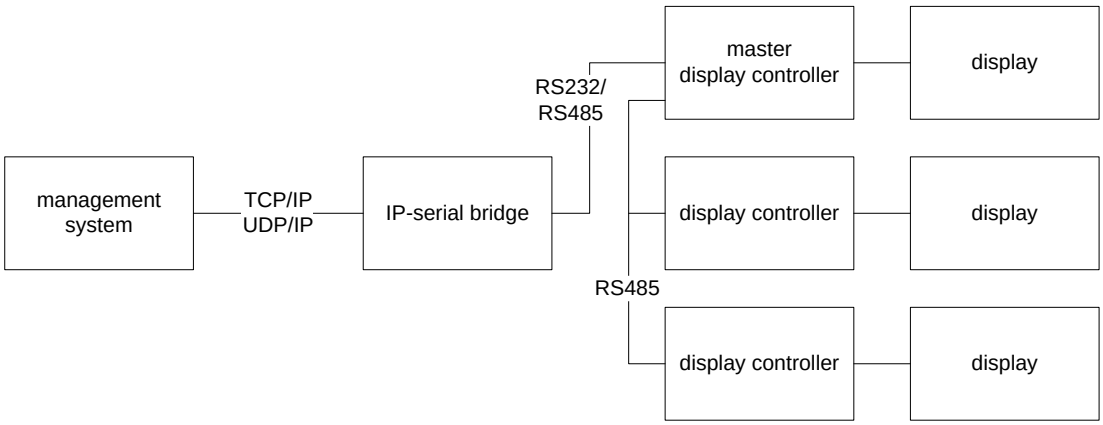

Figure 3: Data connection in which a master controller with serial interface controls a group of displays.

2.2 Graphical functions

The protocol is designed to control matrix displays. The images are supplied by the management system as raster images. The protocol doesn't have specific drawing commands for lines or texts.

2.2.1 Image memory

The display has memory slots for images that can be shown. Images can be created in working memory and stored in a writeable memory slot. Images can be composed from uploaded images and from images from memory slots. Memory slots can be used to store small images, such as symbols, that are only used for the composition of larger images.

An image in a memory slot can be smaller than the resolution of the display. If this kind of image is displayed, it is shown in the top left position, with a black area at the right and/or the bottom.

The protocol defines the following operations on working memory:

- initialize memory with a black image of the specified size;
- upload an image to a specified position in memory;
- clear a rectangle in the image;
- copy an image from a memory slot to a specified position in memory;
- store the image from working memory in a specified slot.

Black pixels of an uploaded or copied image are treated as fully transparent when they are added to working memory.

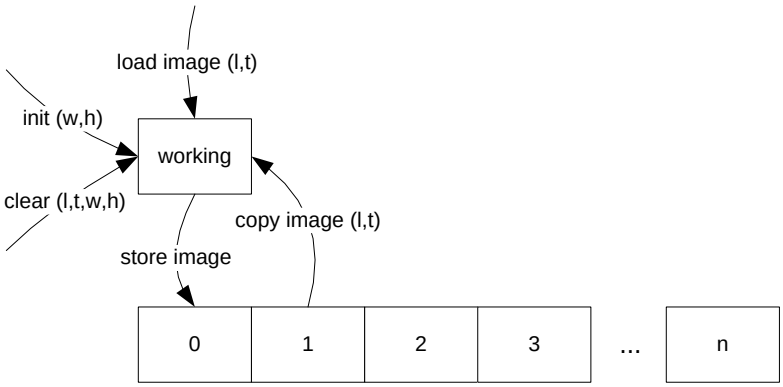

Figure 4: Operations on the image in working memory

2.2.2 Checking of images in memory slots

The protocol can be used to request the CRC of one or more images in memory slots. The CRC can be used to check that the memory slot contains the expected image.

The CRC of an image is computed using a left-to-right, top-to-bottom scan of all pixels. The R, G and B byte values of every pixel is taken and added to the CRC calculation. If a display uses indexed colors then the corresponding RGB value of the pixels should be used for the CRC computation.
See section 3.1.8 for the specification of the CRC.

In case of a fixed image, 0 must be used as a CRC.

2.2.3 Showing an image

The display shows images from the memory slots. The protocol allows showing:

- no image;
- a single image;
- (optional) a slide show of images, where the time between image changes can be specified per image.

Note: there are no slide show transition effects.

2.2.4 Image formats

Images can be uploaded with various formats. The protocol uses the following formats:

- PNG

2.2.5 Color model

The display controller should indicate whether it uses a fixed palette of colors or an RGB color model. If the display uses a fixed palette, then the management system should only send indexed images using these particular colors. However, the management system can use different indexes, e.g. to send a monochrome image using only one of the colors of the palette. If a display uses an RGB color model,

then the management system can send RGB color images as well as indexed color images.

2.2.6 Brightness table

A brightness table can be uploaded to the display. The table contains the brightness of the display for the measured light intensity. For every step of 10% in measured intensity the corresponding brightness is given as a percentage of the maximum brightness. The display can interpolate the table for intermediate values.

2.3 Support functions

The protocol contains some support functions. Thus it is possible to request the capabilities and status of the display. The display can also send notifications.

2.3.1 Notifications

The display can send notifications for:

- warm/cold start;
- communication timeout;
- display defect non critical (only a few pixels);
- display defect;
- software defect;
- hardware defect;
- intrusion or vandalism;
- lighting defect;
- heating / cooling defect;
- temperature low;
- temperature high;
- luminance measurement defect;
- communication error;

Some notification, such as cold/warm start and intrusion, will stay active until the management system clears them with a command.

2.3.2 Status request

When requested, the display controller should send the status of the display containing:

- currently shown image (slot + CRC);
- brightness display;
- measured light intensity;
- (optional) GPS position;
- temperature;
- heating/cooling active.

2.3.3 Discovery

The management system can request the properties of the display. The system can use the properties to correctly control the display. A complete overview of the properties of a display can be found at the specification of the command in chapter 4.

2.3.4 Display reboot

The display can be rebooted with a command. After a requested reboot or after a power cycle the display controller should notify the management system of the reboot. This notification should be sent when the first message is received from the management system.

A distinction is made between cold and warm reboot. A warm reboot implies that all settings have been maintained in memory. The currently visible image is undefined and must be set by the management system.

A cold reboot implies that all settings may have been lost. The management system should upload all settings. The management system can check the CRC's of the image slots to verify whether they need to be uploaded again.

2.3.5 Communication timeout

The display can be configured to show a predefined image when it has not received any messages for a longer period. This period is configurable and can be disabled. To prevent expiration of the communication timeout the management system can send keep-alive messages.

2.4 Supplier specific service mode

The display controller (optionally) can be switched to a supplier specific service mode. This service mode can be used to update software and diagnose and configure the display. The protocol has a command to switch to the service mode. The command should be sent to all displays on one data connection at the same time. After this command, a supplier-specific protocol will be used and Disperanto no longer applies. The display will return to Disperanto after a reboot.

The supplier service application will give the command to switch to service mode. The management system should release the data connection in favor of the service application. As soon as the service application has rebooted the display, the management system can reconnect again.

2.5 Application of the protocol

2.5.1 Text rendering on matrix display

The management system renders all texts using the correct font. The display does not contain a font and the protocol cannot upload texts.

The management system will create a raster image and upload the complete raster image or those parts that have changed. The management system can also upload single symbols and text fragments to memory slots to compose images without uploading full raster images every time.

2.5.2 VVX(G)-functionality on matrix display

A matrix display can be efficiently used as a VVX(G) display (full, free, closed, and number). The V, V and X images are stored in a memory slot. The digits 0 to 9 are stored as small images in other slots. A number is created by composing a new image from those small images.

2.5.3 Non-matrix displays

Non-matrix displays, such as panels with fixed images for arrows, VVX, rotation panels or text displays, can also be controlled with the protocol.

The arrow- and VVX-displays show fixed images in unmodifiable slots. These images are addressed with the same commands as images in writable slots. A special case are VVXG displays that are capable of showing numbers. The numbers correspond to slots 0 to 9999. Slots 10000 till 10002 are used for V, V and X. Slot 10003 is used to indicate an error (for example when free spaces could not be determined).

For the text displays a ASCII text can be send and will be rendered by the display.

2.6 Remarks

The protocol does not explicitly support the detection of displays on the data connection.
Note: this can be done implicitly by probing all display addresses on a connection.

The protocol does not offer authentication or data encryption support. It is assumed that the network is secure.

3. COMMUNICATION LAYER

The protocol consists of two parts, a communication layer and messages. This chapter describes the communication layer. The communication layer defines how messages are exchanged.

3.1 Messages

There are three types of messages: commands, responses and notifications. A command is a message from the management system to the display controller. The controller replies with a response message. There should be a response for every command. If the controller cannot reply to the message due to a failure, it should send a notification. A notification is a message from the display without corresponding command. The display should send notifications for failures and important status changes.

3.1.1 Message numbers

Messages sent by the management system have a cyclic message number. The responses from the display controller have the message number of the corresponding command message. In this way the management system can match requests and responses. The message numbers are cyclic from 1 to 255. Number 0 is used for notifications.

3.1.2 Addressing

Several displays can be connected to a single data connection. Every display has an address. An address consists of a number from 1 to 255.

Messages from the management system to the display contain one or more addresses. The display controller should send a single response for every address in the command message.

Messages from the display controller to the management system contain exactly one address, the address of the originating display. Address 0 is reserved for notifications coming from a master controller that controls several displays.

3.1.3 Grouping messages in a packet

Messages to and from the display controller are grouped in packets. A packet is a sequence of message of which the last message bears the indication ‘last message’.

The display controller should process all messages of a packet and send one packet in return with all responses and notifications.

Example 1: Command and response

Commands to controller:

cmd A for display 1 and 2
cmd B for display 1
cmd C for display 2; last message

Response from controller:

response A of display 1
response A of display 2
response B of display 1
response C of display 2; last message

Example 2: Command and response with notification

Commands to controller:

cmd A for display 1 and 2
cmd B for display 1
cmd C for display 2; last message

Response of controller:

response A of display 1
response A of display 2
response B of display 1
response C of display 2
notifications of display 1: warm restart, critical display failure
notification of display 2: warm restart; last message

Example 3: Command and response with error

Commands to controller:

cmd A for display 1 and 2
cmd B for display 1
cmd C for display 2; last message

Response of controller:

response A of display 1
response A of display 2
notification of display 1: communication failure, illegal command
response C of display 2; last message

3.1.4 Message structure

The structure of a message is:

- message type (command/response);
- flag last message of packet;
- cyclic message number;
- address count (1..32 for command, 1 for response);
- addresses;
- command ID;
- length of data VLQ encoded;
- data;
- CRC (16 bits).

Every message ends with a 16 bit CRC. The CRC is calculated over all bytes of the message (except for the 2 CRC bytes).

A notification is encoded as a response with command ID 0x00.

Structure of message:

byte 0	bit7: 1 = command, 0 = response bit 6: 1 = last message of packet, 0 = not last message bit 0-5: address count (at least 1)
byte 1	message number (0..255)
byte 2..n + 1	n times display address (0..255)
byte n+2	command ID
byte n+3 ..	VLQ (see 3.1.6) length of data
m bytes	DATA
last 2 bytes	CRC (16 bits)

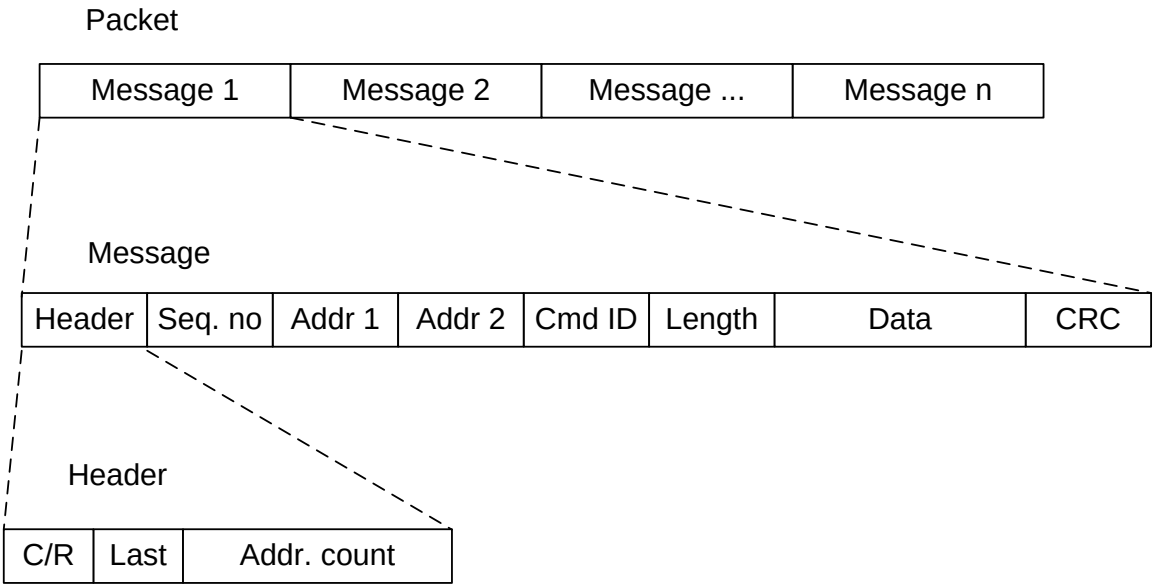

Figure 5: Structure of packet and message

3.1.5 Message coding

Messages are TLV (tag-length-value)-coded. This is a compact coding with a flexible binary format. If the data of a message has a flexible structure then this data is encoded as (compact) TLV.

In compact TLV encoding, the tag is only 6 bits and the highest 2 bits of the first byte are used as length indication. These bits indicate whether there are 0, 1, 2 or more bytes of data. If the data is longer than 2 bytes, the length is given in a VLQ encoded value after the tag.

The meaning of bits 6 and 7 of the first byte in compact TLV:

bit 7	bit 6	length of data
0	0	no data

0	1	1 byte data immediately after tag
1	0	2 bytes data immediately after tag
1	1	after the tag there is a VLQ value with the length of the data

The description of messages with data in compact TLV encoding contains the 6 bits tag. The length indication must be derived from the length of the data.

3.1.6 Variable Length Quantity (VLQ)

Unsigned integer values in the protocol are VLQ (variable length quantity) coded. A VLQ value is stored in a variable number of bytes. The highest bit of every byte indicates whether there are more bytes, i.e. bit 7 is 1 if there are more bytes following and bit 7 is 0 for the last byte of the value. The other 7 bits represent the value. The order of the bytes is big endian. The most significant bits are first in the stream.

The maximum value for VLQ values in this protocol is 2^{31}-1 (2147483647), i.e. they always fit in a signed 32 bit integer.

Values up to 127 fit into one byte. Values from 128 up to 16383 are stored in two bytes. Values from 16384 up to 2097151 are stored in 3 bytes. Values from 2097152 to 268435455 are stored in 4 bytes. Values up to 2147483647 are stored in 5 bytes.

3.1.7 Message timeout

The management system expects a reply to every command. The behavior of the management system after/during a timeout is implementation-dependent. The system can resend the same messages or send other messages, depending on the behavior desired.

3.1.8 CRC

A 16 bits CRC is applied to message and images. The CRC uses the CCITT polynomial with initial value 0xFFF and no mask.

The CCITT polynomial is $x^{16} + x^{12} + x^5 + 1$ (= 0x1021).

Appendix A contains a code example of CCITT (0xFFFF) in Java.

3.2 Requirements for the display controller

Modification of the connection configuration on the controller is supplier-specific. The configuration cannot be changed via Disperanto. Disperanto has some requirements for the connection as detailed below.

3.2.1 Serial connection

A display controller with a serial connection should have a long and configurable inter-character timeout (> 1 s). A short timeout could lead to communication errors with IP-to-serial conversion because one packet of messages could be larger than one IP packet and the timing of IP packets cannot be guaranteed.

3.2.2 TCP/IP connection

The controller must have a timeout on the TCP connection. The controller should close the connection when no data has been received for the duration of the specified period. This timeout must be configurable.

A timeout on the TCP connection is necessary, because the management system could lose the connection while the controller is not notified of this event. This can happen when the management system has a power failure or when there are network failures. The management system cannot connect to the controller when the controller still has an open connection. Therefore the controller should close the connection after a timeout.

4. MESSAGE DEFINITIONS

This chapter describes the messages to and from the display controller.

4.1 Notifications

Notifications are messages from a display controller that are not replies to a command. They are sent to the management system in a packet with responses.

4.1.1 Notifications of the display

Command ID: 0x00

Notifications are coded as response messages with command ID 0x00.

Notifications are compact TLV encoded (see section 3.1.5).

Notifications

Name	Communication error
Description	Command cannot be handled by controller
Tag	0x01
Data length	1 byte
Data	0: CRC error 1: unknown command 2: illegal data in command

Name	Software failure
Description	An error occurred in the software.
Tag	0x02
Data length	no data
Data	-

Name	Hardware failure
Description	A failure has been detected in the hardware
Tag	0x03
Data length	no data
Data	-

Name	Cold restart
Description	The display has restarted and all settings could be erased from memory. This notification stays active until it is explicitly cleared by the management system. If it was not cleared before a warm start, then this notification should stay active.
Tag	0x04
Data length	no data
Data	-

Name	Warm restart
Description	The display had a restart while maintaining all settings in memory. Only the currently shown image is undefined. This notification stays active until it has been explicitly cleared by the management system.
Tag	0x05
Data length	no data
Data	-

Name	Communication timeout
Description	The display has not received any commands during the specified period. The configured timeout image is being shown. This notification stays active until it is explicitly cleared by the management system.
Tag	0x06
Data length	no data
Data	-

Name	Non critical display defect
Description	Some pixels on the display are defective, but this is below the critical threshold.
Tag	0x07
Data length	no data
Data	-

Name	Critical display defect
Description	Several pixels on the display are defective and this is above the critical threshold.
Tag	0x08
Data length	no data
Data	-

Name	Intrusion
Description	This notification signals that the housing has been opened or could have been damaged. It could be detected with various sensors. This notification stays active until it has been explicitly cleared by the management system.
Tag	0x09
Data length	no data
Data	-

Name	External lighting defect
Description	External lighting is defective.
Tag	0x0A
Data length	no data
Data	-

Name	Heating defect
Description	Heating is defective.
Tag	0x0B
Data length	no data
Data	-

Name	Cooling defect
Description	Cooling is defective.
Tag	0x0C
Data length	no data
Data	-

Name	Temperature low
Description	Temperature is low.
Tag	0x0D
Data length	no data
Data	-

Name	Temperature high
Description	Temperature is high.
Tag	0x0E
Data length	no data
Data	-

Name	Luminance sensor defect
Description	One of the luminance sensors is defective.
Tag	0x0F
Data length	no data
Data	-

4.1.2 Clear notifications

Command ID: 0x00

The command with ID 0x00 is a special command. It is used to clear notifications. The description of the notifications above indicate which notifications need to be cleared. The data of this command consists of a list of tags of the notifications that need to be cleared.

The response for this command is a new notification message with the notifications that are still active. This could be an empty notification message when there are no active notifications.

Command data:

notifications	List with tags of the notifications to clear. These are tags without data. The two most significant bits of the tag are always 0.

Response data:
The response is a notification according to section 4.1.1.

4.2 General commands

4.2.1 Display properties

Command ID: 0x01

Command data:

<none>	

Response data is compact TLV encoded (see section 3.1.5). The data elements must be sorted by tag in ascending order.

Response data:

Name	Protocol version
Description	The version of the protocol implemented by the controller.
Mandatory	Always
Tag	0x00
Length	1 byte
Data	0x03 = Current protocol version

Name	Display type
Description	Display type according to the protocol usage. Note: A matrix display used as VVX(G) is still a matrix display.
Mandatory	Always
Tag	0x01
Length	1 byte
Data	0x01: Matrix 0x02: VVX 0x03: VVXG 0x04: Arrows 0x05: Rotation panel 0x06: Text display

Name	Supplier and product type
Description	Free format text with name of supplier and product.
Mandatory	Always
Tag	0x02
Length	1..40
Data	ASCII max. 40 characters

Name	Serial number
Description	Free format text with serial number.
Mandatory	Always
Tag	0x03
Length	1..20
Data	ASCII max. 20 characters

Name	Software version
Description	Free format text with software version.
Mandatory	Always
Tag	0x04
Length	1..20
Data	ASCII: max. 20 characters

Name	External lighting
Description	This tag should be present if the display has external lighting.
Mandatory	Optional
Tag	0x05
Length	no data
Data	-

Name	Display height
Description	Height of display in pixels.
Mandatory	Mandatory for matrix displays, not used for other displays
Tag	0x10
Length	1 or 2 bytes
Data	VLQ coded height (max. 16383)

Name	Display width
Description	Width of the display in pixels.
Mandatory	Mandatory for matrix displays, not used for other displays
Tag	0x11
Length	1 of 2 bytes
Data	VLQ code width (max. 16383)

Name	Number fixed images
Description	Number of fixed images on the display controller.
Mandatory	Optional
Tag	0x12
Length	1 of 2 bytes
Data	VLQ coded number images (max. 16383)

Name	Number writable images
Description	Number of writable images on the display controller.
Mandatory	Optional
Tag	0x13
Length	1 of 2 bytes
Data	VLQ coded number images (max. 16383)

Note: if a display has both fixed and writable images then the first n slots are used for the fixed images and the following m slots for the writable images.

Name	Slide show
Description	This tag should be present if the display can show a sequence of images.
Mandatory	Optional
Tag	0x14
Length	1 byte
Data	maximum number of images in the slide show (max. 127)

Name	RGB colors
Description	This tag indicates that the display uses RGB color coding. The data contains the color depth per color. The management system could use this information for a correct representation of the images on the user interface.
Mandatory	Matrix displays should send the tag ‘RGB colors’ or the tag ‘fixed color palette’. Not used for other displays
Tag	0x15
Length	3 bytes
Data	data[0]: number of bits red (max. 8) data[1]: number of bits green (max. 8) data[2]: number of bits blue (max. 8)

Name	Fixed color palette
Description	This tag indicates that the display uses indexed colors with a fixed color palette. The management system should send only images with color of specified color palette.
Mandatory	Matrix displays should send either the tag ‘RGB colors’ or the tag ‘fixed color palette’. Not used for other displays
Tag	0x16
Length	multiple of 3
Data	3 bytes for every entry in the palette: R, G, B.

Name	PNG supported
Description	Indicates that the display controller can decode PNG images.
Mandatory	Mandatory for matrix displays. Not used for other displays.
Tag	0x17
Length	0 bytes
Data	-

Name	Text display height
Description	Height of display in number of text lines.
Mandatory	Mandatory for non-matrix text displays, not used for other displays
Tag	0x18
Length	1 byte
Data	Number of lines (max 255)

Name	Text display width
Description	Width of display in number of characters.
Mandatory	Mandatory for non-matrix text displays, not used for other displays
Tag	0x19
Length	1 byte
Data	Number of characters (max 255)

4.2.2 Status

Command ID: 0x02

Command data:

<none>	

Response data is compact TLV-encoded (see section 3.1.5). The data elements must be sorted by tag in ascending order.

Response data:

Name	Shown image
Description	Image that is currently being shown. If the display is showing a slide show, then the response contains all images of the slide show. If no image is being shown, then the data is empty. Note: all images of an active slide show should be returned. There is no indication of which image of the slide show is currently being shown.
Mandatory	Always
Tag	0x01
Length	variable
Data	For every image: VLQ slot (1 or 2 bytes), CRC (2 bytes)

Name	Brightness of the display
Description	Current brightness of the display.
Mandatory	Mandatory, except for rotation panel
Tag	0x02
Length	1 byte
Data	0..100 (%)

Name	Intensity external lighting
Description	Current intensity external lighting.
Mandatory	Mandatory if external lighting is present.
Tag	0x03
Length	1 byte
Data	0..100 (%)

Name	Measured light intensity
Description	Measured light intensity of every sensor in logical order. The sensors are supposed to have sequential numbers on the display.
Mandatory	Mandatory if light sensors are present
Tag	0x04
Length	1 byte per sensor
Data	a byte per sensor with value: 0..100 (%)

Name	GPS position
Description	GPS position of a mobile display
Mandatory	Optional
Tag	0x05
Length	variable (max. 40 characters)

Data	Readable ASCII text:
	`<longitude>, <latitude>`
	where longitude and latitude are decimal values in degrees with a point as decimal separator, e.g.
	`5.659607831011106,51.47965605014039`

Name	Temperature
Description	Temperature in display housing.
Mandatory	Mandatory if temperature sensor is present
Tag	0x06
Length	1 byte
Data	signed byte: degrees Celsius Note: this is a signed value and therefore *not* VLQ-coded.

Name	Heating
Description	State of the heating
Mandatory	Mandatory if heating is present
Tag	0x07
Length	1 byte
Data	0: off, 1: on

Name	Cooling
Description	State of cooling.
Mandatory	Mandatory if cooling is present
Tag	0x08
Length	1 byte
Data	0: off, 1: on

4.2.3 Reboot

Command ID: 0x03

Request a reboot of the display controller.

Command data:

<none>	

Response data:

<none>	

The display first sends the response and then restarts.

4.2.4 Keep-alive

Command ID: 0x04

The keep-alive is an empty message to check communication and prevent a communication timeout.

Command data:

<none>	

Response data:

<none>	

4.2.5 Set communication timeout

Command ID: 0x05

If the display has not received any commands for a period longer than the communication timeout it will show the configured image.

Command data:

mode	0x00: no timeout 0x01: clear display after timeout 0x02: show specified image after timeout
communication timeout	VLQ-coded timeout in seconds (only present if mode is 0x01 or 0x02)
image	VLQ image slot (only present if mode is 0x02)

Response data:

<none>	

4.2.6 Set brightness table

Command ID: 0x06

Command data:

Brightness at 0% measured intensity	1 byte: 0..100 (%)
Brightness at 10% measured intensity	1 byte: 0..100 (%)
Brightness at 20% measured intensity	1 byte: 0..100 (%)
Brightness at 30% measured intensity	1 byte: 0..100 (%)
Brightness at 40% measured intensity	1 byte: 0..100 (%)
Brightness at 50% measured intensity	1 byte: 0..100 (%)
Brightness at 60% measured intensity	1 byte: 0..100 (%)
Brightness at 70% measured intensity	1 byte: 0..100 (%)
Brightness at 80% measured intensity	1 byte: 0..100 (%)
Brightness at 90% measured intensity	1 byte: 0..100 (%)
Brightness at 100% measured intensity	1 byte: 0..100 (%)

The brightness varies from 0 to 100% of the maximum brightness. The display can interpolate the brightness for intermediate values of the intensity.

Response data:

<none>	

4.2.7 Set external lighting

Command ID: 0x07

This command sets the state of the external lighting.

Command data:

lighting state	0: off 1: on 2: automatic

Response data:

<none>	

4.2.8 Diagnostics

Command ID: 0x08

In response to the diagnostics command the display should send a human-readable diagnostics message. The text is supplier-specific and contains the details of defects, such as the number of defective pixels.

Command data:

<none>	

Response data:

diagnostics message	UTF8 coded human-readable text. Max. 1024 bytes. Line feeds (LF) can be used to improve readability.

4.3 Image functions

4.3.1 Manipulate memory slot

Command ID: 0x10

The controller should manipulate the image in working memory and store it in a memory slot. If the display was showing the (old) image of the specified slot, then it should immediately replace the image displayed.

The command data is compact TLV-encoded (see section 3.1.5).

Command data:

Name	Initialize working memory
Description	Initialize working memory with a black image of specified size.
Tag	0x00
Length	2..4 bytes
Data	VLQ width, VLQ height

Name	Clear rectangle
Description	Clear a rectangle in the image (results in black region).
Tag	0x01
Length	variable
Data	VLQ left, VLQ top, VLQ width, VLQ height

Name	Load image
Description	Loads on image on specified position
Tag	0x02
Length	variable
Data	VLQ left, VLQ top, image type (1 byte), image data (n bytes) image type: 0x01: BMP (available for backward compatibility) 0x02: PNG

Name	Copy image
Description	Copy an image from a memory slot to the specified position in working memory.
Tag	0x03
Length	variable
Data	VLQ left, VLQ top, VLQ memory slot of image

Name	Store image
Description	Store image in specified memory slot.
Tag	0x04
Length	1 or 2 bytes
Data	VLQ memory slot

Response data:

CRC16 of image	2 bytes (16 bits), see 2.2.2

4.3.2 Calculate CRC of images

Command ID: 0x11

The controller should calculate the CRC of the images in specified memory slots. The command data contains a list of memory slots.

Command data

Images	Per image VLQ of memory slot

Response data:

CRC16	2 bytes (16 bits) per image, see 2.2.2

4.3.3 Show no image

Command ID: 0x12

The display should show no images. The display controller could switch to an energy saving mode. The controller could also lighten some pixels in the corner of the display to show the status of the display.

Command data:

<none>	

Response data:

<none>	

4.3.4 Show image

Command ID: 0x13

The image in the specified memory slot should be shown on the display.

If the image in the slot is being modified the changes should be effectuated immediately.

Command data:

Image	VLQ-coded image slot

Response data:

CRC16 of image	2 bytes (16 bits) , see 2.2.2

4.3.5 Start slide show

Command ID: 0x14

The display should show the sequence of images. The sequence can be shown once or cyclically. If the sequence is shown once, then the last image will remain on the display.

The resolution is a tenth of a second to create blinking texts/symbols.

Command data:

Cyclic	1 byte: 0: show once 1: show cyclic

Per image:

image	VLQ memory slot
time to show image	VLQ time in tenths of a second

Response data:

CRC16	2 bytes (16 bits) per image, see 2.2.2

4.4 Non-matrix functions

4.4.1 Set text

Command ID: 0x20

The display should render the text for the given row with the set alignment. The command shall always contain a full update of the display (all rows are sent).

The data elements must be sorted by tag in ascending order.

Command data:

Number of rows	1 byte: number of rows

Per row:

Name	Alignment
Description	Set the text alignment
Tag	0x00
Length	1 byte
Data	0: align left 1: align right 2: align center

Name	Text
Description	Set the text for the row
Tag	0x01
Length	1..255
Data	ASCII coded text max. 255 characters

Response data:

<none>	

4.5 Service mode

4.5.1 Supplier service mode

Command ID: 0x30

This command switches the display controller into service mode.

Command data:

<none>	

Response data:

<none>	

5. NOTES

5.1 Abbreviations

A list of abbreviations used.

Abbreviation	Meaning
IDD	Interface Design Description
VVX(G)	Dutch: vol, vrij, kruis, (getal) English: full, free, closed (number)
TLV	Type, length, value of tag length value.
VLQ	Variable length quantity. Value that is coded with a variable number of bytes. The highest bit of every byte indicates whether there are more bytes. The other 7 bits represent the value. The order of the bytes is big endian. The most significant bits are first in the stream. Values up to 127 fit into one byte. Values from 128 up to 16383 are stored in two bytes. Values from 16384 up to 2097151 are stored in 3 bytes. Values from 2097152 to 268435455 are stored in 4 bytes. Values up to 2147483647 are stored in 5 bytes.

5.2 Terminology

A list of terminology used.

Term	Explanation
Management system	(server) application managing the displays.
Display address	Address of a display (1..255)

APPENDIX A. CRC CODE EXAMPLE

Below is a sample implementation of the CCITT (0xFFFF) CRC.

The CRC of the ASCII data of “123456789” is 0x29B1.

```
    private static int[] CCITT_HASH = {
            0x0000,0x1021,0x2042,0x3063,0x4084,0x50a5,0x60c6,0x70e7,
            0x8108,0x9129,0xa14a,0xb16b,0xc18c,0xd1ad,0xe1ce,0xf1ef,
            0x1231,0x0210,0x3273,0x2252,0x52b5,0x4294,0x72f7,0x62d6,
            0x9339,0x8318,0xb37b,0xa35a,0xd3bd,0xc39c,0xf3ff,0xe3de,
            0x2462,0x3443,0x0420,0x1401,0x64e6,0x74c7,0x44a4,0x5485,
            0xa56a,0xb54b,0x8528,0x9509,0xe5ee,0xf5cf,0xc5ac,0xd58d,
            0x3653,0x2672,0x1611,0x0630,0x76d7,0x66f6,0x5695,0x46b4,
            0xb75b,0xa77a,0x9719,0x8738,0xf7df,0xe7fe,0xd79d,0xc7bc,
            0x48c4,0x58e5,0x6886,0x78a7,0x0840,0x1861,0x2802,0x3823,
            0xc9cc,0xd9ed,0xe98e,0xf9af,0x8948,0x9969,0xa90a,0xb92b,
            0x5af5,0x4ad4,0x7ab7,0x6a96,0x1a71,0x0a50,0x3a33,0x2a12,
            0xdbfd,0xcbdc,0xfbbf,0xeb9e,0x9b79,0x8b58,0xbb3b,0xab1a,
            0x6ca6,0x7c87,0x4ce4,0x5cc5,0x2c22,0x3c03,0x0c60,0x1c41,
            0xedae,0xfd8f,0xcdec,0xddcd,0xad2a,0xbd0b,0x8d68,0x9d49,
            0x7e97,0x6eb6,0x5ed5,0x4ef4,0x3e13,0x2e32,0x1e51,0x0e70,
            0xff9f,0xefbe,0xdfdd,0xcffc,0xbf1b,0xaf3a,0x9f59,0x8f78,
            0x9188,0x81a9,0xb1ca,0xa1eb,0xd10c,0xc12d,0xf14e,0xe16f,
            0x1080,0x00a1,0x30c2,0x20e3,0x5004,0x4025,0x7046,0x6067,
            0x83b9,0x9398,0xa3fb,0xb3da,0xc33d,0xd31c,0xe37f,0xf35e,
            0x02b1,0x1290,0x22f3,0x32d2,0x4235,0x5214,0x6277,0x7256,
            0xb5ea,0xa5cb,0x95a8,0x8589,0xf56e,0xe54f,0xd52c,0xc50d,
            0x34e2,0x24c3,0x14a0,0x0481,0x7466,0x6447,0x5424,0x4405,
            0xa7db,0xb7fa,0x8799,0x97b8,0xe75f,0xf77e,0xc71d,0xd73c,
            0x26d3,0x36f2,0x0691,0x16b0,0x6657,0x7676,0x4615,0x5634,
            0xd94c,0xc96d,0xf90e,0xe92f,0x99c8,0x89e9,0xb98a,0xa9ab,
            0x5844,0x4865,0x7806,0x6827,0x18c0,0x08e1,0x3882,0x28a3,
            0xcb7d,0xdb5c,0xeb3f,0xfb1e,0x8bf9,0x9bd8,0xabbb,0xbb9a,
            0x4a75,0x5a54,0x6a37,0x7a16,0x0af1,0x1ad0,0x2ab3,0x3a92,
            0xfd2e,0xed0f,0xdd6c,0xcd4d,0xbdaa,0xad8b,0x9de8,0x8dc9,
            0x7c26,0x6c07,0x5c64,0x4c45,0x3ca2,0x2c83,0x1ce0,0x0cc1,
            0xef1f,0xff3e,0xcf5d,0xdf7c,0xaf9b,0xbfba,0x8fd9,0x9ff8,
            0x6e17,0x7e36,0x4e55,0x5e74,0x2e93,0x3eb2,0x0ed1,0x1ef0,
    };

    /**
     * Initial value to use when calculating a CRC.
     */
    private static final int CRC_INITIAL = 0xFFFF;

    /**
     * Calculates CRC16-CCITT.<br>
     *
     * The given buffer is inclusive two CRC bytes. These CRC bytes are
     * not used in the CRC calculation.
     *
     * @param data Bytes to calculate CRC on.
     * @return CRC
     */
    public static short calculateCrc(byte[] data) {
        int crc = CRC_INITIAL;
```

```
        // The used buffer already has two bytes reserved for the crc.
        // These bytes must not be included in the crc calculation.
        for (int j = 0; j < data.length - 2; j++) {
            crc = updateCrc(crc, data[j]);
        }

        return (short)crc;
    }

    /**
     * CRC calculation part.
     * Implementation from:
     * https://gist.github.com/rafacouto/59326c90d6a55f86a3ba
     *
     * @param crc the previously returned CRC, or CRC_INITIAL
     * @param b the byte to use
     * @return the updated CRC value
     */
    private static int updateCrc(int crc, byte b) {
        return (crc << 8) ^ CCITT_HASH[((crc >> 8) ^ b) & 0x00FF];
    }
```

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