Readerboard User's Guide
WORKING DRAFT

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For readerboard hardware version 1.0.0 and firmware version 0.0.0.

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CHAPTER 1

Protocol Description

> I don't stand on protocol. Just call me your Excellency.
>
> —Henry Kissinger

The control protocol used to display information on the readerboard sign is very simple. Commands are expressed largely in plain ASCII characters and are executed immediately as they are received.[1]

In addition to plain, printable 7-bit ASCII characters, a few control codes are recognized as described below. String data may include any 8-bit value except as otherwise indicated.

Command Addressing

Commands may be received over the USB port (a point-to-point connection with a host computer) or the RS-485 port (as part of a network of devices all connected to a single host computer's port). Commands received over the USB port MAY be prefixed by an address specifier as described below. Those received over the RS-485 network MUST have such a prefix.

The address specifier prefix has the form:

0	1	⋯	n	$n+1$
/	$\langle ad_0 \rangle$	⋯	$\langle ad_{n-1} \rangle$	$

[1] Technically, they may even be executed *while* they are being received.

The ⟨*ad*⟩ parameters give the address(es) of the sign(s) which should obey the following command. Each is a value from 0–63 encoded as shown in Table 1.4. If the list of addresses is empty, all signs should respond to the command. The address list terminator may be a dollar-sign or escape character (hex byte 1B), indicated in the protocol description as $.

If sent over the USB port, the address prefix is allowed but ignored, and the readerboard acts as if all commands are addressed to it, since the commands are received over a private connection between the host and that readerboard.

Command Termination and Error Handling

The command terminator is "^D" (hex byte value 04). This character *must* follow each readerboard command, since the interpretation of the next command won't start until receipt of the ^D, effectively ignoring any data sent after the end of the command and before the terminating ^D.

The exception to this rule is the set of Busylight-compatible commands *, ?, F, S, and X. Since the Busylight unit did not use any command terminator in its protocol, the readerboard unit won't demand one either, although we *recommend* that you do anyway. At the very least, you should have a ^D character sent after a sequence of one or more Busylight-compatible commands.

In case of an error, such as the inability to parse the incoming command or an invalid field value, the readerboard will signal the error condition by lighting the white and both red discrete LEDs, and will then ignore all input until the next ^D byte is received.

Whenever a ^D byte is received, any command being parsed is aborted and the sign's input parser is reset. Thus, this byte may be sent in case a partial command has been sent but the host becomes aware that it cannot be completed. Note that the command may have been partially acted upon by that point, so no assumption should be made as to the sign's state.

Command Summary

The eight discrete LEDs are intended for a simple display of status information in a manner analogous to the Busylight project by the same author.[2] To support this usage, the F, S, X, *, and ? commands are recognized in a manner compatible with how Busylight uses those same commands. These are categorized as "Busylight compatibility commands." Unlike all other commands listed here, these are recognized regardless of case. Since the readerboard has a power supply capable of illuminating all of the status LEDs at once,[3] a new command L is added which allows any arbitrary pattern of steady LEDs to be turned on.

[2] See github.com/MadScienceZone/busylight.

[3] The Busylight cannot, since it is powered from the host computer's USB port.

Command	Description	Notes
*	Strobe LEDs in Sequence	[1]
?	Query discrete LED status	[1] [2] [4]
F	Flash LEDs in Sequence	[1]
L	Light one or more LEDs steady	[3]
S	Light one LED steady	[1]
X	All LEDs off	[1]
^D	Abort/terminate command	
<	Scroll text across display	
=	Set operational parameters	[4]
@	Move current column cursor	
A	Select character font	
C	Clear matrix display	
H	Add histogram/bargraph data point	
I	Draw bitmap graphic image	
Q	Query matrix display statue	[2] [4]
T	Display text on display	

[1] Busylight compatibile command
[2] Sends response (USB only)
[3] Busylight extension (not in original Busylight)
[4] USB only

Table 1.1: Summary of All Commands

The remaining commands are used for management of the matrix display. All commands are summarized in Table 1.1.

Although the rev 2 hardware supports the ability to enable the RS-485 transmitter and send data back onto the network, this is not currently implemented by the firmware, and the intent is to have all devices listen passively to RS-485 traffic at all times.

*—Strobe Lights in Sequence

0	1	2	3	⋯	n	$n+1$	$n+2$
*	$\langle led_0 \rangle$	$\langle led_1 \rangle$	$\langle led_2 \rangle$	⋯	$\langle led_{n-1} \rangle$	$	^D

Each $\langle led \rangle$ value is an ASCII digit character corresponding to a discrete LED as shown in Table 1.8.

This command functions identically to the F command (see below), except that the lights are “strobed” (flashed very briefly with a pause between each light in the sequence).

Code	Hex	Description
^C⟨*pos*⟩	03⟨*pos*⟩	Move current column cursor to ⟨*pos*⟩
^D	04	Never allowed in strings (command terminator)
^F⟨*digit*⟩	06⟨*digit*⟩	Switch current font
^H⟨*pos*⟩	08⟨*pos*⟩	Move cursor left ⟨*pos*⟩ columns
^L⟨*pos*⟩	0C⟨*pos*⟩	Move cursor right ⟨*pos*⟩ columns
^[	1B	Never allowed in strings (string terminator)

Table 1.2: Control Codes in String Values

<—Scroll Text Across Display

0	1	2	···	*n*+1	*n*+2	*n*+3
<	⟨*loop*⟩	⟨*string*⟩			ESC	^D

Displays the text ⟨*string*⟩ by scrolling it across the display from right to left. If ⟨*loop*⟩ is ".", the text is only scrolled once; if it is "L" then it repeatedly scrolls across the screen in an endless loop.

The text is rendered in the current font and may contain any 8-bit bytes except as otherwise noted (but avoiding ASCII control codes is wise to be safe from conflict with future control codes which may be added to the protocol). The string is terminated by an escape character (hex byte 1B), indicated in the protocol description as ESC.

The string may include control codes as listed in Table 1.2.

=—Set Operational Parameters

0	1	2	3	4
=	⟨*ad*⟩	⟨*uspd*⟩	⟨*rspd*⟩	^D

This command sets a few operational parameters for the sign. Once set, these will be persistent across power cycles and reboots.

If the ⟨*ad*⟩ parameter is "*" then the RS-485 interface is disabled entirely. Otherwise it is a value from 0–63 encoded as described in Table 1.4. This enables the RS-485 interface and assigns this sign's address to ⟨*ad*⟩.

The baud rate for the USB and RS-485 interfaces is set by the ⟨*uspd*⟩ and ⟨*rspd*⟩ values respectively. Each is encoded as per Table 1.3.

This command may only be sent over the USB port.

By default, an unconfigured readerboard is set to 9,600 baud with the RS-485 port disabled.

Code	Speed	
0	300	
1	600	
2	1,200	
3	2,400	
4	4,800	
5	9,600	(default)
6	14,400	
7	19,200	
8	28,800	
9	31,250	
A	38,400	
B	57,600	
C	115,200	

Table 1.3: Baud Rate Codes

?—Query Discrete LED Status

0	1
?	^D

This command causes the sign to send a status report back to the host to indicate what the discrete LEDs are currently showing. This response has the form:

0	1	2	3	4	5	6	7	8
L	$\langle led_0 \rangle$	$\langle led_1 \rangle$	$\langle led_2 \rangle$	$\langle led_3 \rangle$	$\langle led_4 \rangle$	$\langle led_5 \rangle$	$\langle led_6 \rangle$	$\langle led_7 \rangle$
F	flasher status (see below)							
S	strober status (see below)							
\n								

The flasher and strober status values are variable-width fields which indicate the state of the flasher (see F command) and strober (see * command) functions. In each case, if there is no defined sequence, the status field will be:

0	1
$\langle run \rangle$	X

Otherwise, the state of the flasher or strober unit is indicated by:

Value	Code	Value	Code
0–9	0–9	17–42	A–Z
10	:	43	[
11	;	44	\
12	<	45	]
13	=	46	^
14	>	47	_
15	?	48	`
16	@	49–63	a–o

(Each code is the numeric value plus 48.)

Table 1.4: ASCII Encoded Integer Values (0–63)

0	1	2	3	4	⋯	$n+3$
⟨*run*⟩	⟨*pos*⟩	@	⟨led_0⟩	⟨led_1⟩	⋯	⟨led_{n-1}⟩

In either case, ⟨*run*⟩ is the ASCII character "0" if the unit is stopped or "1" if it is currently running. If there is a defined sequence, ⟨*pos*⟩ indicates the 0-origin position within the sequence of the light currently being flashed or strobed, encoded as described in Table 1.4. The ⟨*led*⟩ values are as given to the F or * command that set the sequence.

Note that the ⟨*pos*⟩ value may be the character "X" to indicate the position value of 40, so it is important to distinguish between the field value "⟨*run*⟩X" vs. "⟨*run*⟩X@⟨*sequence*⟩".

The status message sent to the host is terminated by a newline character (hex byte 0A), indicated in the protocol description above as "\n".

This command may only be sent on the USB port.

@—Set Column Cursor Position

0	1	2
@	⟨*pos*⟩	^D

Sets the column cursor position to the value indicated by ⟨*pos*⟩. See Table 1.4.

A—Select Font

0	1	2
A	⟨*digit*⟩	^D

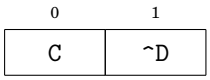
Sets the font to use for rendering text with the < and T commands. The font codes for ⟨*digit*⟩ are listed in Table 1.5. The full text fonts support the

Code	Font Description
0	Fixed-width 5×7 matrix plus descenders in 8th row
1	Variable-width version of font 0
2	Bold alphanumerics and special symbols

Table 1.5: Font Codes

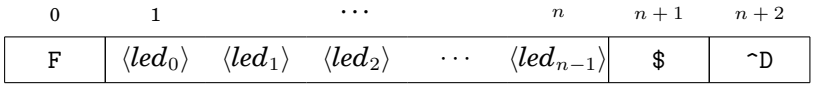
printable ASCII characters plus a majority of the Unicode glyphs with codepoints less than 256. See Tables 1.6–1.7 for a complete font glyph listing with codepoint assignments.

C—Clear Matrix Display



Clears the matrix display so that no LEDs are illuminated. Does not affect the discrete LEDs.

F—Flash Lights in Sequence



Each ⟨*led*⟩ value is an ASCII digit character corresponding to a discrete LED as shown in Table 1.8. Note that the assignment of colors to these LEDs is dependent on your particular hardware being assembled that way. As an open source project, of course, you (or whomever assembled the unit) may choose any color scheme you like when building the board.

Up to 64 ⟨*led*⟩ codes may be listed. The sign will cycle through the sequence, lighting each specified LED briefly before moving on to the next one. The sequence is repeated forever in a loop until an L, S or X command is received.

If only one ⟨*led*⟩ is specified, that light will be flashed on and off. Setting an empty sequence (no codes at all) stops the flasher's operation.

The sequence is terminated by either a dollar-sign ("$") character or the escape control character (hex byte 1B), indicated in the protocol diagram above simply as "$".

This command may be given in upper- or lower-case ("f" or "F").

	0	*1*	*2*	*3*	*4*	*5*	*6*	*7*	
00x				move	end		font		0*x*
01x	back				forw				
02x									1*x*
03x				esc					
04x		!	"	#	$	%	&	’	2*x*
05x	(	)	*	+	,	-	.	/	
06x	0	1	2	3	4	5	6	7	3*x*
07x	8	9	:	;	<	=	>	?	
10x	@	A	B	C	D	E	F	G	4*x*
11x	H	I	J	K	L	M	N	O	
12x	P	Q	R	S	T	U	V	W	5*x*
13x	X	Y	Z	[	\	]	^	_	
14x	‘	a	b	c	d	e	f	g	6*x*
15x	h	i	j	k	l	m	n	o	
16x	p	q	r	s	t	u	v	w	7*x*
17x	x	y	z	{	|	}	~	///	
20x	“	”	‘	’	†	‡	…	′	8*x*
21x	″	!!	‾	←	→	↑	↓	≠	
22x	≤	≥	≈	Γ	Δ	Ξ	Π	Σ	9*x*
23x	Ω	π	ρ	σ	—	‰			
24x		¡	¢	£	¤	¥	¦	§	A*x*
25x		©	ª	«	¬	-	®		
26x	°	±	2	3		μ	¶	•	B*x*
27x		1	º	»	1/4	1/2	3/4	¿	
30x	À	Á	Â	Ã	Ä	Å	Æ	Ç	C*x*
31x	È	É	Ê	Ë	Ì	Í	Î	Ï	
32x	Đ	Ñ	Ò	Ó	Ô	Õ	Ö	×	D*x*
33x	Ø	Ù	Ú	Û	Ü	Ý	Þ	ß	
34x	à	á	â	ã	ä	å	æ	ç	E*x*
35x	è	é	ê	ë	ì	í	î	ï	
36x	ð	ñ	ò	ó	ô	õ	ö	÷	F*x*
37x	ø	ù	ú	û	ü	ý	þ	ÿ	
	8	9	A	B	C	D	E	F	

Table 1.6: Font Table for Fonts #0 and #1

	0	*1*	*2*	*3*	*4*	*5*	*6*	*7*	
00x				move	end		font		0*x*
01x	back				forw				
02x									1*x*
03x				esc					
04x		!							2*x*
05x					,		.		
06x	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	3*x*
07x	**8**	**9**							
10x	©	**A**	**B**	**C**	**D**	**E**	**F**	**G**	4*x*
11x	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	
12x	**P**	**Q**	**R**	**S**	**T**	**U**	**V**	**W**	5*x*
13x	**X**	**Y**	**Z**						
14x		🡐	🡒	🡑	🡓	↖	↗	↘	6*x*
15x	↙	←	→	↑	↓	▚	■		
16x	✓	√	∞	Œ	œ	€	∴	∵	7*x*
17x	✖	◀	▶	▲	▼	↕	♦	◊	
20x	λ	Θ	Φ	Ψ					8*x*
21x									
22x									9*x*
23x									
24x		TS1	TS2	TS3	TS4	TS5	TS6	TS7	A*x*
25x	TS8								
	8	9	A	B	C	D	E	F	

TS⟨*n*⟩ = Thin space of ⟨*n*⟩ pixels

Table 1.7: Font Table for Font #2

Code	Light	Color
0	L_0	white
1	L_1	blue
2	L_2	blue
3	L_3	red
4	L_4	red
5	L_5	yellow
6	L_6	yellow
7	L_7	green

Table 1.8: Discrete LED Codes and Colors

H—Draw Bar Graph Data Point

0	1	2
H	⟨*n*⟩	^D

This command is used to draw a bar-graph element. Repeating this command causes a scrolling data display which shows a set of data samples over some period of time. The value ⟨*n*⟩ is an ASCII digit character in the range "0"–"8", and is drawn in the far-right column of the matrix display, as a column of ⟨*n*⟩ lights stacked up from the bottom row (a value of 0 results in no lights, up to 8 which is a full column of eight lights; a value of 9 is treated as if it were 8). All existing matrix data are scrolled left one column.

I—Draw Bitmap Image

0	1	2	3	4	5	6	7	8
I	⟨*merge*⟩	⟨*pos*⟩	⟨*trans*⟩	⟨*coldata*$_0$⟩		⟨*coldata*$_1$⟩		···
⟨*coldata*$_{n-1}$⟩		$	^D					

Draws an arbitrary bitmap image onto the matrix display starting at column ⟨*pos*⟩, encoded as per Table 1.4. A ⟨*pos*⟩ value of "~" represents the current column cursor position.

Each column data, from left to right, are given by ⟨*coldata*⟩ values, each of which is a two-digit ASCII hexadecimal value with the least-significant bit representing the top row of the matrix.

The column data values are terminated by either a dollar-sign ("$") character or the escape control character (hex byte 1B), indicated in the protocol diagram above simply as "$".

The column cursor is moved to be after the end of the image.

If ⟨*merge*⟩ is the character "." then each column's contents is cleared before setting the pixels as per the ⟨*coldata*⟩ value. If ⟨*merge*⟩ is "M" the bits set in ⟨*coldata*⟩ are added to the lit pixels already in the column.

The ⟨*trans*⟩ value indicates the transition effect to use when adding the image to the display. See Table 1.9.

L—Light Multiple LEDs

0	1		···		n	$n+1$	$n+2$
L	⟨*led*$_0$⟩	⟨*led*$_1$⟩	⟨*led*$_2$⟩	···	⟨*led*$_{n-1}$⟩	$	^D

This command is identical to the S command (see below), except that multiple discrete LEDs can be specified, all of which are illuminated simultaneously. See Table 1.8. Note that if a strobe sequence is running (via a previous * command), it remains running.

Code	Transition
.	No transition
>	Scroll in from left
<	Scroll in from right
^	Scroll up from bottom
v	Scroll down from top
L	wipe left
R	wipe right
U	wipe up
D	wipe down
|	wipe left and right from middle column
-	wipe up and down from middle row
?	choose a random transition

Table 1.9: Transition Effect Codes

Q—Query Readerboard Status

0	1
Q	^D

This command causes the sign to send a status report back to the host to indicate the general status of the device except for the discrete LED display which may be queried using the ? command. The response has the form:

0	1	2	3	···				
Q	⟨*model*⟩	V	⟨*hwversion*⟩		$	R	⟨*romversion*⟩	
$	S	⟨*serial*⟩			$	M	⟨*coldata*$_0$⟩	
⟨*coldata*$_1$⟩		···	⟨*coldata*$_{63}$⟩		=	⟨*ad*⟩	⟨*uspd*⟩	⟨*rspd*⟩
\n								

The ⟨*model*⟩ field may be "L" for the legacy hardware the author still has lying around (but this shouldn't be something anyone else would need to see), or "M" for the current 64×8 matrix display hardware.

⟨*hwversion*⟩ and ⟨*romversion*⟩ indicate the versions, respectively, of the hardware the firmware was compiled to drive, and of the firmware itself. Each of these fields are variable-width and conform to the semantic version standard 2.0.0.[4] Each is terminated by a dollar-sign ($) character (and thus those strings may not contain dollar signs).

[4] See semver.org.

The ⟨*serial*⟩ field is a variable-width alphanumeric string which was set when the firmware was compiled. It should be a unique serial number for the device (although that depends on some effort on the part of the person compiling the firmware to insert that serial number each time). Serial numbers 0–299 are reserved for the original author's use. This string is also terminated with a dollar sign.

The ⟨*coldata*⟩ bytes are sent just as with the `I` command, as hexadecimal values indicating the LEDs lit on the matrix display, with ⟨$coldata_0$⟩ being the leftmost column of the display and ⟨$coldata_{63}$⟩ being the rightmost. In each column, the least significant bit indicates the LED on the top row.

The ⟨*ad*⟩, ⟨*uspd*⟩, and ⟨*rspd*⟩ values are as last set by the = command (or the factory defaults if they were never changed).

The status message sent to the host is terminated by a newline character (hex byte `0A`), indicated in the protocol description above as "`\n`".

S—Light Single LED

0	1	2
S	⟨*led*⟩	^D

Stops the flasher (cancelling any previous `F` command) and turns off all discrete LEDs. The single LED indicated by ⟨*led*⟩ is turned on. See Table 1.8. Note that if a strobe sequence is running (via a previous ∗ command), it remains running.

This command may be given in upper- or lower-case ("`s`" or "`S`").

T—Display Text

0	1	2	3	4	···	n+4	n+5
T	⟨*merge*⟩	⟨*align*⟩	⟨*trans*⟩	⟨*string*⟩		ESC	^D

Displays the text ⟨*string*⟩ at the current cursor position. The cursor position is then moved past the text to be ready for the next string to be printed.

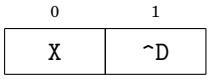
The ⟨*align*⟩ code indicates how the text is aligned on the display (TBD).

The ⟨*trans*⟩ code specifies the transition effect to be used to add this string to the display as shown in Table 1.9.

The text is rendered in the current font and may contain any 8-bit bytes except as otherwise noted (but avoiding ASCII control codes is wise to be safe from conflict with future control codes which may be added to the protocol). The string is terminated by an escape character (hex byte `1B`), indicated in the protocol description as ESC.

The string may include control codes as listed in Table 1.2.

X—Turn off Discrete LEDs



Turns off the flasher, strober, and all discrete LEDs.
This command may be given in upper- or lower-case ("x" or "X").