

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 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.

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

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.

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

Those commands listed with “response” in their Notes column send data back to the host as described below. None of the other commands do this.

*—Strobe Lights in Sequence

0	1	2	3	...	n	$n + 1$	$n + 2$
*	$\langle led_0 \rangle$	$\langle led_1 \rangle$	$\langle led_2 \rangle$...	$\langle led_{n-1} \rangle$	\$	<code>^D</code>

Each $\langle led \rangle$ value is an ASCII digit character corresponding to a discrete LED as shown in Table 1.7.

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).

<—Scroll Text Across Display

0	1	2	...		
<	$\langle loop \rangle$	$\langle string \rangle$		ESC	^D

²See github.com/MadScienceZone/busylight.

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

Command	Description	Notes
*	Strobe LEDs in Sequence	Busylight compatible
?	Query discrete LED status	Busylight compatible, response
F	Flash LEDs in Sequence	Busylight compatible
L	Light one or more LEDs steady	Busylight extension
S	Light one LED steady	Busylight compatible
X	All LEDs off	Busylight compatible
^D	Abort/terminate command	Matrix control
<	Scroll text across display	Matrix control
@	Move current column cursor	Matrix control
A	Select character font	Matrix control
C	Clear matrix display	Matrix control
H	Add histogram/bargraph data point	Matrix control
I	Draw bitmap graphic image	Matrix control
Q	Query matrix display statue	Matrix control, response
T	Display text on display	Matrix control

Table 1.1: Summary of All Commands

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 Allowed in String Values

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.

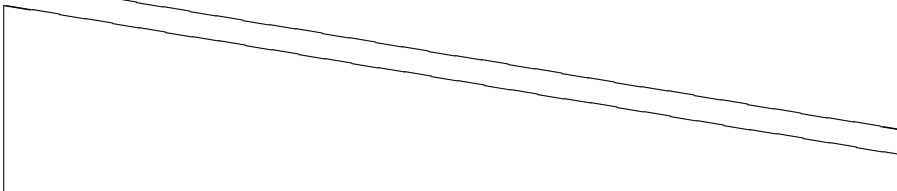
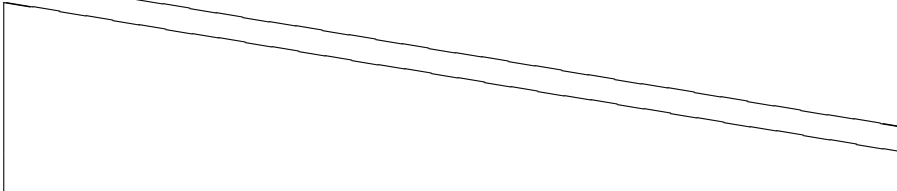
The text is rendered in the current font and may contain any 8-bit bytes except as otherwise noted (but avoiding ASCII control codes is wise to be safe from conflict with future control codes which may be added to the protocol). The string is terminated by an escape character (hex byte 1B), indicated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

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

?—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:

0	1	2	3	...	$n + 3$
$\langle run \rangle$	$\langle pos \rangle$	@	$\langle led_0 \rangle$	$\langle led_1 \rangle$... $\langle led_{n-1} \rangle$

In either case, $\langle run \rangle$ is the ASCII character “0” if the unit is stopped or “1” if it is currently running. If there is a defined sequence, $\langle pos \rangle$ indicates the 0-origin position within the sequence of the light currently being flashed or

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 1.3: ASCII Encoded Integer Values (0–63)

strobed, encoded as described in Table 1.3. 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”.

@—Set Column Cursor Position

0	1	2
@	<i><pos></i>	~D

Sets the column cursor position to the value indicated by *<pos>*. See Table 1.3.

A—Select Font

0	1	2
A	<i><digit></i>	~D

Sets the font to use for rendering text with the < and T commands. The font codes for *<digit>* are listed in Table 1.4. The full text fonts support the printable ASCII characters plus a majority of the Unicode glyphs with codepoints less than 256. See Tables 1.5–1.6 for a complete font glyph listing with codepoint assignments.

C—Clear Matrix Display

0	1
C	~D

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 1.4: Font Codes

	0	1	2	3	4	5	6	7	
00x				move	end		font		0x
01x	back				forw				
02x									1x
03x				esc					
04x		!	"	#	\$	%	&	'	2x
05x	()	*	+	,	-	.	/	
06x	0	1	2	3	4	5	6	7	3x
07x	8	9	:	;	<	=	>	?	
10x	@	A	B	C	D	E	F	G	4x
11x	H	I	J	K	L	M	N	O	
12x	P	Q	R	S	T	U	V	W	5x
13x	X	Y	Z	[\]	^	_	
14x	'	a	b	c	d	e	f	g	6x
15x	h	i	j	k	l	m	n	o	
16x	p	q	r	s	t	u	v	w	7x
17x	x	y	z	{		}	~	///	
20x	“	”	‘	’	†	‡	...	'	8x
21x	”	!!	—	←	→	↑	↓	≠	
22x	≤	≥	≈	Γ	Δ	Ξ	Π	Σ	9x
23x	Ω	π	ρ	σ	—	‰			
24x		ı	¢	£	¤	¥	¦	§	Ax
25x		©	ª	«	¬	-	®		
26x	°	±	²	³		μ	¶	•	Bx
27x		¹	º	»	¼	½	¾	¿	
30x	À	Á	Â	Ã	Ä	Å	Æ	Ç	Cx
31x	È	É	Ê	Ë	Ì	Í	Î	Ï	
32x	Ð	Ñ	Ò	Ó	Ô	Õ	Ö	×	Dx
33x	Ø	Ù	Ú	Û	Ü	Ý	Þ	ß	
34x	à	á	â	ã	ä	å	æ	ç	Ex
35x	è	é	ê	ë	ì	í	î	ï	
36x	ð	ñ	ò	ó	ô	õ	ö	÷	Fx
37x	ø	ù	ú	û	ü	ý	þ	ÿ	
	8	9	A	B	C	D	E	F	

Table 1.5: Font Table for Fonts #0 and #1

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

TS $\langle n \rangle$ = Thin space of $\langle n \rangle$ pixels

Table 1.6: Font Table for Font #2

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

F—Flash Lights in Sequence

0	1	...	n	$n + 1$	$n + 2$		
F	$\langle led_0 \rangle$	$\langle led_1 \rangle$	$\langle led_2 \rangle$	\cdots	$\langle led_{n-1} \rangle$	\$	$\neg D$

Each $\langle led \rangle$ value is an ASCII digit character corresponding to a discrete LED as shown in Table 1.7. 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 $\langle led \rangle$ codes may be listed. The sign will cycle through the sequence, lighting each specified LED briefly before moving on to the next

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 1.7: Discrete LED Codes and Colors

one. The sequence is repeated forever in a loop until an L, S or X command is received.

If only one $\langle led \rangle$ 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”).

H—Draw Bar Graph Data Point

0	1	2
H	$\langle n \rangle$	$\sim D$

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 $\langle n \rangle$ 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 $\langle n \rangle$ 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	$\langle merge \rangle$	$\langle pos \rangle$	$\langle trans \rangle$	$\langle coldata_0 \rangle$		$\langle coldata_1 \rangle$		\cdots
$\langle coldata_{n-1} \rangle$		\$	$\wedge D$					

Draws an arbitrary bitmap image onto the matrix display starting at column $\langle pos \rangle$, encoded as per Table 1.3. A $\langle pos \rangle$ value of “~” represents the current column cursor position.

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 1.8: Transition Effect Codes

Each column data, from left to right, are given by $\langle coldata \rangle$ 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 $\langle merge \rangle$ is the character “.” then each column’s contents is cleared before setting the pixels as per the $\langle coldata \rangle$ value. If $\langle merge \rangle$ is “M” the bits set in $\langle coldata \rangle$ are added to the lit pixels already in the column.

The $\langle trans \rangle$ value indicates the transition effect to use when adding the image to the display. See Table 1.8.

L—Light Multiple LEDs

0	1	...	n	$n + 1$	$n + 2$		
L	$\langle led_0 \rangle$	$\langle led_1 \rangle$	$\langle led_2 \rangle$	\cdots	$\langle led_{n-1} \rangle$	\$	$\neg \mathcal{D}$

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 1.7. Note that if a strobe sequence is running (via a previous * command), it remains running.

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	<i><model></i>	V	<i><hwversion></i>	R	<i><romversion></i>	S
<i><serial></i>		\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

The *<serial>* field is a variable-width 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.

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	<i><led></i>	~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 1.7. 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	...		
T	<i><merge></i>	<i><align></i>	<i><trans></i>	<i><string></i>	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).

⁴See semver.org.

The *⟨trans⟩* code specifies the transition effect to be used to add this string to the display as shown in Table 1.8.

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

0	1
X	~D

Turns off the flasher, strober, and all discrete LEDs.

This command may be given in upper- or lower-case (“x” or “X”).