MG013 Alphanumeric Display

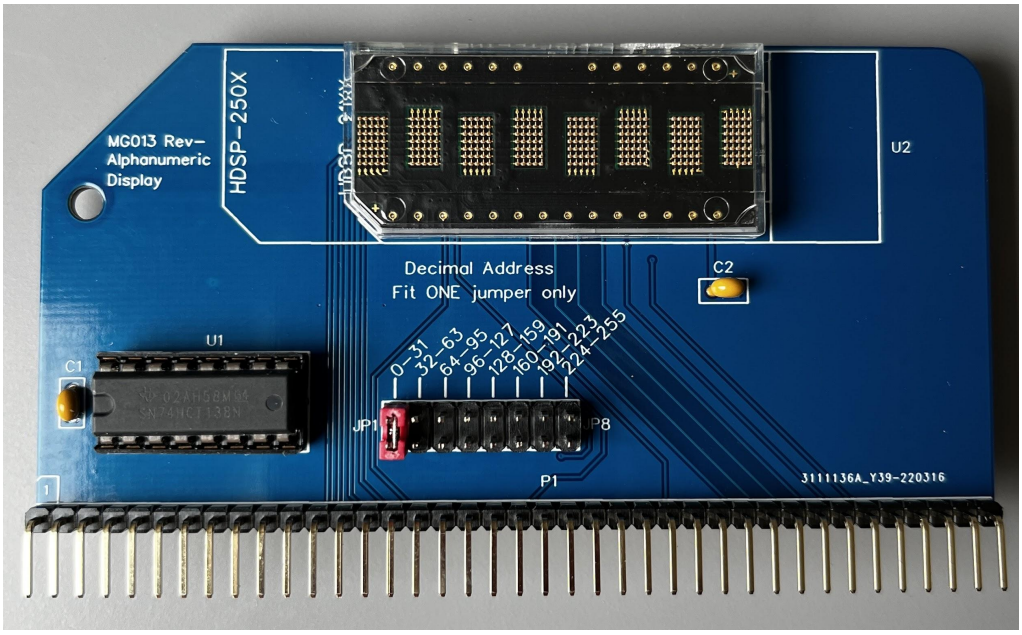
What is it?

MG013 is an Alphanumeric Display that uses one of the following 8 character LED modules:

- HDSP-21XX
- HDSP-250X
- HDSP-253X[1]

It uses standard BASIC OUT and IN (for self test) commands and is capable of displaying 128 different ASCII characters as well as 16 programmable symbols.

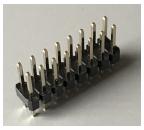
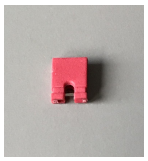
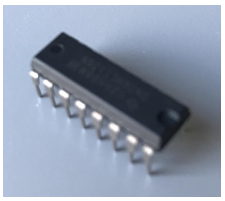
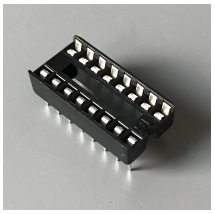
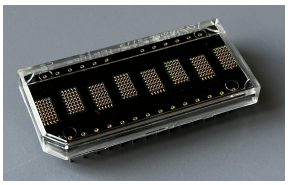
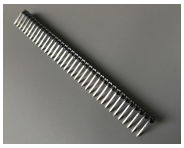
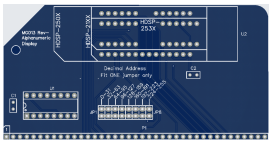
The HDSP displays are available new from Broadcom®[2] stockists, but they tend to cost over £40 in the UK. The ones provided in the kit will be fully tested "new old" stock, but the kit can be bought minus display in case a purchaser wishes to go out and buy a new one.



[1] Where "X" = a digit that determines the colour of the display. HDSP-21XX and -253X have characters approximately 5mm tall, HDSP-250X characters are 7mm tall

[2] HDSP displays also appear to have been marketed under HP/Agilent and Avago trade marks

What's in the kit?

Name	Quantity	Description	Picture	Present?
C1-2	2	Capacitor, ceramic, 100 nF		❜
JP1-8	1	Header, male, 2 x 8 pin, straight		❜
JP1 Shunt	1	Jumper shunt		❜
U1	1	74HCT138		❜
U1 socket	1	16-pin DIP socket		❜
U2	1	Display: HDSP-21XX, or HDSP-250X, or HDSP-253X		
P1	1	Pin Header, Right Angle		❜
PCB	1	MG013 PCB		❜

How do I build it?

There's a good chance you will have some soldering experience, as you're likely to have built an RC2014 or equivalent to plug your MG013 into. If you haven't, I recommend searching for an online tutorial, there are some good ones on YouTube.

Recommended tools include:

- Soldering iron (ideally temperature controlled)
- Multicore solder
- Small snips to cut off leads
- Small pliers
- Desoldering pump and/or braid
- Anti-static wrist strap (or steer clear of materials that cause static and touch a grounded object every now and then).

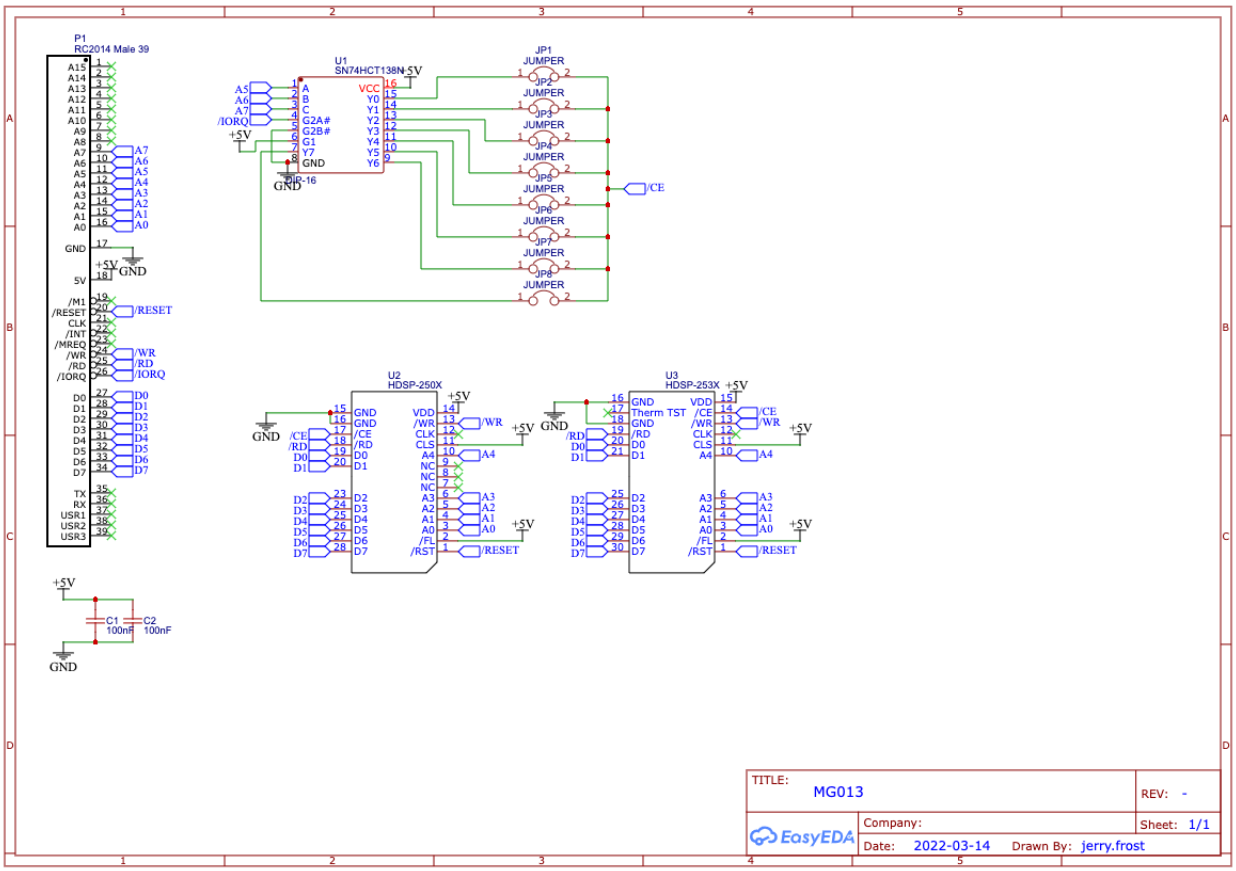
The normal rule of thumb is to solder the lowest height components first, working up:

- P1. This is normally supplied with 40 pins, therefore one needs to be carefully cut off using a sharp knife. Then, solder one joint only, check the alignment, melt solder and correct alignment if required before soldering remaining joints.
- C1-2. Orientation doesn't matter.
- Socket for U1 (do not fit IC itself yet). Similarly to P1, solder two opposite corners, check the socket is flat on the board before continuing. Make sure the notches at the end of the socket matches with the PCB graphics, to reduce the risk of installing the IC the wrong way round
- U2. Make sure the corner notch matches the PCB graphic
- JP1-8 (actually a single part)

If you have flux cleaner, clean all joints. Now inspect them carefully for issues (a magnifying glass of some sort can be very helpful, the camera on some phones works quite well).

The final step prior to plugging into the host system and testing is to fit IC1 into its socket. Its legs will probably need a bit of gentle bending on a table or similar surface, to bring the two rows a little closer to each other. Pay attention to orientation.

How does it work?



The HDSP display has two possible pin layouts, and hence is shown twice in the above diagram, as U2 and U3. Only one display can be fitted, however. On the PCB itself only the label U2 is used. The display connects straight to the RC2014 8 bit data bus, and 5 of the 8 address lines that are used for I/O:

- A0 to A2 select the required character
- A3 and A4 select the register/RAM to be accessed

This leaves 3 I/O address lines to set the MG013 address (A5 to A7). These go to U1, which is a 3 to 8 line decoder. Each of the 8 possible values of A5 to A7 will cause a corresponding output pin to go low. If this is the pin that is jumpered in JP1-8, then the low will be fed to the /CE pin of the display, enabling it for a read or write.

How do I use it (basics[3])?

The following example uses BASIC as employed by the RC2014 Classic etc. For users that have an RC2014 Pro or similar, my website (https://jerryfrost1.wixsite.com/tech) provides C source code and executables suitable for CP/M.

The first step is to set the address. For the MG013 one (and one only) of JP1-8 must be jumpered, to give one of the following decimal address ranges:

A	0-31	D	96-127	G	192-223
B	32-63	E	128-159	H	224-255
C	64-95	F	160-191		

If the standard RC2014 serial I/O board is in use, then E and F above should not be used, as they will cause MG013 to interfere.

Broadcom's website has some good downloadable data sheets[4] that cover all modes of operation. The only one not supported by MG013 is /FL (the ability to flash individual characters). The basics of operation are covered below.

The use of the address lines is:

A4	A3	Usage	A2, A1, A0
0	0	User Defined Character (UDC) Register	Doesn't matter
0	1	UDC RAM	Row Address
1	0	Control Word Register	Doesn't matter
1	1	Character RAM	Character Address

[3] A brief description of more advanced usage is in Appendix B
[4] At the time of writing they're at https://www.broadcom.com/products/leds-and-displays/smart-alphanumeric-displays/parallel-interface (filter for 8 digits to cut the list down)

Noting that the decimal values of A0 to A4 are:

A4	16
A3	8
A2 - A0	7 total (4+2+1)

Assuming we want to write some standard ASCII characters to the display, and that the JP1-8 jumper is in "A" position. The addresses we need are:

- 0 (starting address of "A")
- + 16 + 8 (A4 and A3 set to 1 for Character RAM)
- + 0 (LH character) up to + 7 (RH character)

Which gives 24 (LH) all the way up to 31 (RH) as the addresses to write to each character. The data that needs to be written is the ASCII code for the character to be displayed, which will be a value from decimal 0 to 127 (See Appendix A for a guide).

Before we go ahead and write characters to the display, it's worth considering display brightness. These displays can draw over 400mA[5] at full brightness, which together with the current draw of the rest of the RC2014 may be a lot for an RC2014 power supply. Therefore it's a good idea to start off at a lower brightness. This will require writing to the control word register:

- 0 (starting address of "A")
- + 16 + 0 (A4 set to 1 and A3 set to 0 for Control Word Register)
- Bits A2 to A0 are "doesn't matter" for Control Word Register so we'll set them all to 0.

This gives 16 as the address to write to the control register. Right now we only need to worry about data bits D2, D1 and D0 and can safely leave the others set to 0:

[5] This is with all 8 characters displaying "#" for 20 dots each (one of the higher dot-count symbols). This current value also varies depending on display colour and temperature.

D2	D1	D0	Brigh tness
0	0	0	100%
0	0	1	80%
0	1	0	53%
0	1	1	40%

D2	D1	D0	Brigh tness
1	0	0	27%
1	0	1	20%
1	1	0	13%
1	1	1	0%

Therefore to set the display to 27% brightness we need to send binary 00000100, which is decimal 4. Putting this together gives us:

BASIC CODE	*Notes*
10 OUT 16, 4	*Set brightness to 27%*
20 OUT 28, 61	*Display "=" at character 5*
30 FOR X = 0 TO 127	*Loop through ASCII Characters*
40 LET U = X	*U is variable for units*
50 LET H = INT (U/100)	*Lines 50 to 80 fill H and T*
60 LET U = U - (H * 100)	*With hundreds and tens*
70 LET T = INT (U/10)	
80 LET U = U - (T * 10)	
90 OUT 24, (H + 48)	*Output ASCII codes for*
100 OUT 25, (T + 48)	*hundreds, tens and units*
110 OUT 26, (U + 48)	*of X to characters 1-3*
120 OUT 30, X	*Output character relating to ASCII code at position 7*
130 FOR Y = 0 TO 1000	*Delay*
140 NEXT Y	
150 NEXT X	*And go round for next character*

Acknowledgements/Legal

MG013 has been designed for RC2014 with reference to the RC2014 Module Template. All pinouts used and the physical outline are in compliance with the RC2014 Module Template.

RC2014 is a trademark of RFC2795 Ltd.

MG013 has been designed for hobbyist use only and is not to be used for safety or business critical applications.

Appendix A - ASCII Characters

The following table gives the characters displayed by ASCII codes decimal 32 to 126 (Hex 20 to Hex 7E).

Other characters (decimal 0 to 31 and 127) can be found in the Broadcom datasheets, or viewed using my example BASIC program.

Dec	Hex	ASCII	Dec	Hex	ASCII	Dec	Hex	ASCII	Dec	Hex	ASCII	Dec	Hex	ASCII	Dec	Hex	ASCII
32	20		48	30	0	64	40	@	80	50	P	96	60	`	112	70	p
33	21	!	49	31	1	65	41	A	81	51	Q	97	61	a	113	71	q
34	22	"	50	32	2	66	42	B	82	52	R	98	62	b	114	72	r
35	23	#	51	33	3	67	43	C	83	53	S	99	63	c	115	73	s
36	24	$	52	34	4	68	44	D	84	54	T	100	64	d	116	74	t
37	25	%	53	35	5	69	45	E	85	55	U	101	65	e	117	75	u
38	26	&	54	36	6	70	46	F	86	56	V	102	66	f	118	76	v
39	27	'	55	37	7	71	47	G	87	57	W	103	67	g	119	77	w
40	28	(	56	38	8	72	48	H	88	58	X	104	68	h	120	78	x
41	29	)	57	39	9	73	49	I	89	59	Y	105	69	i	121	79	y
42	2A	*	58	3A	:	74	4A	J	90	5A	Z	106	6A	j	122	7A	z
43	2B	+	59	3B	;	75	4B	K	91	5B	[	107	6B	k	123	7B	{
44	2C	,	60	3C	<	76	4C	L	92	5C	\	108	6C	l	124	7C	|
45	2D	-	61	3D	=	77	4D	M	93	5D	]	109	6D	m	125	7D	}
46	2E	.	62	3E	>	78	4E	N	94	5E	^	110	6E	n	126	7E	~
47	2F	/	63	3F	?	79	4F	O	95	5F	_	111	6F	o			□

Appendix B - More Advanced Usage

The main body of these instructions shows how to display standard characters, and vary display brightness, which is all many users will ever need. For the sake of completeness, the HDSP datasheet also illustrates how to:

- Flash the display
- Run self test and check the result
- Define User Defined Characters (UDCs) and display them

The following paragraphs give a quick introduction to the above.

The full control word definition is:

D7	D6	D5	D4	D3	D2	D1	D0
Clear display	Start Self Test	Self Test Result	Blink	Flash	Brightness (See Page 6)		

The function of most of these is obvious. A 1 on D7 clears the display, and on D3 causes the whole display to flash (the individual digit blinking enabled by D4 does not work on MG013).

A 1 on D6 puts the display in self test mode, with the result being made available on D5 (1 equalling “pass”, and the only time an “INP” from MG013 is ever likely to be needed).

This just leaves UDCs, and the top level process is:

- Output a UDC register word (A4 and A3 0, A2 to A0 don’t care) with the UDC character to be modified (0 - 15) in D3 to D0.
- For each row of this character, output a UDC RAM word (A4 0, A3 1, A2 to A0 selecting the row from 1 to 7) with D0 to D4 selecting the dots on that row to be lit.
- The UDC character can then be selected the same as a normal character, but with D7 set to 1, and UDC character number in D3 to D0.