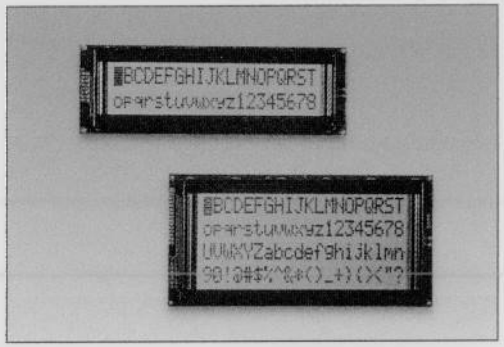
This feature introduces the reader to the use of alphanumeric LCD modules as used in many electronic devices that have to display information back to the user.

Popular sizes of these modules range from 16, 20, 24 and 40 characters with 1 to 4 lines available on the screen

These displays usually have a controller chip on board such as the Hitachi HD44780 or an equivalent which responds to the same command format.

Use of these modules is simplified due to the use of a fairly basic interface which can be programmed by a microcontroller such as the Microchip PIC, 8051 core processor, Z80, MC68HCxxx, or even by the use of manually operated push-button switches.

Table1. shows the connections to the most popular modules, as you can see the interface comprises of 14 pins, the functions in further detail are:



Pin 1. The ground connection common to the power supply and the controlling device.

Pin 2. The positive supply usually +5volts dc.

Pin 3. The contrast pin, a voltage varying from Vdd to 0v will adjust the contrast of the pixels on the display, some modules may require this control voltage to extend to a negative voltage such as –7V.

Pin 4. The register select pin, when this pin is low any data latched into the display will be interpreted as a module **command**, when it is high the data will be interpreted as **character** information such as 'ABCD!"£$'.

Pin 5. The Read/Write pin, when this pin is low the module will accept any information Written to it, when this pin is High the LCD module can send information out such as the Module Busy flag.

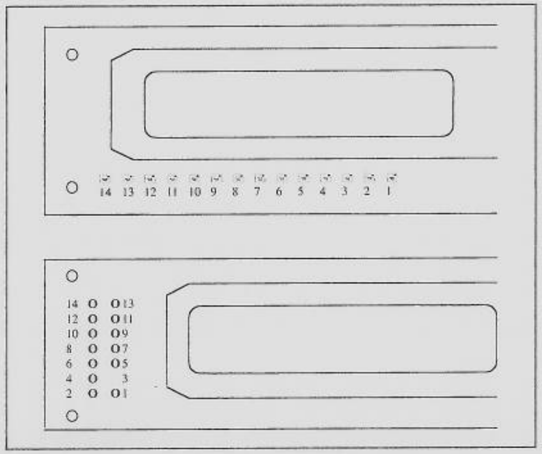
Pin 6. The 'E' pin, this is the strobe line to latch data or commands into the module, the data is transferred into the module on the high to low transition. If **reading** from the module, the data will be valid on the data bus shortly after the low to high transition and will remain only whilst the pin is held high.

Pins 7-14. These pins are the databus connections used to carry the information either into or out of the module.

Table1. Interface pin-out diagram

Pin function	Name	Pin number
Ground	Vss	1
+ve supply	Vdd	2
Contrast	Vee	3
Reg. Select	RS	4
Read/Write	R/W	5
Enable	E	6
Data bit 0	D0	7
Data bit 1	D1	8
Data bit 2	D2	9
Data bit 3	D3	10
Data bit 4	D4	11
Data bit 5	D5	12
Data bit 6	D6	13
Data bit 7	D7	14

Pinouts of the two basic LCD formats



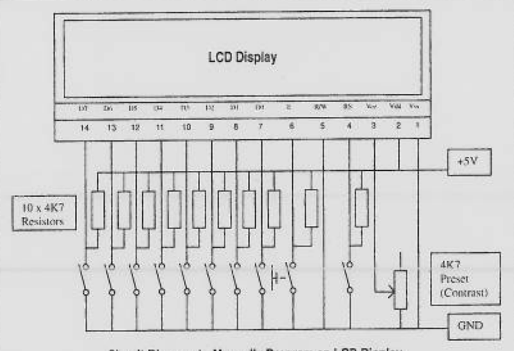
Making A Manual Test Rig

The interface can be easily controlled via a set of Dip switches and push-buttons, this will enable the user to control the functions of the module byte-by-byte.

The connection diagram 2 shows a basic setup, the switches for the databus could be an 8-way DIP switch, the strobe line (E) being a normally open push-button switch and the register select pin (RS) a two position toggle or slide switch. The potentiometer for the contrast being a 4K7 preset type, set this control to midpoint initially.

The R/W line has been grounded for this test as the module will only have data written to it.

On initial power-up the display defaults to a 'display off' mode, this means that even if valid characters have been sent to the module they will not show on the screen until a 'display On' command has been sent. Looking at the information in table 3. It can be seen that the display on/off /cursor command byte will do this function, it also controls the cursor style as well. To set the module to 'display-on', 'Cursor-on' with underlining and a cursor that blinks, the binary value '00001111' has to be loaded as a command. To do this set the Register Select (RS) pin to low, this is **command entry mode**, then set the DIP switches D0-D7 to '00001111', the (E) input must now be briefly pressed to 'strobe' the command into the module. If all is well at this point the display should now be on with a flashing cursor in the left-hand corner, adjust the contrast control for optimum viewing darkness. On a two line LCD module, the display needs a further command to set it to two-line mode. This is accomplished by sending a 'function set' command with the appropriate bit set to enable this mode, this time the byte to send would be '00101000' which is again achieved by setting the value on the DIP switches with register Select low and then 'strobing' the data in.



Circuit Diagram to Manually Program an LCD Display

Table 3 Command Control Codes

Command	D7	D6	D5	Binary D4	D3	D2	D1	D0	Hex
Clear Display	0	0	0	0	0	0	0	1	01
Display & Cursor Home	0	0	0	0	0	0	1	x	02or 03
Character Entry Mode	0	0	0	0	0	1	I/D	S	04 to 07
Display On/Off & Cursor	0	0	0	0	1	D	U	B	08 to 0F
Display/Cursor Shift	0	0	0	1	D/C	R/L	x	x	10 to 1F
Function Set	0	0	1	8/4	2/1	10/7	x	x	20 to 3F
Set CGRAM	0	1	A	A	A	A	A	A	40 to 7F
Set Display Address	1	A	A	A	A	A	A	A	80 to FF

I/D: 1 = Increment*, 0 = Decrement
S: 1 = Display shift on, 0 = Display shift off*
D: 1 = Display On, 0 = Display Off*
U: 1 = Cursor underline on, 0 = Underline off*
B: 1 = Cursor blink on, 0 = Cursor blink off*
D/C: Display shift, 0 = Cursor move

R/L: 1 = Right shift, 0 = Left shift
8/4: bit interface*, 0 = 4 bit interface
2/1: 1 = 2 line mode, 0 = 1 line mode*
10/7: 1 = 5 x 10 dot format, 0 = 5 x 7 dot format

x = Don't care * = Initialisation settings

Character Table and User Definable Characters

Now for the characters to be displayed, referring to table 4 shows the address values of the characters stored in the module's internal ROM. The codes to access these characters conform to the ASCII standards, so that sending the code '01000001' which is the ASCII code for 'A' will put the character 'A' on the display.

To send characters to the display, the Register Select pin must now be set to high (data entry mode), and the ASCII code for a character must be set on the DIP switches, for the moment set up the byte '01000110' which is the letter 'F', enter the data by 'strobing' the enable pin, the letter 'F' should now appear. Further pressing of the enable pin fills up the display with letter F's. In this way, any text can displayed on the screen. The enable pin is very fast, so any contact bounce from the push-button will produce multiple character entries to be displayed. When used with a microcontroller this situation would not be a problem as only one pulse per 'character entry' would be generated by the program.

You will have noted that the first 16 locations in the character table are blank, this is because the Character Generator can hold user definable characters at these locations. This is a very useful feature in which special characters used for 'bar-graphs' or animated graphics may be set-up and accessed as easily as normal text.

Codes from '11100000' to '11111111' are slightly different characters in that they are lowercase symbols with 'descenders', these are the letters with tails on them such as y, j, q, g and p, these would need the display to be set up to 5 x 10 dot format to display

Standard LCD character table

Table 4 Correspondence between Character Codes and Character Patterns

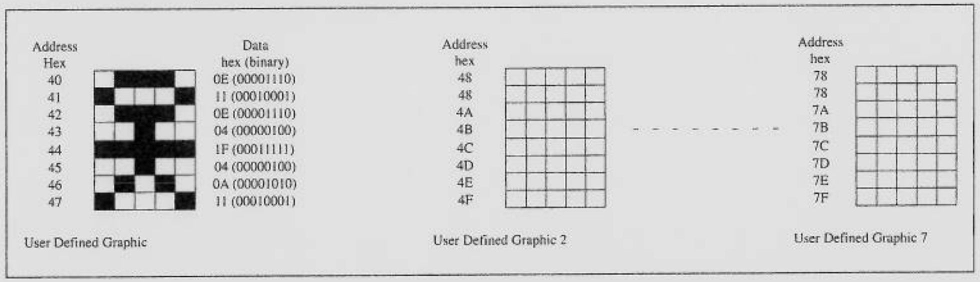
Lower 4 Bits \ Upper 4 Bits	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
xxxx0000	CG RAM (1)			0	@	P	`	p				ー	タ	ミ	α	p
xxxx0001	(2)		!	1	A	Q	a	q			。	ア	チ	ム	ä	q
xxxx0010	(3)		"	2	B	R	b	r			「	イ	ツ	メ	β	θ
xxxx0011	(4)		#	3	C	S	c	s			」	ウ	テ	モ	ε	∞
xxxx0100	(5)		$	4	D	T	d	t			、	エ	ト	ヤ	μ	Ω
xxxx0101	(6)		%	5	E	U	e	u			・	オ	ナ	ユ	σ	ü
xxxx0110	(7)		&	6	F	V	f	v			ヲ	カ	ニ	ヨ	ρ	Σ
xxxx0111	(8)		'	7	G	W	g	w			ァ	キ	ヌ	ラ	g	π
xxxx1000	(1)		(	8	H	X	h	x			ィ	ク	ネ	リ	√	x̄
xxxx1001	(2)		)	9	I	Y	i	y			ゥ	ケ	ノ	ル	⁻¹	y
xxxx1010	(3)		*	:	J	Z	j	z			ェ	コ	ハ	レ	j	千
xxxx1011	(4)		+	;	K	[	k	{			ォ	サ	ヒ	ロ	ˣ	万
xxxx1100	(5)		,	<	L	¥	l	|			ャ	シ	フ	ワ	¢	円
xxxx1101	(6)		-	=	M	]	m	}			ュ	ス	ヘ	ン	£	÷
xxxx1110	(7)		.	>	N	^	n	→			ョ	セ	ホ	゛	ñ	
xxxx1111	(8)		/	?	O	_	o	←			ッ	ソ	マ	゜	ö	█

Note: The user can specify any pattern for character-generator RAM.

correctly, otherwise the character may 'borrow' a couple of pixels from the line below on a two-line LCD module.

To generate a 'user definable character' the control commands '01000000' to '01111111' are used. First of all initialise the display to be 'display-on', cursor-on and then with a 'clear-display' command issued the module should be ready to start. The command 'Set display address' should now be entered, to position the cursor at address '00000000'. To view the contents of the eight user definable characters, enter the data '00000000' to '00000111', this will show up as random pixels in each character location until some valid data has been initialised into each location. Setting up the data in each location is accomplished by entering the 'bit-pattern' of the character pixel-by-pixel. To do this enter the command 'Set CGRAM' (01000000), data entered from now on will be interpreted as 'bit-pattern' data and each byte will build up a character image row-by-row. By entering the following data, the image of a small man will appear on the display: 00001110, 00010001, 00001110, 00000100, 00011111, 00000100, 00001010, 00010001. By continuing to enter bytes of data, all the user definable characters may be built up and then used accordingly. Remember that these eight locations are in **volatile RAM** and any information stored here will be lost if the module is powered-down, so if they are required within a routine, they must be loaded on system power-up.

CGRAM addresses relating to the individual pixels.



Address Hex	Data hex (binary)
40	0E (00001110)
41	11 (00010001)
42	0E (00001110)
43	04 (00000100)
44	1F (00011111)
45	04 (00000100)
46	0A (00001010)
47	11 (00010001)

User Defined Graphic

Address hex: 48, 48, 4A, 4B, 4C, 4D, 4E, 4F

User Defined Graphic 2

Address hex: 78, 78, 7A, 7B, 7C, 7D, 7E, 7F

User Defined Graphic 7

Addressing

When power is first applied to the LCD module the cursor is positioned at location '00000000', which is the beginning of the first line. When a character is entered the address increments to the next address and so on. It may be required to position a string of characters at a position other than at the beginning of the line, to do this a new starting address must be entered as a command. Any address from '00000000' to '11101111' may be entered (128 addresses), but not all of the addresses may have a physical display location on the LCD module being used.

The relationship between the display locations and addresses used does vary between the different types and sizes of display module. The most common types are shown in table 6.

Display Shift

The controller has control of 80 display locations regardless of the size of the display being used. The smaller LCD modules will not be able to display all 80 locations at the same time, but will display a movable 'window' which can be moved to display a section of the 80 locations. This shifting of the display 'window' must be done with care as it alters the relationship between the display address and the positions they actually show up on the screen.

To try this function out, initialise the display with the 'display-on', 'cursor-on' and 'clear-display' commands, then enter the data for all 26 letters of the alphabet. On a small screen LCD module the whole 26 letters will not be visible, but only a portion of the characters will be on the screen. The 'Cursor / Display Shift' (00011000) command can now be used to scroll the characters, each time the command is used, the display will shift one place left and more of the 'hidden' letters will become visible. If the shift command is continued, then the display will eventually come back to it's starting position. Using the command (00011100) will shift the letters to the right.

Remember that the screen 'window' is the part that is shifting, not the actual address of the location, issuing the 'Cursor Home' (00000010) command resets the cursor and shift address back to zero. The command 'Clear Display' does the same function as cursor home, but this command **also** clears all the display locations.

4-bit Data transfer

This is an extremely useful feature of these LCD modules in that the number of interface lines to the controlling circuit can be reduced. This is particularly important when I/O lines are at a premium such as on a microcontroller. Once the LCD module has been set to 4-bit mode, the data must be sent in two 4-bit 'nibbles' instead of one 8-bit byte. When using the 4-bit mode, only data lines D4 to D7 are used, the data lines D0 to D3 are redundant and must be tied low via resistors. Only connect them directly to ground if the R/W pin has also been tied low, this is in case the module is put into READ mode and the output from the data lines would be shorted to ground.

When the LCD module is first powered-up it will start in 8-bit mode.

Table 6. LCD addresses and locations

00	01	02	03	04	05	06	07	08	09	40	41	42	43	44	45	46	47	48	49

20 Character 1 Line (TLCM2011)

00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F
40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F

16 Character 2 Line (TLCM1621 or LM016L)

00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	10	11	12	13
40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	50	51	52	53

20 Character 2 Line (LM032L)

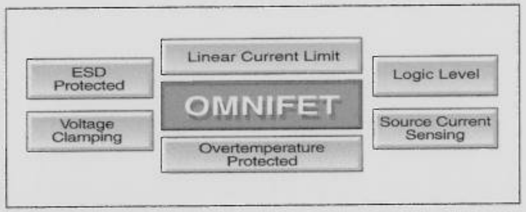
The function set command to place the module into 4-bit mode must be sent (00100000), the code for this mode has been chosen carefully so that the lower four bits of the command are (0000) which is the default of these pins as they would be tied to ground in a 4-bit application. After this command has been sent, any further commands such as 'display-on', 'Cursor-on' etc must be sent as two 4-bit nibbles. the **upper nibble first** and then the lower nibble.

For further reading, the data sheets for these modules are available from the Farnell website **www.farnell.com**, using these datasheets the reader can fully appreciate all the features and control modes of these versatile modules.

OMNIFETs Fully Autoprotected Power MOSFETs

DESCRIPTION

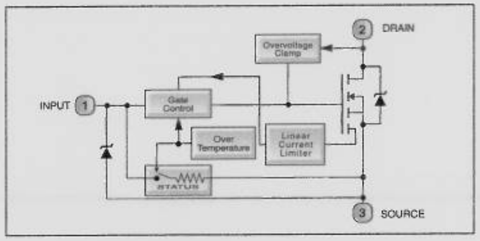
SGS-THOMSON Microelectronics, the world's number one supplier of smart power devices offers OMNIFETs, an outstanding family of fully autoprotected low voltage Power MOSFETs that will make application design much easier. During normal operation OMNIFETs react just as "dumb" MOSFETs, however they provide complete protection when required. Overvoltage clamp, overtemperature and short circuit protection, status feedback, linear current limitation and ESD protection functions mean that OMNIFETs are able to face any abnormal condition. They can also be driven from both analog and logic-level signals and can be housed in a standard 3 pin package such as TO-220, D2PAK or DPAK!



APPLICATIONS

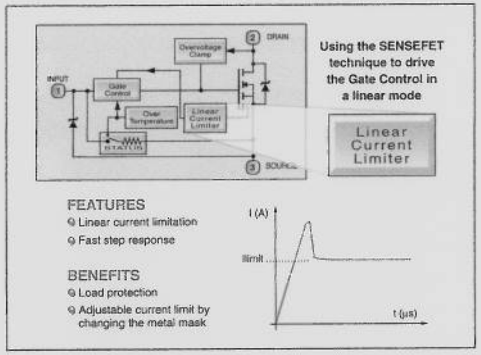
Pin-to-pin compatibility with standard MOSFETs along with a more compact, reliable and less expensive protection circuitry built inside, make OMNIFETs ideal replacements for low voltage discrete Power solutions in all applications requiring high reliability and safety levels.

Clamp voltages for OMNIFETs range from 40 to 70 Volts. This makes them perfect for all battery powered applications using low-side configuration switches. Fan control in automotive or portable drill equipment are two excellent examples



Overvoltage Clamp Protection

This feature gives OMNIFETs unrivalled energy capability when driving inductive loads. At device switch-off, the energy stored in the inductance load must be dissipated, and in normal Power MOSFETs this is accomplished by the avalanche breakdown mechanism. However, this results in overstress of the of the MOSFETs under harsh conditions. The OMNIFET's ability to switch itself on at an output voltage lower than the breakdown level allows the load energy to be safely dissipated. This translates into an unrivalled energy handling capability.



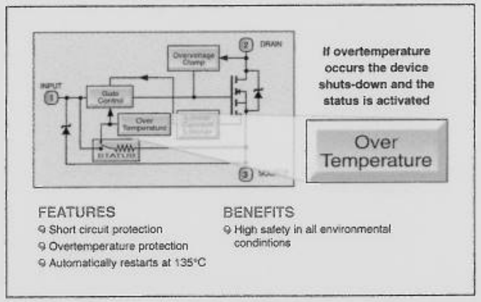
Using the SENSEFET technique to drive the Gate Control in a linear mode

FEATURES
- Linear current limitation
- Fast step response

BENEFITS
- Load protection
- Adjustable current limit by changing the metal mask

Logic Level and Analog Driving Operation

OMNIFETs operate from analog driving (due to direct access to the gate of the Power MOSFET) as well as from TTL/CMOS driver circuits for a logic level operation, with just a small increase in R(DS)ON. The intrinsic body drain diode is rated at the same current as the Power MOSFET and can be used as a freewheeling diode when required by the application.



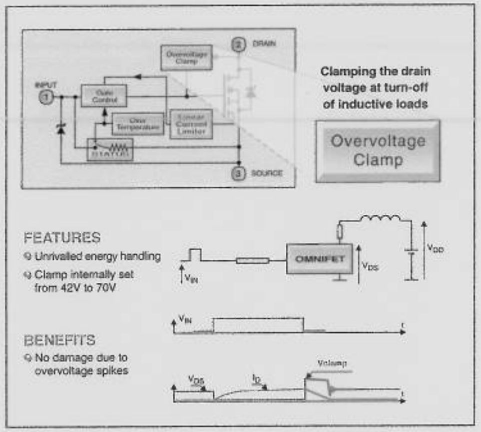
If overtemperature occurs the device shuts-down and the status is activated

FEATURES
- Short circuit protection
- Overtemperature protection
- Automatically restarts at 135°C

BENEFITS
- High safety in all environmental condintions

CREATION

At present the OMNIFET family consists of 11 different devices in 8 package alternatives, for a total range of 42 device options (see OMNIFET product range). Devices are available in three clamping voltages: 42, 60 and 70 Volts. Current limitation values spread from 5 to 100 Amps.



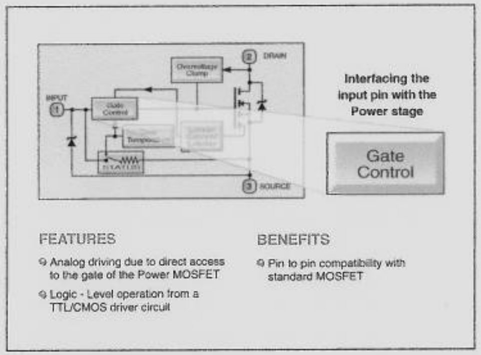
Clamping the drain voltage at turn-off of inductive loads

FEATURES
- Unrivalled energy handling
- Clamp internally set from 42V to 70V

BENEFITS
- No damage due to overvoltage spikes

Linear Current Limitation and ESD Protection

Using the SENSEFET technique, the drain current is compared with a built-in reference. If the maximum current level is exceeded the gate drive is reduced until the current falls below the maximum limit. This makes OMNIFETs particularly suited to handle in-rush currents. ESD input pin protection is also provided according to both the Human Body Model and machine models.



Interfacing the input pin with the Power stage

FEATURES
- Analog driving due to direct access to the gate of the Power MOSFET
- Logic - Level operation from a TTL/CMOS driver circuit

BENEFITS
- Pin to pin compatibility with standard MOSFET

Overtemperature and Overload Protection

Overtemperature and overload protection are based on sensing the chip temperature, independently from the input voltage. The location of the sensing element in the power stage allows a fast and accurate detection of the junction temperature.