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Constructional Project

VERSATILE PIC FLASHER

STEVE CHALLINOR

Enhance your Christmas decorations or your child's ceiling with this versatile PIC-controlled flasher display

BEHIND this design was an idea to make an interesting ceiling display for a child's bedroom. One of the author's colleagues had seen a display of blue lights in a shopping centre and wanted to know if the author could duplicate this.

The lights needed to be slowly increasing and decreasing in brightness and behaving in a random fashion. Thereby was perceived a means by which the author could lull his own insomniac toddler to sleep, and so set to work immediately!

TAKE YOUR PIC

Basing the system on a PIC microcontroller, it was found that the results were so pleasing that it was thought to be of interest to *EPE* readers – but absolutely no guarantee about the sleep remedy!

The original idea has been expanded to create a number of different effects, so that apart from the slow and soothing bedroom display, quite a number of other display options are possible. Pre-programmed PICs are available as stated later for the benefit of readers who do not have PIC programming facilities.

There are five dual-in-line (d.i.l.) switches which select a total of thirty-two possibilities. There are eight outputs, but the light emitting diodes (l.e.d.s) may be chained together to multiply this number. There is too much going on to notice if two or more l.e.d.s are doing the same thing!

APPLICATIONS

Apart from the ceiling display, one variant is a wall display, with a luminous moon crescent mounted on a circle of black card and eight blue l.e.d.s scattered over the rest of the circle. Another is a star, again for wall mounting, with 21 l.e.d.s of different colours. Again this is a wall display but it would make an excellent star for the Christmas tree, or why not a miniature tree for the interior of the car? There must be many imaginative applications.

Although an l.e.d. display was in mind from the outset, the open collector outputs can sink up to 500mA, thus it would also be possible to drive filament bulbs. This could drive the Christmas tree lights in a new way (after substituting a normal bulb for the flasher bulb). This *only* applies to low voltage types, though, with a +24V supply and multiple strings of low voltage bulbs. However, this article only discusses the l.e.d. version.

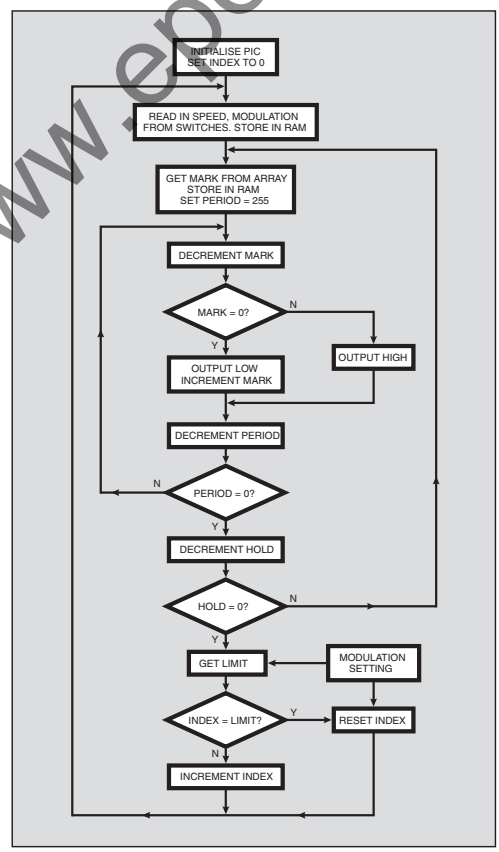

Fig.1. Flow chart for the PIC Flasher.

Looking at his own tree lights in this way, which are +24V and have eight strings of ten 2·4V bulbs, the author wondered is this could be matched using the PIC. However, the problem was the way in which the strings were interlaced, which seemed like a headache to sort out!

The star display is found to be most effective where all the l.e.d.s can be seen together. The ever-changing outputs create a fascinating display.

LIGHTING CONCEPT

Ideally, the light output should be analogue, with the l.e.d.s varying from fully on to fully off. However, the author refused to entertain the idea of eight digital-to-analogue converters with associated drivers.

Instead the circuit uses Pulse Width Modulation (PWM), with the mark/space ratio controlling the brightness of the l.e.d.s – space fully off, mark fully on.

The mark is obtained from an array in programmed PIC memory, which may be termed the *brightness profile*. Thus one complete cycle, from off to maximum and back to off again is obtained as the program reads in values from the whole array. However, each output has a slightly different array length, giving a continual shift in phase between the outputs and hence an apparently random effect.

Each value of mark/space is repeated a number of times to give control over the speed of flashing. Referring to the flow chart in Fig.1, the core operation is the central loop where the mark is decremented to see whether to output a high or a low. The output is set high as long as the mark is non-zero, then low for the rest of the period (the space).

This is repeated up to eight times according to speed and then for every other mark in the array (about two hundred of these) at the same time as jumping about between all eight outputs. This keeps the PIC busy enough not to require delay routines, with the oscillator running at top speed, 20MHz.

CIRCUIT DIAGRAM

Referring to the circuit diagram in Fig.2, switches S1a and S1b set the speed. Switches S1c and S1d control the depth of modulation, meaning how

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far from fully on the l.e.d. goes towards off, i.e. selecting just a central portion of the brightness array. This gives a pulsating effect rather than an on/off flash.

Switch S1e selects between two brightness profiles. One is smooth, but the other has a high speed flash built into the profile. The speed is related to the controls set by the other switches, and at higher speeds gives an "icy shimmer" to the display. Table 1 summarises the settings for the switches.

The PIC16F84A microcontroller is shown as IC1 and is run at 20MHz, as set by crystal X1. Note that the "ordinary" PIC16F84 (without the "A" suffix) is *not suitable* for this design since it has not been manufactured to run at the 20MHz rate required.

The switches S1a to S1e are biased normally high by five resistors. These are within a single resistor module, marked as RM1. The status of the switches is read by the PIC's Port A lines, RA0 to RA4.

The l.e.d.s are controlled by the PIC's RB0 to RB7 lines. They control the switching of transistors TR1 to TR8, via current limiting resistors R1 to R8. As said earlier, the transistors are used in open-collector mode to drive the l.e.d.s, with resistors R10 to R17 limiting the current flow.

The PIC16F84A's Port B is capable of sourcing a maximum of 100mA or sinking 150mA, so it would be feasible to directly control eight single l.e.d.s. However, the provision of the open collector transistors allows several l.e.d.s to be chained together for this larger display.

The number chained will depend on the voltage supply, with roughly 1·8V per l.e.d. required (double this for blue or white) with enough voltage left over to provide a sensible current limiting resistor.

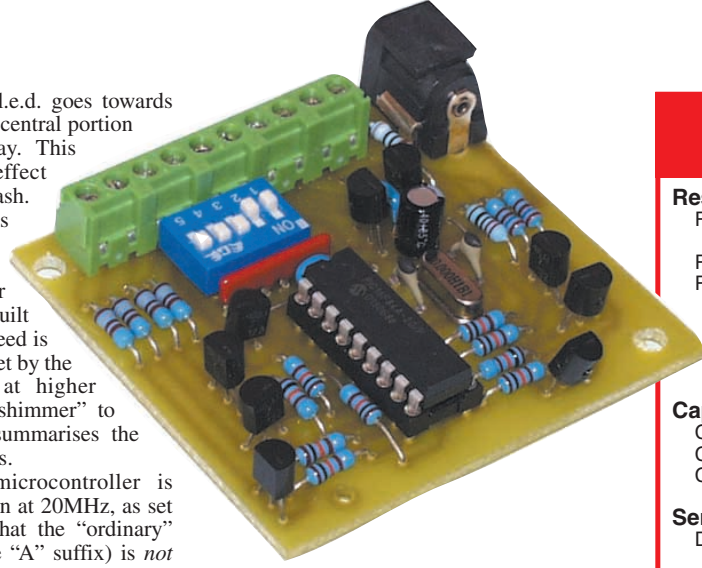

Table 1: Mode switches settings (0 = switch on)

S1a	*S1b*	*Speed*
0	0	Fast
1	0	Medium fast
0	1	Medium slow
1	1	Slow

S1c	*S1d*	*Modulation*
0	0	100%
1	0	50%
0	1	25%
1	1	12·5%

S1e	*Profile*
0	Smooth
1	Flash

COMPONENTS

Resistors

RM1	10k 5-way commoned resistor module, s.i.l.
R1 to R8	10k (8 off)
R9	1k
R10 to R17	see Table 2

See SHOP TALK page

Capacitors

C1, C2	10p ceramic (2 off)
C3, C5	100n ceramic (2 off)
C4	100μ radial elect. 10V

Semiconductors

D1 to D8	l.e.d., see text regarding quantities and styles
TR1 to TR8	BC337 *npn* transistor (8 off)
IC1	PIC16F84A microcontroller, preprogrammed (see text)
IC2	78L05 +5V voltage regulator

Miscellaneous

S1	5-way d.i.l. switch, p.c.b. mounting
X1	20MHz crystal
TB1	2-way terminal block, p.c.b. mounting (5 off)
SK1	2·1mm d.c. power socket, p.c.b. mounting

Printed circuit board, available from the *EPE PCB Service*, code 377; 18-pin d.i.l. socket; display construction material

Approx. Cost Guidance Only **£16** *excl. l.e.d.s*

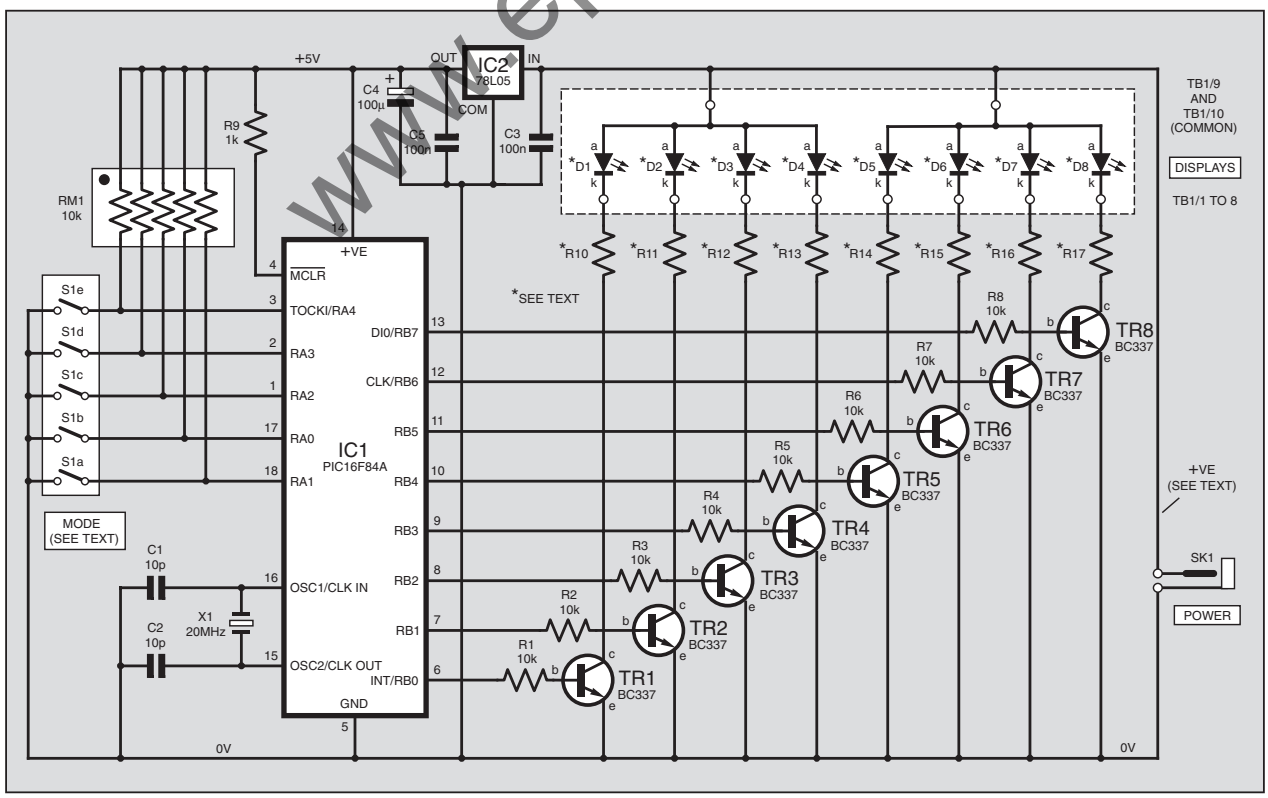

Fig.2. Complete circuit diagram (except power supply – see text) for the Versatile PIC Flasher.

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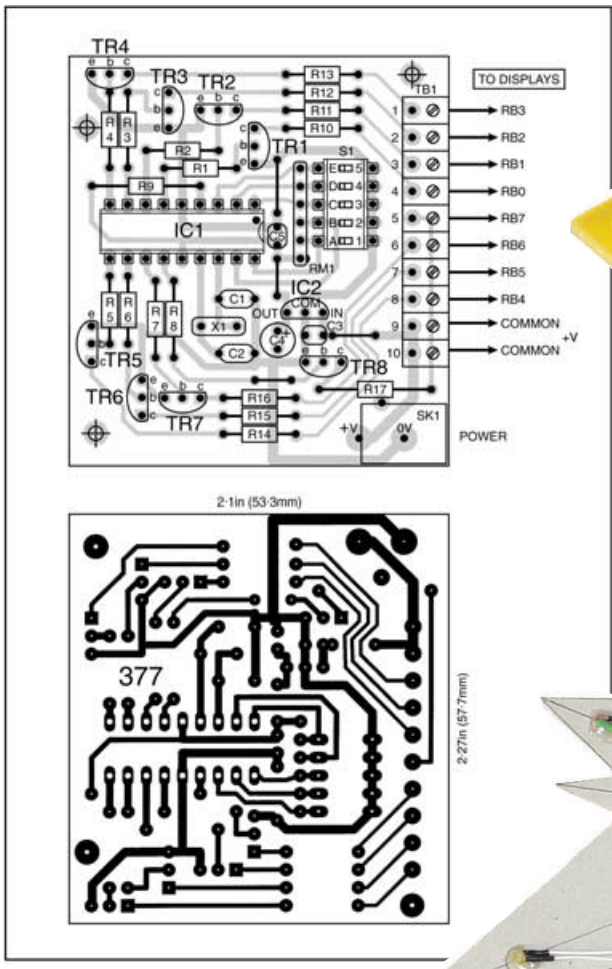
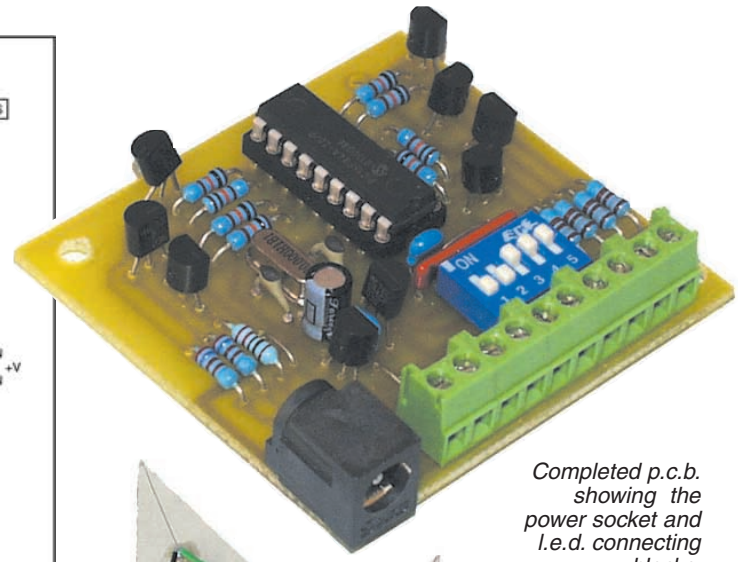
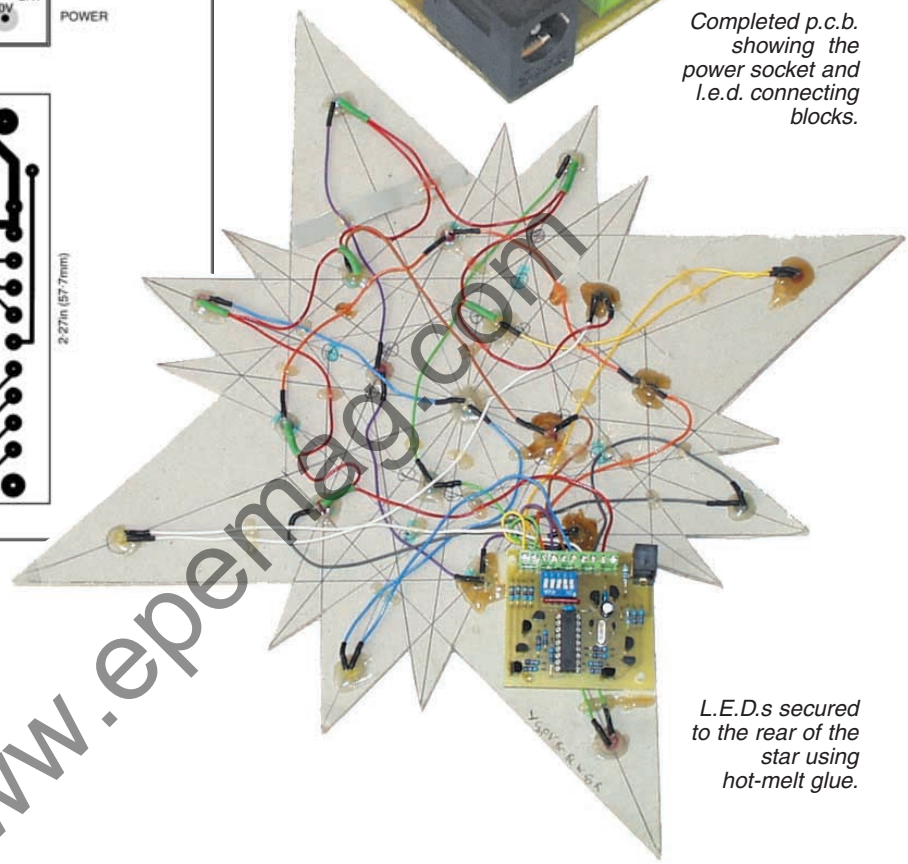


Fig.3. Flasher printed circuit board component layout, full-size copper foil master and lead-off wires to the l.e.d. "chains".



Completed p.c.b. showing the power socket and l.e.d. connecting blocks.



L.E.D.s secured to the rear of the star using hot-melt glue.

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Table 2 shows suitable resistor values to use with a power supply of +12V or +24V. These values are very conservative as the peak current is only reached at the peak of the profile, and this is only a very small part of the overall cycle.

It is worth considering which l.e.d.s to use to suit ambient lighting conditions. For normal room lighting, "standard" l.e.d.s are far too dim, although for a night-time ceiling display they would be fine. However, for use in a normal room lighting situation, super-bright, ultra-bright and even hyper-bright l.e.d.s are available with output intensities comparable with filament bulbs, and these will be suitable for the majority of applications.

In the prototype, diffused 5mm l.e.d.s having 400mcd intensity were used. They provide a wide viewing angle which works very well for wall displays. Should you want to go for even larger displays, there is an abundance of different intensities and sizes available to choose from.

Voltage regulator IC2 provides the PIC with the +5V required. The regulator may be fed with any d.c. voltage between about 7V and 24V or so. The l.e.d.s are powered from the input voltage supply, not by the +5V from the regulator.

Table 2: L.E.D. current limiting resistor values for +12V and +24V power supplies

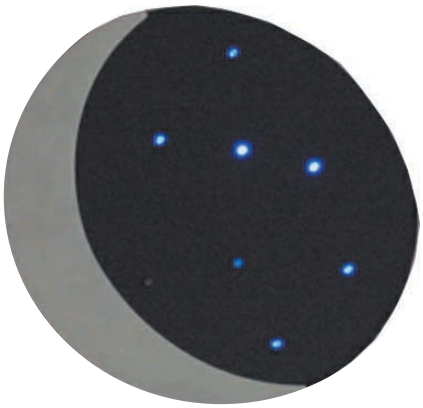
L.E.D.s per output (n)	*Red/Yellow/Green*	*R10 to R17 at 20mA Blue*	*White*	*One Blue +n(R/Y/G)*	*One White +n(R/Y/G)*
		+12V Power Supply			
1	470Ω	390Ω	470Ω	270Ω	330Ω
2	390Ω	180Ω	270Ω	220Ω	220Ω
3	330Ω	–	–	120Ω	150Ω
4	220Ω	–	–	–	–
		+24V Power Supply			
3	1K	560Ω	680Ω	680Ω	820Ω
4	820Ω	390Ω	560Ω	560Ω	680Ω
5	680Ω	220Ω	390Ω	470Ω	560Ω
6	560Ω	–	220Ω	390Ω	470Ω

CONSTRUCTION

The printed circuit board (p.c.b.) component and track layout details are shown in Fig.3. This board is available from the *EPE PCB Service*, code 377.

Assemble the board in order of component size. Use a socket for the PIC16F84A, IC1. Do not insert the PIC until you have checked the correctness of the output voltage from regulator IC2.

The prototype p.c.b. was glued to the back of a Christmas Star and Moon cut from stout card. Holes were punched into the card and the l.e.d.s pushed through and secured using holt-melt glue.



Prototype wall mounted luminous "moon" with blue l.e.d. "stars" mounted on the black "sky".

The l.e.d. quantity and the order in which they are connected is entirely up to the user.

Remember, though, that each l.e.d. has a voltage drop across it and so there is a limit to the number of l.e.d.s that can be connected in series in relation to the power supply voltage. There is also a limit to the number of l.e.d.s that can be used in parallel without overloading their driving transistor, or the power supply.

Having wired up the l.e.d.s, there are then just two external wires required, to the chosen power supply.

There are no great requirements for the power supply. A plug mounted type should suffice, with a rating of 250mA. There's no necessity for it to be regulated either, as the PIC is powered via the +5V regulator.

Having completed the assembly, apply power (without the PIC inserted) and check that the output voltage from IC2 is +5V. Always disconnect the power supply before making changes to the construction.

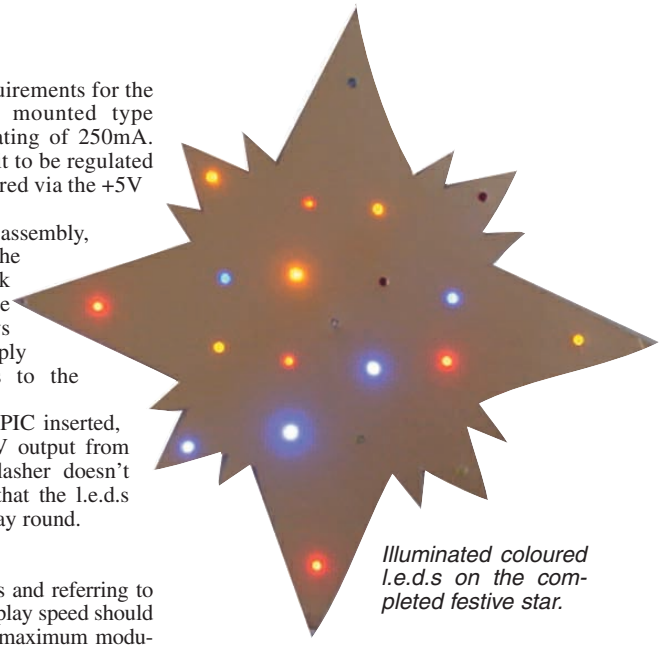
With the programmed PIC inserted, check again that the +5V output from IC2 is correct. If the flasher doesn't work straight off check that the l.e.d.s are connected the right way round.

SETTING UP

Using the d.i.l. switches and referring to Table 1, the maximum display speed should be selected together with maximum modulation (the l.e.d.s should go from fully off to fully on) and with a smooth brightness profile. Then it's just a matter of finding the most suitable settings according to situation and taste. There are thirty-two possibilities.

SOFTWARE

The software is available for free download from the *EPE* ftp site. This is most easily accessed via the main page of the *EPE* web site at **www.epemag.wimborne.co.uk**. At the top is a click-link saying **FTP site (downloads)**, click it then click on **PUB** and then on **PICS**, in which screen you will find the Versatile PIC Flasher folder.



Illuminated coloured l.e.d.s on the completed festive star.

The software can also be obtained on 3.5-inch disk (Disk 5) from the Editorial office. There is a nominal handling charge to cover admin costs. Details are given on the *EPE PCB Service* page, and in this month's *Shoptalk*, which also gives details about obtaining preprogrammed PICS.

Enjoy your display of PIC Noelogy! □

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