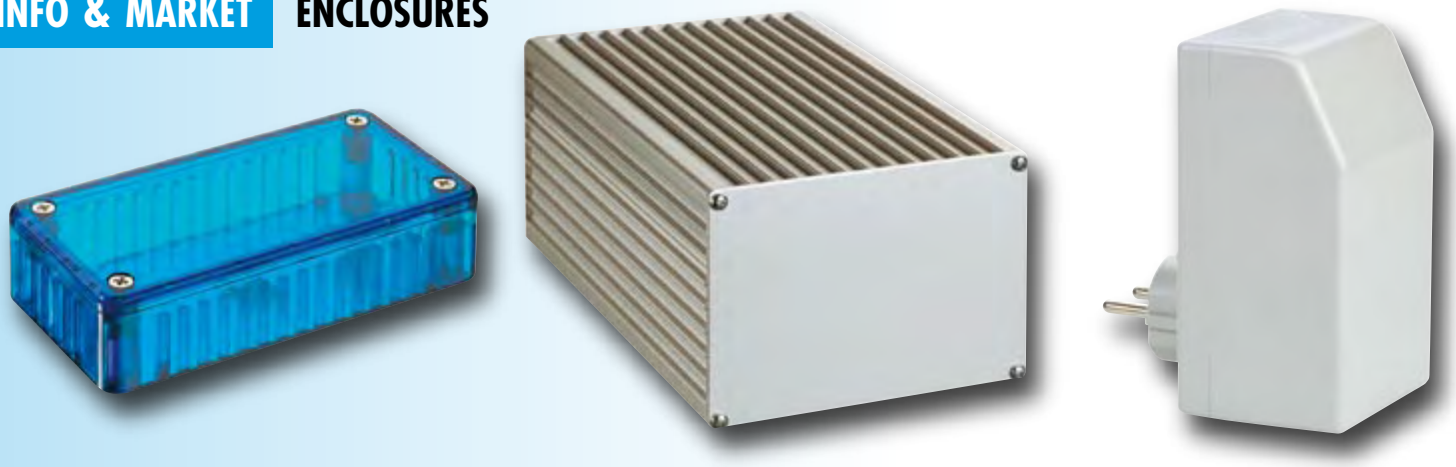


Tightly Packed

Enclosures and front panels

Thijs Beckers

There are an incredible number of options these days for the safe 'packing up' of electronic circuits. Open any catalogue from any well-known mail-order company and you will get an impression of the extensive range on offer. This article gives an overview of the different types with their particular characteristics and provides hints as to how you can make a professional looking front panel yourself.

From an economic and marketing perspective, the enclosure, including the front panel, of commercial equipment is very important for the manufacturer. Equipment that does not look attractive will sell poorly, of course, and is nearly impossible to extol its virtues in advertisements. So it is logical that much time and effort is spent on the design of these enclosures. An additional consideration is the ergonomics of equipment that has many operating controls. The design of the enclosure is then already taken into account during the development of the circuit.

This is usually not the case for prototypes, small (hand-made) production runs and home-built circuits. Of course, the marketing aspect is not a consideration here either. Specific characteristics, such as extra heavy-duty waterproof and explosion resistant boxes, are a little bit over the top for the average home project. A standard box is usually good enough. But that does not distract from the fact that appearance and function certainly also do play a role in your own circuits. With a little bit of searching for a nice and appropriate enclosure and a little bit of effort for a front panel you can definitely make a nice looking piece of equipment that would not look out of place when displayed in the average electronics shop window. With a clean design and your own logo on the front panel it will look like the real thing.

Making a choice

For prototypes you usually choose from a few types of enclosures that may optionally conform to some standard, (see inset *Industrial Enclosures*). For each design you will look at what type of enclosure suits best. There are a number of different types of enclosures that may be categorised as follows:

1. 19-inch enclosures, which can be easily built into, or removed from, a standard rack or industrial box.

2. Enclosures that are deliberately sized for the common 'Euro format' PCB.



3. Console enclosures with a tailored front panel or (sloping) top for control or mixing panels.

4. Small enclosures with a built-in mains plug, which plugs into a power point just like a mains power adapter.
5. Enclosures for handheld applications, such as multimeters.

6. Enclosures for DIN rail systems, which are commonly used in an industrial environment.

A few of the factors that are important for the type of enclosure are of course the size, safety, construction material, method of mounting and – mainly important in industrial applications – the NEMA and/or IP classification [1].

The size obviously depends on the components that have to fit in the enclosure, together with the connection and mounting options, internal and external access, thermal conditions and potential future extensions. The material selected needs to be able to withstand the conditions that the enclosure will be subjected to at the location at which it will be used. Considerations are corrosion resistance and rigidity requirements. The NEMA and/or IP classification is an industrial standard for the protective characteristics of an enclosure. **Tables 1** and **2** in the inset *Industrial Enclosures* give an overview of these two common protection classifications.

Machining

The internal electronics will, in all likelihood, be connected to the outside world via cables and plugs. This requires a number of plugs and contact points, which usually requires some machining of the enclosure.

In addition, the operating buttons need to be given a logical position, generally on the front panel. The front panel usually demands the most attention. To make an attractive aluminium front panel, complete with labelling, requires a fair amount of equipment (drills, routers, screen printer, sander, etc.) and the process is not easy. Also, if you only need to do these things every once in a while it is not worthwhile to invest in the required equipment. There are a number of companies that specialise in the manufacture of front panels, such as the German company Schaeffer [2], the American Internet company eMachineShop [3], the English company CTL-Components [4], the international company Elma [5] and the Dutch company Antronics [6]. Schaeffer and eMachineShop even offer their own (free!) software, which makes it easy to draw your own design. This design can then be sent to the manufacturer who will then machine and screen print the front panel. In this way you can obtain a professional looking front panel.

Do it yourself

The specialist equipment that is required for this machining has its price, of course. This is often clearly noticed from the amount of money you have hand over for a custom manufactured front panel. A cheaper solution is the self-adhesive, transparent film that can be printed with a laser printer. This film gives only limited protection from scratches and gives a somewhat dull result. The latter can be improved with some plastic spray.
In addition to the special film for laser printers there is also the overhead transparency for inkjet printers. This

Case manufacturers

Manufacturer	Website
ABB	www.abb.nl
APW	www.apw.com
Bernstein	www.bernstein-ag.de
Bopla	www.bopla.de
Boss	www.boss-enclosures.co.uk
Box	www.boxenclosures.com
Cooper	www.b-line.com
Deltron Emcon	www.deltron-emcon.com
Dold	www.dold.com
Erni	www.erni.com
Eurobox	www.euroboxenclosures.com
Fibox	www.fibox.nl
Himel	www.himelenclosures.com
Hammond Manufactoring	www.hammfg.com
Lawtronics	www.lawtronics.co.uk
Monacor	www.monacor.nl
Moeller	benelux.moeller.net/nl
OKW	www.okw.com
Pactec	www.pactecenclosures.com
Retex	www.retex.es
Rittal	www.rittal.nl
Rolec	www.rolec.de
ROSE Systemtechnik	www.rose-pw.de
Sarel	www.sarel.nl
Schroff	www.schroff.co.uk
Serpac	www.serpac.com
Spelsberg	www.spelsberg.nl
TEKO	www.tekoenclosures.com
VERO	www.vero-electronics.com
Weidmüller	www.weidmuller.nl

Table 1: Description degrees of protection
to DIN EN 60529 (VDE 0470) (IP-type)

Number	Degrees of protection for people and solid objects (first number)	Degrees of protection against water (second number)
0	No protection	No protection
1	Protection against solid objects greater than 50 mm diameter	Vertically falling drops of water do not cause damage
2	Protection against solid objects greater than 12 mm diameter	Drops of water with up to 15° from vertical do not cause any damage
3	Protection against solid objects greater than 2.5 mm diameter	Drops of water with up to 60° from vertical do not cause any damage
4	Protection against solid objects greater than 1 mm diameter	Splashing water from any direction does not cause any damage.
5	Completely protected against accidental touch, partially against dust	Low pressure water jets from any direction do not cause any damage
6	Completely protected against accidental touch and against dust	Strong jets of water do not cause any damage
7	-	Water does not cause any damage if the enclosure is submerged by 0.15-1 m
8	-	Water does not cause any damage if the enclosure is submerged by a specified amount
9	-	Water under high pressure from any angle does not cause any damage

Table 2: NEMA standard for enclosures

NEMA standard	Description
NEMA 1	Enclosures constructed for indoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment and to provide a degree of protection against falling dirt.
NEMA 2	As NEMA 1, and to provide a degree of protection against dripping and light splashing of liquids.
NEMA 3	Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt, rain, sleet, snow, and windblown dust; and that will be undamaged by the external formation of ice on the enclosure.
NEMA 3R	As NEMA 3, except no protection against dust
NEMA 3S	As NEMA 3, and in which the external mechanism(s) remain operable when ice laden
NEMA 4	As NEMA 3, and hose-directed water and that will be undamaged by the external formation of ice on the enclosure
NEMA 4X	As NEMA 4, and protected against corrosion
NEMA 5	As NEMA 2, but protection against airborne dust, lint, fibers
NEMA 6	As NEMA 4, and protected against water during occasional temporary submersion at a limited depth
NEMA 6P	As NEMA 6, but protected against water during prolonged submersion at a limited depth
NEMA 7	Enclosure for indoor use at locations specified as Class I, Group A, B, C and D (refer National Electrical Code, NEC) withstands pressure caused by internal explosion and prevents the ignition if explosive gasses. Also internal heat does not cause danger to the environment
NEMA 8	As NEMA 7, enclosure submerged in oil
NEMA 9	Enclosures for indoor use at locations specified as Class II, Group E, F en G (refer NEC). Protected against dust, internal
NEMA 10	over-heating does not create an explosion hazard for surrounding gasses
NEMA 11	Suitable for use in corrosive environments, enclosure submerged in oil
NEMA 12	As NEMA 5, for industrial use
NEMA 12K	As NEMA 12, with knock-outs
NEMA 13	As NEMA 5, also protected against oil and non-corroding cooling fluids

film is printed on the reverse side. First stick clear, double-sided adhesive foil (available in stationery shops) to the front panel and then the mirror-printed film. In this way the ink is also protected against scratches. In colour and using at least 300 dpi it will also look good and is not expensive.

Before sticking the film to the front panel, you first have to make the holes in it. Tip: it is better to deburr the front side of small holes once the film is in place. The opening in the film will then have the correct diameter at the same time. You can easily cut square or large openings in the film with a sharp knife.
On (ugly) plastic front panels you can use the standard sticker sheets for the front panel layout. Or alternatively, you can use standard paper and the above-mentioned double-sided adhesive foil. The colour of the paper will obviously determine the colour of the front of the enclosure.

Tip: a 'membrane keyboard' can be made quite easily with an additional printed film between the front panel and the adhesive foil. Behind the printed keyboard is an opening in the front panel that could contain miniature pushbuttons. The front panel can be made from cheap materials, of course.

Drilling

To drill small round holes, twist drills are obviously the best choice. A good drill stand is very handy and a drill press is ideal. If you mark the locations of the holes with a centre punch then the tip of the drill will not wander if you are drilling free-hand. Large, round holes are best made by first drilling a smaller hole and then enlarging it with a reamer.

Rectangular openings are a little harder. With simple tools it is best to proceed as follows: drill, within the cutout, a hole that's large enough for the saw blade of a hacksaw. Now cut the material to within about 0.5 to 1 mm of the desired opening. Remove the last little bit with a file.
If you are using thin sheet for the enclosure it is better to use a jigsaw for this, instead of a hacksaw. Sandwich the thin sheet with thin plywood or something similar, that you cut at the same time. In this way the thin sheet will not bend. Leave the plywood in place also when filing.

For very narrow openings (for slide potentiometers, for example), drill a number of small holes next to each other (with a good drill press and a short drill these holes can even overlap). With a little key file you can then remove the remaining unwanted material.

A nice result

Both in industry as well as for your own applications, the purpose of the enclosure is mainly to protect the electronics components from permanent damage caused by moisture, chemicals and dust. At the same time it provides a protective function for the environment. This can be protection to prevent the accidental touching of hazardous voltages but also for EMI.
A second good reason to package a circuit is to make it look more attractive. The average user is not fascinated with a collection of components on a circuit board. A good front panel layout will also make it immediately obvious what each operating button does and how to use the equipment.
In industry there is often great emphasis on the physical appearance. That is why specifically designed enclosures are often used, that are evaluated at an early stage of the

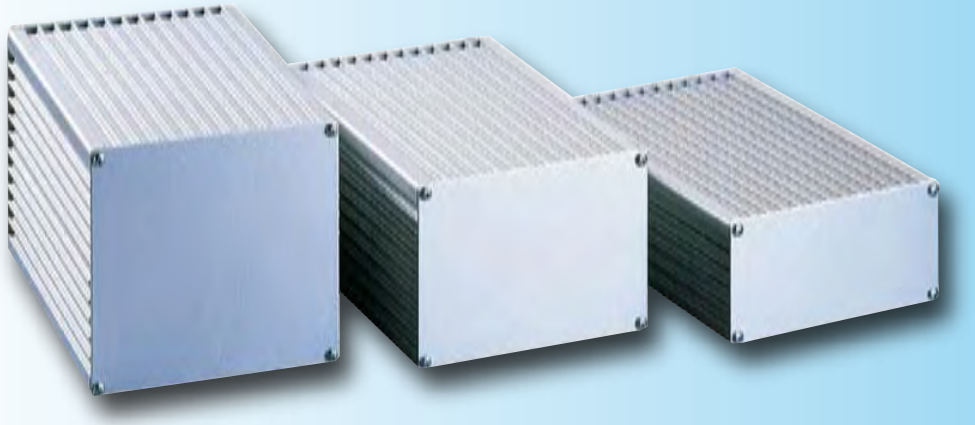
Industrial enclosures

The material from which an enclosure is made determines its physical properties for the most part. Plastic is usually chosen for portable applications, because of its weight and wear resistance. In other applications other factors such as mechanical strength, electrical and thermal resistance and fire resistance are more important. ***Tables 1*** and ***2*** show the protection classification that an enclosure can offer for two common standards.

To provide protection against EMI, the enclosures can be coated with, for example, carbon, aluminium or copper. This is very important, in particular for sensitive electronics, if the circuit is to operate without problems. Up to 1 MHz you can use electronic filters and metal screens. Above that frequency a decent Faraday cage is required. To also keep out magnetic fields, an aluminium or steel sheet enclosure is inadequate. This application requires special *μ-metal.*

A number of common materials for plastic enclosures are polycarbonate, polystyrene, polypropylene and ABS. Some enclosures are transparent for IR. This is very handy for remote controls, for example. And there are many more special properties along these lines.

If we select a metal enclosure, we can make a distinction between aluminium, galvanised steel sheet, stainless steel and a number of other materials. A metal enclosure has the advantage that it will largely block electric fields, of course.



overall design. The initial costs of a newly designed enclosure may be quite high, but large numbers reduce the price per enclosure considerable. Buying large numbers of standard enclosures would be much more expensive in the end, because the various holes still need to be machined.
If you are working with prototypes then the considerations are completely different of course. It is often the case that the circuit is already finished and you only need an enclosure that will fit everything. With the directions given above, it is entirely possible to make a front panel that does not have to look inferior to that of a professional piece of equipment.

(060298-I)

All photographs: Conrad Electronics.

Weblinks:

[1] www.nema.org
[2] www.schaeffer-ag.de
[3] www.emachineshop.com
[4] www.ctl-components.com
[5] www.elma.de
[6] www.supermoduul.nl

GLOSSARY

ABS: Acrylonitrile Butadiene-Styrene. Rigid man-made fibre with very little tendency to shrink.

EMI: Electromagnetic Interference. Undesired interference from electromagnetic fields.

NEMA: National Electronic Manufacturers Association, American association which represents the designers and manufacturers of electronic equipment.

IP: Ingress Protection, protection against access or touch.

Stainless Steel: alloy of iron, chromium and carbon which forms a layer of chromium-oxide on the outside so that the material does not corrode any further.

***μ*-metal** (mu-metal)**:** Nickel-iron alloy with 2% copper and molybdenum with a very high magnetic permeability. As a result it is very suitable for blocking magnetic fields.