

Transformer Bobbin

This invention relates to a transformer bobbin, in particular for supporting concentric transformer windings.

5 In concentrically wound transformers, a primary winding is wound onto a bobbin, a layer of insulation is applied around the primary winding and then a secondary winding is wound around the primary winding. Such concentrically wound transformers have, in comparison with side by side
10 wound transformers, certain advantages. In particular the leakage inductance can be much lower making the transformer easier to match, and to have a higher frequency response, a wider bandwidth and improved crosstalk characteristics.

15 Side by side transformers are often encapsulated to achieve the necessary levels of safety, whereas safety isolation is usually provided on concentrically wound transformers by other means. Encapsulation typically
20 impairs the performance of the magnetic core such that concentrically wound transformers may often use less magnetic material than their (encapsulated) side by side equivalents.

25 In transformer manufacture, in particular in safety isolating signal transformers for use in telecommunications, the isolation of one winding from another is critical and has to be maintained under all conditions. These requirements are often difficult to
30 achieve without adding to the complexity of the manufacturing process, and in particular it can be difficult to provide the necessary isolation for the entry and exit wires to/from the primary winding of a concentrically wound transformer, relative to the
35 secondary winding which will be wound on top.

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According to the invention, there is provided a bobbin for supporting concentric transformer windings, the bobbin having an area for receiving a primary winding, shoulders at each end of the primary winding area to define the space for the primary winding, an area for receiving a secondary winding surrounding the primary winding, and flanges at each end of the secondary winding area, wherein one of the shoulders bounding the primary winding area has a slot for the primary winding entry and exit wires, the slot extending across the shoulder from the primary winding area to the adjacent end of the bobbin, the slot communicating with an undercut region of the shoulder, below an upper surface of the shoulder, one lateral edge of the slot and the corresponding lateral edge of the undercut region diverging from one another in the direction of said adjacent bobbin end.

By feeding the primary winding exit and entry wires through an undercut region of the shoulder, the necessary distance through solid insulation between each part of the primary winding and any part of the secondary winding is achieved by the thickness of the shoulder, where it extends across the top of the undercut region. The diverging lateral edges of the slot and of the undercut region ensure that the primary winding exit wire not only can be wound by a conventional winding machine, but also can be reliably placed in a position where it will be separated from any part of the secondary winding by the necessary insulation, be it distance through solid insulation, creepage, clearance or thin sheet insulation.

It is normal for transformer bobbins with laminated cores to have a generally rectangular cross section, and in such a case the end of the slot adjacent to the primary winding area preferably lies on a corner of the bobbin rectangular cross section. Because the windings will always be pulled into closest contact with the bobbin and with the

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underlying windings at this point, this allows the exit wire to be taken off from the primary winding substantially level with the upper surface of the shoulder. Thus it is ensured that all the primary winding space is used and, for a given size of primary winding, allows the bobbin and thus the transformer to be of small dimensions.

The end of the slot remote from the primary winding preferably lies midway between the position which will be taken up by entry and exit terminals for the primary winding. The lateral edge of the undercut region preferably lies substantially parallel to the bobbin axis, and the lateral edge of the slot lies at substantially 45° to the bobbin axis. The end of the slot adjacent to the primary winding area can be formed with a surface to engage and retain the wire as the wire passes over it, to hold the wire against axial tension. The undercut preferably extends laterally on both sides of the slot and both lateral edges of the undercut region lie parallel to the bobbin axis. The edge of the slot on the exit wire side of the slot is chamfered.

Mountings for both primary and secondary winding terminals can be located radially outside the winding spaces so that there is sufficient creepage distance between the entry and exit wires and the magnetic core, with primary winding terminals being at one end of the bobbin and secondary winding terminals at the other end.

If the primary winding area is located axially centrally relative to the secondary winding area, an advantageous, space-saving arrangement is achieved.

The invention also extends to a concentrically wound transformer formed on a bobbin as set forth above.

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According to another important and separate aspect of the invention, there is provided a housing for an electronic component comprising a box-like enclosure open at one side, snap-fit securing means for enabling a component to
5 be fitted into the housing and retained in the housing, and openings through the housing walls at edges and/or corners of the housing. This aspect of the invention extends to the combination of an electronic component and a housing therefor, the housing comprising a box-like
10 enclosure open at one side, snap-fit securing means in the housing, snap-fit features on the component, the snap-fit securing means and the snap-fit features enabling the component to be snap-fitted into the housing and retained in the housing, and openings through the housing walls at
15 edges and/or corners of the housing.

This type of construction has many benefits when compared with the conventional 'potting', 'encapsulation' or 'varnish impregnation' processes. Assembly of the
20 component into the housing now requires only one mechanical action and provides all the required electrical insulation and isolation for the component. Because there is no encapsulating or varnish compound consolidating the component, disassembly and recycling of the materials from
25 which the component is made is easily possible. When the component is a transformer as described here, the plastics housing can be broken to remove the transformer. The laminations can be extracted, as they are only held in position by the housing, and the copper wire can be
30 unwound from the bobbin. The plastics bobbin and housing can be recycled using conventional plastics recycling techniques; the copper wire can be recycled after remelting and the laminations can be reused without any further treatment (or can be recycled after remelting).
35 The material of the laminations is expensive, and this recycling can be worthwhile if only to recover and reuse the laminations. None of this would be feasible with an

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encapsulated, varnished or over-moulded component which would have to be disposed of in landfill.

Thus, according to a further aspect of the invention,
5 there is provided a housing for an electronic component, the housing having a set of walls for surrounding the component and lugs past which the component can snap to retain the component in the housing.

10 The housing will preferably have five walls (ie an open bottom through which the component can be introduced), and openings at or near the apexes of the housing.

The housing will be particularly suitable for components
15 which are to be mounted on a printed circuit board.

The invention will now be further described, by way of example, with reference to the accompanying drawings in which:

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Figure 1 is a perspective view of a wound transformer, wound on a bobbin in accordance with the invention;

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Figure 2 is cross-section through the transformer of Figure 1, on the lines II-II;

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Figures 3 and 4 are opposite perspective views of a transformer bobbin in accordance with the invention;

Figure 5 shows the bobbin of Figures 3 and 4 with the primary winding completed;

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Figure 6 is a detail on an enlarged scale showing the exit wire of the primary winding;

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Figure 7 is a perspective view of the bobbin, ready to accept interlayer tape and a secondary winding;

5 Figure 8 is a plan view of the bobbin;

Figure 9 is a side view of the bobbin, both Figures 8 and 9 carrying indications showing the required creepage/clearance dimensions;

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Figure 10 is an underneath view of a transformer housing in accordance with the invention;

Figure 11 is a top view of the housing of Figure 10;

15 Figure 12 shows a bobbin in accordance with the invention modified for use with the housing of Figures 10 and 11;

20 Figure 13 is a side view illustrating springs which control interlamination pressure;

Figure 14 shows a completed, housed transformer with a part cut away; and

25 Figures 15 to 19 show housings in accordance with the invention with different spring arrangements.

30 The transformer shown in Figure 1 has a bobbin 10 moulded from a suitable insulating plastics material. Two terminal pins 12, 14 are provided for the primary winding, and the entry 16 and exit 18 wires can be seen connected to these pins. Two terminal pins 20 and 22 are provided for the secondary winding 24, and again the entry and exit
35 wires for this winding are shown at 26, 28. A third location pin is provided at 30. This may receive a tap from the secondary winding and/or serve to ensure that the

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transformer is positioned the correct way around when connected to other components. The transformer is completed with a stack of sheet metal laminations, each of which has a central limb 36 which fits through the centre of the bobbin 10 and external limbs 77 which fit around the outside of the secondary winding 24. Alternatively (but not shown in the drawings) the core may be a ferrite core.

The cross section shown in Figure 2 shows, at the centre, the limbs 36 of the core laminations, at 38 the (plastics) bobbin central region, at 34 a primary winding wound onto the bobbin central region 38, at 40 a layer of tape insulation (which may consist of several layers of thin tape) which isolates the primary winding 34 from the secondary winding 24, and at 42 an external tape winding covering the secondary winding 24.

Concentrically wound transformers may have all these general features.

Figures 3 and 4 show a bobbin 10 in accordance with the invention without any of the remaining transformer components applied to it. It will be seen that the central region 38 of the bobbin is generally rectangular in cross-section (with rounded corners), and is bounded at each end by a shoulder 44, 46. As can be seen in Figure 4, the shoulder 44 is continuous and provides a barrier at one end to a primary winding area around the central region 38. The shoulder 46 at the other end is formed with a slot 48, and part of the shoulder 46 is cut away at 50 to provide an undercut region between the primary winding area and bobbin end flanges 52, 54.

To apply the primary winding, the primary winding terminal pins 12, 14 are first located and fixed in corresponding holes 56, 58. Using a conventional coil winding machine,

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the primary winding entry wire is wound around the pin in the hole 56, passes down behind the flange 54, through the undercut 50 and is then wound tightly around the central region 38 of the bobbin, with the turns of wire being wound back and forth to fill the primary winding area until the winding occupies the whole length of the central region 38, and extends up to the full height of the shoulders 44, 46. Once this position has been reached, the exit end of the primary winding is taken out of the primary winding area, through the slot 48, underneath a shelf 60 which bounds the undercut through the shoulder 44 and onto a pin in the aperture 58 where it is wound to make a connection, and then severed. The primary winding is now complete, and the positions of the entry and exit wires can be seen from Figure 5.

The position of the exit wire 18 is shown more clearly in Figure 6. The wire leaves the winding area on the corner of the winding cross section, and is held in this position by a small landing surface 62 (see Figure 3). Initially the wire is carried through the slot 4. At this stage, the wire lies parallel to the length of the lateral edge 61 of the slot and thus follows a path at an angle to the coil axis. Once behind the flange 54, the wire is tensioned against the lateral edge 63 of the undercut region and is taken to the pin 14 where it is terminated.

The edge 61 of the slot is chamfered to assist the wire in moving under the shelf 60 when the nozzle from which the wire is fed plunges, moves axially outwards and then moves sideways behind the bobbin.

Once this stage has been completed, the transformer appears as shown in Figure 7. To complete the transformer, layers of insulating tape will be wound around the shoulders 44, 46 and around the primary winding 34 and then a secondary winding will be applied over the

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top of the insulating tape, extending right up to the flanges 52,54. The application of the secondary winding follows conventional practice, and will not be described in any further detail, save for noting that the secondary
5 can be wound right out to both flanges 52,54, making for an efficient design.

In designing a transformer, and in achieving the necessary relationship between the primary and secondary windings,
10 the designer has to bear in mind the following parameters:

Cr = creepage
Cl = clearance
D = distance through insulation
15 M = multiple thin films

These distances are shown on Figures 8 and 9 in a manner which demonstrates how the necessary distances are achieved with the aid of the bobbin described.

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At the shoulder 44 at the right hand end (referring to Figures 8 and 9) the primary winding extends no further towards the flange 52 than the inner end of the shoulder 44 and thus the shortest path between the primary and
25 secondary windings, without travelling through any insulation, will be the distance Cr/Cl indicated by the arrow 70. For this dimension, this is simultaneously the creepage and the clearance path. The entry and exit wires of the secondary winding will be no closer to the primary
30 winding than the turns of the secondary winding, and therefore no special considerations have to be given to those entry and exit wires.

As can be seen in Figure 9, where the insulating tape 40
35 is indicated, this provides a multiple thin film insulation (there are several overlapping layers of tape making up the insulation 40) indicated by a dimension M.

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However where the primary winding entry and exit wires pass under the secondary winding, to the terminals 12, 14 careful consideration has to be given to the placing of
5 these wires.

Mechanical considerations encourage the exit wire to diverge from the coil at a corner of the rectangular cross section. At the centre of each flat face of the cross
10 section, there will be a degree of bellling out, and thus it would be difficult to take a wire wound to the full height of the shoulders into a position where it drops below the shelf 60. If the wire diverges at the corner, it can be taken under the shelf 60, even though the height
15 of the winding at the centre of the flat face is at or slightly proud of the shoulder.

At the flange end of the shoulder 46 however the considerations are related to electrical isolation, and at
20 this point there needs to be a distance D_1 (represented by the thickness of the flange) between the secondary winding 24 and the primary winding entry and exit wires 16,18 where they extend to the terminals 12, 14. The distance D_1 is typically 0.4mm.

25 There also needs to be a distance through insulation D_2 represented by the thickness of the shelf 60, and a shortest creepage path Cr_2 between the primary winding entry and exit wires and any possible "dropped" turns of
30 the secondary winding which may drop over the edge of the intermediate tape wrapping 40, against the flange 54.

By designing the shoulder 46 with an angled slot 48, and with an undercut region 50, the primary winding can easily
35 be applied using a conventional winding machine. When the intermediate tape wrapping has been applied and the secondary winding has been wound, all the required safety

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isolation requirements will be met, and no additional components or windings need to be added to the structure to achieve the necessary isolation.

- 5 Because the primary can be wound to completely fill the space allowed for it, no oversizing is necessary, and as a result, the smallest possible overall dimension of component, to meet any given specification, can be achieved. The transformer thus has very good utilisation
10 of winding space.

- A transformer constructed as described here has no need of encapsulation or varnish impregnation which is sometimes required to meet the isolation requirements. It is
15 desirable to avoid the need for encapsulation and varnishing because these add cost and production time and degrade signal distortion performance.

- Because of the efficiency advantages obtained with this
20 construction, some transformers may need less magnetic material in their core than would have been the case with prior art transformers. This can be achieved by using less laminations 32. The laminations which together make up the magnetic core of the transformer have to be lightly
25 pressed together to perform their function. Figures 10 to 14 show how this can be achieved, using a moulded housing which also gives other benefits to the completed construction, and which can be used with electronic components other than transformers.

- 30 A housing 70 is in the form of a moulded five-sided body. The housing can be moulded with a multi-impression simple open-shut tool without slides.

- 35 In Figure 10, we are looking in from underneath. Inside the housing can be seen snap-fit lugs 72 (there will be four of these) into which appropriately positioned feet 74

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of the bobbin (Figure 12) will locate. The bobbin is shown 'naked' in Figure 12, but will be wound and provided with laminations before being snapped into the lugs 72.

5 Also inside the housing are four moulded springs 76 (two are visible in Figure 10). These springs are moulded from the same material as walls of the housing, and act to provide the necessary interlamination pressure, as will be described below.

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The housing has open corners 78 (see particularly Figures 11 and 14) which allow any liquid penetrating inside the housing to drain away and air to circulate. As the transformer to be housed inside the housing is not
15 encapsulated, it is important that any rinsing fluid be allowed to escape if rinsing of the circuit board has to take place after the components have been mounted. The bottom edges of the housing also have cut-away portions 80
between the corners 82 to allow drainage.

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Finally, the top of the housing has a flat area 84 which can receive component identification information and manufacturer's trade marks.

25 Figure 14 shows the housing walls cut away in the area of the lugs 72. It is preferred to have these lugs located behind a continuous area of wall, as shown in Figures 10 and 11, to ensure that the correct creepage/clearance dimensions are maintained by the walls of the housing.

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In Figures 15 to 19, the basic form of the housing is similar to that shown in Figures 10, 11, 13 and 14. The same reference numerals are used for the same features. These figures show various different ways in which the
35 function of the springs 76 can be provided.

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Although not shown in the drawings, it will be clear to the skilled man that the lugs 72 can take different forms to those shown in the drawings. The important thing is that there should be a snap-fit engagement between the lugs 72 and the feet 74 of the bobbin, and there are many different arrangements which can be used to achieve this function.

Figures 15a and 15b show a housing with, on each side, two independent spring arms 176, 178. These arms are each in a V-shape with one of the ends 180 of each arm moulded integrally with the walls of the housing and the other end 182 being free. The free end 182 will press against the stack of laminations. The top of the housing is cut-away across the top of the springs as can be seen in Figure 15b.

Figures 16a and 16b show a housing with, on each side, two independent spring arms 276, 278. These arms cross over, have one end 280 moulded integrally with the walls of the housing and extend towards the opposite side of the housing so that their free ends 282 are on the opposite side of the middle of the housing than their fixed ends. The top of the housing is cut-away across the top of the springs as can be seen in Figure 16b.

Figure 17a and 17b show a housing with, on each side, a single, double-ended arm 376 integrally moulded at its centre 380 to a side wall of the housing. Spring arms 382 and 384 extend in opposite directions from the centre 380 and the ends of these arms are provided with depending flanges 386 which, in use, will press against the laminations stack. The top of the housing is cut-away across the top of the springs as can be seen in Figure 17b.

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Figures 18a and 18b show a housing with, on each side, spring arms 476 similar to the arms 276 of Figures 16. The difference between these two is that in Figures 18, the arms do not cross and they exert pressure on the lamination stack through contact ends 482 at the centre of the housing, rather than at points close to the lateral walls. The top of the housing is cut-away across the top of the springs as can be seen in Figure 18b.

Figures 19a and 19b show a housing where there is a single spring arm 576 on each side, the arms each being formed by a continuous web which extends from one housing wall, at 580, to the opposite wall at 582. In the middle of the arm 576 is a contact area 584 which will exert a spring force on the lamination stack. This embodiment has the disadvantage that, as the spring arms 576 flex, they will exert an outward force on the housing walls causing some bowing of these walls. The top of the housing is cut-away across the top of the springs as can be seen in Figure 19b.

The housing walls are of electrically insulating material, preferably at least 0.4mm thick, so that the housing provides solid insulation and sufficiently long creepage and clearance paths through the open portions to insulate the transformer from other adjacent components and from any close surfaces of a housing in which the circuit incorporating the transformer is housed.

As mentioned earlier, the efficiencies resulting from the transformer design described here allow a smaller number of laminations 32 to be used to achieve the desired transformer performance. It will be seen from Figure 2 that the central core of the bobbin is designed to receive a specific number of laminations, making up a stack of a certain height. If a lesser number of laminations is

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used, there needs to be some way in which they can be lightly pressed together to achieve optimum performance.

This can be achieved by the moulded springs 76 in the housing 70. When the completed transformer is fitted into the housing, the external limbs 77 of the laminations 32 will lie against the springs 76. When the transformer is pushed home into the housing, so that the feet 74 snap into the lugs 72, the springs 76 will be depressed, as shown in the left-hand part of Figure 13. This will provide a force on the laminations pressing them lightly against one another, and the form, length and position of the springs will be designed to provide this force, whether the transformer has a full stack of laminations, or has less than a full stack.

The springs will also ensure that pressure is kept on the lug/foot joints 72,74 thus producing a rattle-free assembly.

The combination of the transformer and the housing 70 thus provides many advantages, beyond those already mentioned. For example, the presence of the housing adds robustness to the components both before and after they are mounted on a PCB. Once on the PCB, contact between the feet 82 and the board reduces stress on the transformer pins when a force is applied; the flat surfaces allow vacuum handling of the components and in general allows them to be manipulated with the same equipment used for encapsulated components.

A housing as described above can also be used for housing electronic components other than the transformers described above. The housing construction described here can have more general application. Many if not all of the advantages discussed above will then apply.

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Claims

1. A bobbin for supporting concentric transformer windings, the bobbin having an area for receiving a primary winding, shoulders at each end of the primary winding area to define the space for the primary winding, an area for receiving a secondary winding surrounding the primary winding, and flanges at each end of the secondary winding area, wherein one of the shoulders bounding the primary winding area has a slot for the primary winding entry and exit wires, the slot extending across the shoulder from the primary winding area to the adjacent end of the bobbin, the slot communicating with an undercut region of the shoulder, below an upper surface of the shoulder, one lateral edge of the slot and the corresponding lateral edge of the undercut region diverging from one another in the direction of said adjacent bobbin end.
2. A bobbin as claimed in Claim 1, wherein the bobbin core in the primary winding area has a generally rectangular cross-section and the end of the slot adjacent to the primary winding area lies on a corner of the bobbin rectangular cross section.
3. A bobbin as claimed in Claim 2, wherein the opposite end of the slot lies midway between the position which will be taken up by entry and exit terminals for the primary winding.
4. A bobbin as claimed in any preceding claim, wherein the lateral edge of the undercut region lies substantially parallel to the bobbin axis, and the lateral edge of the slot lies at substantially 45° to the bobbin axis.
5. A bobbin as claimed in any preceding claim, wherein the end of the slot adjacent to the primary winding area



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is formed with a surface to engage and retain the wire as the wire passes over it, to hold the wire against axial tension.

- 5 6. A bobbin as claimed in any preceding claim, wherein the undercut extends laterally on both sides of the slot and both lateral edges of the undercut region lie substantially parallel to the bobbin axis.
- 10 7. A bobbin as claimed in any preceding claim, wherein the edge of the slot on the exit wire side of the slot is chamfered.
- 15 8. A bobbin as claimed in any preceding claim, wherein mountings for both primary and secondary winding terminals are located radially outside the winding spaces, with primary winding terminals being at one end of the bobbin and secondary winding terminals at the other end.
- 20 9. A bobbin as claimed in any preceding claim, wherein the primary winding area is located axially centrally relative to the secondary winding area.
- 25 10. A concentrically wound transformer formed on a bobbin as claimed in any preceding claim.
11. A bobbin for supporting concentric transformer windings substantially as herein described with reference to the accompanying drawings.
- 30 12. A concentrically wound transformer substantially as herein described with reference to the accompanying drawings.

