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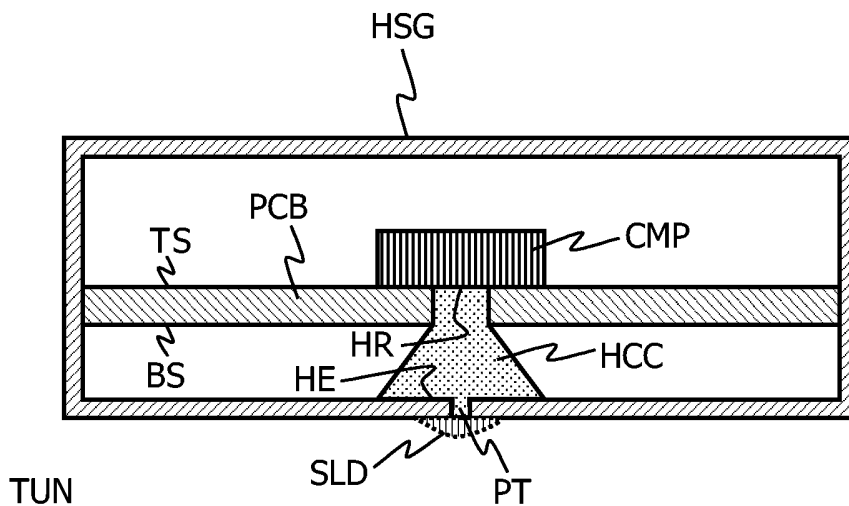
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(54) Title: ELECTRONIC CIRCUIT MODULE COMPRISING A HEAT PRODUCING COMPONENT



(57) Abstract: An electronic module comprises a printed circuit board (PCB) on which a heat producing component (CMP) is mounted. A heat conductive coupling (HCC) passes through a hole in the printed circuit board (PCB). The heat conductive coupling (HCC) has a heat reception surface (HR) that is thermally coupled to the heat producing component (CMP), and a heat evacuation surface (HE) that is thermally coupled to a heat sink (HSG).

Electronic circuit module comprising a heat producing component

FIELD OF THE INVENTION

An aspect of the invention relates to an electronic circuit module that comprises a heat producing component. The electronic circuit module may be, for example, a tuner that can be tuned to any particular channel in a radiofrequency band with numerous
5 different channels. Such a tuner can be applied in various different types of electronic apparatuses, such as, for example, a television receiver, a personal computer, a personal digital assistant or a cellular phone. Other aspects of the invention relate to a heat-evacuation-prepared printed circuit board, a method of manufacturing a heat-evacuation-prepared printed circuit board, an electronic apparatus and an information rendering system, such as, for
10 example, a video display system.

DESCRIPTION OF PRIOR ART

US patent number 5,796,170 describes a ball grid array package that comprises a heat spreader in the form of a conductive layer. Plated through holes electrically
15 connect the heat spreader with selected solder balls that form part of a ball grid array. Accordingly, the heat spreader is electrically connected to signal ground when contacts are made from the ball grid array to a corresponding array of contact areas on a printed circuit board.

20 SUMMARY OF THE INVENTION

According to an aspect of the invention, an electronic module comprises a printed circuit board on which a heat producing component is mounted. A heat conductive coupling passes through a hole in the printed circuit board. The heat conductive coupling has a heat reception surface that is thermally coupled to the heat producing component, and a
25 heat evacuation surface that is thermally coupled to a heat sink.

The invention takes the following aspects into consideration. An electrical component that produces relatively much heat may be provided with a heat sink so as to prevent the electrical component from overheating. The aforementioned prior art is an example.

A heat sink has a cooling capacity that depends on various factors. Size is an important factor. The larger the heat sink is, the higher the cooling capacity is. However, size may be a problem if the electrical component forms part of an electronic module that needs to be miniaturized. Forced convection may be a solution. Forced convection increases the cooling capacity of a heat sink having a given size. However, forced convection is relatively expensive and also requires certain space.

Another solution to the size problem is to place the heat sink at a location that is relatively remote from the electrical component, instead of placing the heat sink directly on the electrical component. This solution requires a heat conductive coupling between the electrical component and the heat sink. However, any heat conductive coupling has a thermal resistance. The electrical component may not sufficiently benefit, as it were, from the cooling capacity that the heat sink provides, if the thermal resistance is relatively high.

In accordance with the aforementioned aspect of the invention, a heat conductive coupling passes through a hole in the printed circuit board on which a heat producing component is mounted. The heat conductive coupling has a heat reception surface that is thermally coupled to the heat producing component, and a heat evacuation surface that is thermally coupled to a heat sink.

The invention allows small size implementations to have a heat sink with a relatively great cooling capacity. For example, the heat sink can be in parallel with the printed circuit board and may be of similar size, which allows relatively great cooling capacity. Such an implementation of the electronic module need not be much larger than an electronic module having the same printed circuit board but without any heat sink. In many applications, a printed circuit board is mounted on a plate that forms part of a housing. The invention allows effectively using the housing as a heat sink. What is more, the heat sink can be relatively close to the heat producing component. Consequently, the heat conductive coupling can be relatively short and wide. This allows the heat conductive coupling to have a relatively low thermal resistance. Accordingly, the heat producing component can effectively benefit from the cooling capacity that the heat sink provides. For those reasons, the invention allows relatively small size implementations of electronic modules having a heat producing component.

Another advantage of the invention relates to the following aspects. An electronic module in accordance with the invention can be manufactured in a relatively simple manner. It is sufficient to provide the printed circuit board with a hole at the location

where the heat producing component will be mounted, and to place the heat conductive coupling in that hole. Consequently, the invention allows low-cost implementations.

Yet another advantage of the invention relates to the following aspects.

Electrical circuits generally provide better signal processing characteristics with increasing power consumption. It has been explained hereinbefore that the invention allows small size implementations having relatively great cooling capacity. Accordingly, the invention allows a small size implementation of an electrical circuit that consumes relatively much power and, therefore, produces relatively much heat. For that reason, the invention allows miniaturization with little sacrifice in terms of signal processing quality.

These and other aspects of the invention will be described in greater detail hereinafter with reference to drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram that illustrates a video display system, which comprises a tuner.

FIG. 2 is a cross section diagram that illustrates the tuner.

FIG. 3 is a bottom view diagram that illustrates a printed circuit board, which is a first intermediate product in a method of manufacturing the tuner.

FIG. 4 is a bottom view diagram that illustrates an assembly of the printed circuit board and a heat conductive coupling, which is a second intermediate product in the method of manufacturing the tuner.

FIG. 5 is a top view diagram that illustrates the assembly of the printed circuit board and the heat conductive coupling, which is the second intermediate product in the method of manufacturing the tuner.

FIG. 6 is a top view diagram that illustrates a solder-paste-printed assembly of the printed circuit board and the heat conductive coupling, which is a third intermediate product in the method of manufacturing the tuner.

FIG. 7 is a top view diagram that illustrates a component-mounted assembly of the printed circuit board and the heat conductive coupling, which is a fourth intermediate product in the method of manufacturing the tuner.

DETAILED DESCRIPTION

FIG. 1 illustrates a video display system VDS. The video display system VDS comprises a receiver REC and a display device DPL. The receiver REC derives a video

signal VID from a desired channel in a radiofrequency spectrum RF, which the receiver REC receives. The display device DPL displays the video signal VID. A user can select the desired channel by means of, for example, a remote control device RCD. The video display system VDS may be in the form of, for example, a television set, a personal computer, a digital
5 personal assistant or a cellular phone. The receiver REC may be in the form of, for example, a settop box, a digital video recorder, or the like.

The receiver REC comprises a tuner TUN, a backend circuit IFDT, and a controller CTRL. The tuner TUN converts the radiofrequency spectrum RF into an intermediate frequency spectrum IF, which the backend circuit IFDT receives. The
10 intermediate frequency spectrum IF comprises a frequency-shifted version of the desired channel. The tuner TUN carries out a frequency shift so that the frequency-shifted version of the desired channel is at a predefined intermediate frequency. The backend circuit IFDT derives the video signal from the frequency-shifted version of the desired channel within the intermediate frequency spectrum IF. To that end, the backend circuit IFDT may carry out
15 various operations, such as, for example, band pass filtering, demodulation, and, in the case of digital signals, channel decoding, error correction, and baseband decoding.

The receiver REC may tune to any channel within a frequency band. This tuning operates as follows. A user selects a particular channel, for example, by entering a program number on the remote control device. In response, the controller CTRL applies a
20 tuning command TC to the tuner TUN. The tuning command TC causes the tuner to carry out a frequency shift corresponding with the channel that the user has selected. The frequency shift is so that the tuner TUN provides a frequency-shifted version of the channel in the intermediate frequency spectrum IF at the predefined intermediate frequency.

FIG. 2 illustrates the tuner TUN in a cross section. The tuner TUN comprises a
25 housing HSG, a printed circuit board PCB, an electrical component CMP, and a heat conductive coupling HCC. The tuner TUN may optionally comprise a solder point SLD, which is illustrated in broken lines.

The printed circuit board PCB, which is within the housing HSG, has a top side TS and a bottom side BS. The electrical component CMP is mounted on the top side TS.
30 The printed circuit board PCB may comprise numerous other electrical components, which form an electrical circuit together with the electrical component CMP illustrated in FIG. 2. FIG. 2 does not show any other electrical component for reasons of clarity and conciseness.

The housing HSG is typically made of electrically conductive material, such as, for example, a metal or an alloy. The housing HSG may be, for example, a tin can. The

housing HSG acts as an electromagnetic shield, which prevents mutual interference between the electrical circuit of the tuner TUN and other electrical circuits. For example, the controller, which FIG. 1 illustrates, may generate a relatively strong interfering radiofrequency spectrum, which would severely degrade reception quality if there was not any electromagnetic shield. Conversely, the electrical circuit of the tuner TUN may generate parasitic electromagnetic signals, which could degrade reception quality of another receiver. Many countries have regulations with respect to electromagnetic interference.

The heat conductive coupling HCC passes through the printed circuit board PCB via a hole. The heat conductive coupling HCC has a heat reception surface HR that is thermally coupled to the electrical component CMP. The heat conductive coupling HCC further has a heat evacuation surface HE that is thermally coupled to the housing HSG. The heat evacuation surface HE is provided with a protrusion PT, which passes through the housing HSG via a hole. The solder point SLD, which is optional, covers the protrusion PT and a circumjacent portion of the housing HSG.

The electrical component CMP typically comprises a silicon chip that produces heat when the electrical component CMP is in an active state. The silicon chip may be glued to a heat conductive substrate in the form of, for example, a metal plate or an alloy plate. Preferably, the heat conductive substrate resides at a side which faces the printed circuit board PCB. Moreover, it is desirable that the heat conductive substrate of the electrical component CMP is exposed so that the heat conductive substrate can come into contact with an external element. In that case, the heat conductive substrate may be thermally coupled to the heat reception surface HR of the heat conductive coupling HCC. Such a thermal coupling may be achieved through, for example, a solder contact between the two.

Let it be assumed that the electrical component CMP is in an active state. The electrical component CMP will produce heat. The heat conductive coupling HCC will evacuate this heat from the electrical component CMP to the housing HSG. Although air is a relatively bad heat conductor, the housing HSG will evacuate the heat to the ambient air in a relatively effective manner. This is because the housing HSG constitutes a relatively large surface that is in contact with the ambient air. The housing HSG thus acts as a heat sink for the electrical component CMP.

The following characteristics further contribute to an effective heat evacuation. Let it be assumed that the heat conductive coupling HCC has a heat conductivity equal to X Watt/meter Kelvin (W/mK). Let it further be assumed that the housing HSG has a heat conductivity equal to Y Watt/meter Kelvin (W/mK). In that case, the ratio between the heat

evacuation surface HE and the heat reception surface HR of the heat conductive coupling HCC is preferably greater than X/Y. For example, let it be assumed that the heat conductive coupling HCC is made out of copper and that the housing HSG is made out of steel. Copper has a heat conductivity of approximately 400 W/mK. Steel has a heat conductivity of approximately 50 W/mK. In that case, the heat evacuation surface HE is preferably at least 8 times the heat reception surface HR of the heat conductive coupling HCC.

The heat conductive coupling HCC preferably has a conical shape. In many applications, the heat reception surface HR and the heat evacuation surface HE are preferably of different size, as explained hereinbefore. The conical shape provides a smooth transition, as it were, between the heat reception surface HR and the heat evacuation surface HE of the heat conductive coupling HCC. This further contributes to an effective heat evacuation.

An effective heat evacuation is important for several reasons. Firstly, an electrical circuit generally provides better signal processing characteristics with increasing power consumption. For example, a tuner generally has a greater dynamic range with increasing power consumption. An effective heat evacuation allows relatively large power consumption, which contributes to signal processing quality. Secondly, an effective heat evacuation allows implementations of smaller size, which would otherwise not be possible due to overheating. For example, the tuner TUN, which FIG. 2 illustrates, may be of relatively small size. The tuner TUN may be smaller than a conventional tuner TUN for a given power consumption. The electrical component CMP does not need any cooling fin.

FIGS. 3 to 7 illustrate various intermediate products in a method of manufacturing the tuner TUN illustrated in FIG. 2. FIG. 3 illustrates the printed circuit board PCB viewed from the bottom side BS. The printed circuit board PCB comprises a ground plane GPL on the bottom side BS. FIG. 3 further illustrates that the printed circuit board PCB is provided with a hole HOL.

FIG. 4 illustrates an assembly PHA of the printed circuit board PCB and the heat conductive coupling HCC viewed from the bottom side BS of the printed circuit board PCB. The assembly PHA is obtained by placing the heat conductive coupling HCC in the hole HOL of the printed circuit board PCB illustrated in FIG. 3. The heat conductive coupling HCC may be pressed into the printed circuit board PCB so that these elements are fixed together by pressure. Glue may also be used for fixing these elements together so as to obtain the assembly PHA, which FIG. 4 illustrates. FIG. 4 shows, amongst other things, the heat evacuation surface HE of the heat conductive coupling HCC and the protrusion PT on that surface.

FIG. 5 illustrates the assembly PHA of the printed circuit board PCB and the heat conductive coupling HCC viewed from the top side TS of the printed circuit board PCB. The top side TS of the printed circuit board PCB comprises various solder pads SP1, ..., SP10 and a ground solder pad SPG. At least a portion of these solder pads SP1, ..., SP10 form part of a network of connection paths on the printed circuit board PCB. These connection paths, which FIG. 5 does not show, electrically couple various electrical components, when these components are mounted on the printed circuit board PCB. The ground solder pad SPG is circumjacent to the heat reception surface HR of the heat conductive coupling HCC.

FIG. 5 shows the heat reception surface HR of the heat conductive coupling HCC, which has been passed through the hole HOL in the printed circuit board PCB illustrated in FIG. 3. The heat reception surface HR is substantially flush with the various solder pads SP1, ..., SP10 of the printed circuit board PCB. The same applies with regard to the ground solder pad SPG.

FIG. 6 illustrates a solder-paste-printed assembly PHS of the printed circuit board PCB and the heat conductive coupling HCC. The solder-paste-printed assembly is obtained by solder paste printing the assembly PHA that FIG. 5 illustrates. The solder-paste-printed assembly PHS comprises various solder prints SX1, ..., SX10 and a ground solder print SXG. Each solder print SX corresponds with a solder pad SP in FIG. 5. The ground solder print SXG corresponds with the ground solder pad SPG in FIG. 5. The ground solder print SXG covers the heat reception surface HR of the heat conductive coupling HCC, which is illustrated in broken lines.

FIG. 7 illustrates a component-mounted assembly PHC of the printed circuit board PCB and the heat conductive coupling HCC. FIG. 7 illustrates the electrical component CMP, which has been mounted on the printed circuit board PCB. The electrical component CMP has various lead connections LC1, ..., LC10. Each lead connection LC corresponds with a solder print SX in FIG. 6.

The component-mounted assembly PHC is obtained by placing the electrical component CMP on the printed circuit board PCB. The electrical component CMP is placed so that the lead connections LC1, ..., LC10 of the electrical component CMP correspond with the solder prints SX1, ..., SX10, which has been provided on the printed circuit board PCB. Subsequently, heat is applied to make the solder prints SX1, ..., SX10 reflow so as to obtain solder connections between the solder pads SP1, ..., SP10 of the printed circuit board PCB, which FIG. 5 illustrates, and the lead connections LC1, ..., LC10 of the electrical component CMP. The ground solder print SXG, which FIG. 6 illustrates, will also reflow. This

reflow couples the electrical component CMP to the heat conductive coupling HCC in a mechanical, electrical and thermal fashion.

The tuner TUN, which FIG. 2 illustrates, is obtained by providing the component-mounted assembly PHC, which FIG. 7 illustrates, with the housing HSG. There are numerous different manners to provide the housing HSG. For example, the housing HSG may comprise two parts, a bottom part and a top part. The component-mounted assembly PHC is placed in the bottom part of the housing HSG. The bottom part is preferably provided with a relatively small hole via which the protrusion PT on the heat evacuation surface HE may pass through. Optionally, the solder point SLD, which FIG. 2 illustrates, may be provided. Once the component-mounted assembly is well-placed in the bottom part and, optionally, fixed thereto, the top part is fixed to the bottom part of the housing HSG, which seals off the component-mounted assembly.

CONCLUDING REMARKS

The detailed description hereinbefore with reference to the drawings illustrates the following characteristics, which are cited in claim 1. An electronic module (tuner TUN) comprises a printed circuit board (PCB) on which a heat producing component (electrical component CMP) is mounted. A heat conductive coupling (HCC) passes through a hole (HOL) in the printed circuit board (PCB). The heat conductive coupling (HCC) has a heat reception surface (HR) that is thermally coupled to the heat producing component (CMP), and a heat evacuation surface (HE) that is thermally coupled to a heat sink (housing HSG).

The detailed description hereinbefore with reference to the drawings illustrates the following characteristics, which are cited in claim 2. The heat evacuation surface (HE) of the heat conductive coupling (HCC) is larger than the heat reception surface (HR). This contributes to an effective heat evacuation.

The detailed description hereinbefore with reference to the drawings illustrates the following characteristics, which are cited in claim 3. The ratio of the heat evacuation surface (HE) and the heat reception surface (HR) is greater than the ratio of the thermal conductivity of the heat conductive coupling (HCC) and the thermal conductivity of the heat sink (HSG). This further contributes to an effective heat evacuation.

The detailed description hereinbefore with reference to the drawings illustrates the following characteristics, which are cited in claim 4. The heat conductive coupling (HCC) has a conical shape. This further contributes to an effective heat evacuation.

The detailed description hereinbefore with reference to the drawings illustrates the following characteristics, which are cited in claim 5. The heat sink is formed by a housing (HSG) of the electronic module (TUN). This allows a good cooling capacity at relatively low cost.

5 The aforementioned characteristics can be implemented in numerous different manners. In order to illustrate this, some alternatives are briefly indicated.

 The electronic module need not necessarily be a tuner. The electronic module may be, for example, a digital signal processing unit. The printed circuit board may have components on both sides. For example, referring to FIGS. 3 and 4, the ground plane GPL
10 may wholly or partially be replaced by a network of connection paths and various solder points for mounting components. The heat producing component may be any type of electrical component. An integrated circuit is merely an example.

 The electronic module can be manufactured in numerous different manners. FIGS. 3 to 7 merely illustrate an example. As another example, the solder-paste-printed
15 assembly PHS, which FIG. 6 illustrates, may be placed in the housing HSG before the electrical component is mounted on the printed circuit board.

 There are numerous ways of implementing functions by means of items of hardware or software, or both. In this respect, the drawings are very diagrammatic, each representing only one possible embodiment of the invention. Thus, although a drawing shows
20 different functions as different blocks, this by no means excludes that a single item of hardware or software carries out several functions. Nor does it exclude that an assembly of items of hardware or software or both carry out a function.

 The remarks made hereinbefore demonstrate that the detailed description with reference to the drawings, illustrate rather than limit the invention. There are numerous
25 alternatives, which fall within the scope of the appended claims. Any reference sign in a claim should not be construed as limiting the claim. The word "comprising" does not exclude the presence of other elements or steps than those listed in a claim. The word "a" or "an" preceding an element or step does not exclude the presence of a plurality of such elements or steps.

CLAIMS:

1. An electronic module (TUN) comprising:
 - a printed circuit board (PCB) on which a heat producing component (CMP) is mounted; and
 - a heat conductive coupling (HCC) that passes through a hole (HOL) in the printed circuit board (PCB), the heat conductive coupling (HCC) having a heat reception surface (HR) that is thermally coupled to the heat producing component, and having a heat evacuation surface (HE) that is thermally coupled to a heat sink (HSG).
2. An electronic module as claimed in claim 1, the heat evacuation surface (HE) of the heat conductive coupling (HCC) being larger than the heat reception surface (HR).
3. An electronic module as claimed in claim 2, the ratio of the heat evacuation surface (HE) and the heat reception surface (HR) being greater than the ratio of the thermal conductivity of the heat conductive coupling (HCC) and the thermal conductivity of the heat sink (HSG).
4. An electronic module as claimed in claim 2, the heat conductive coupling (HCC) having a conical shape.
5. An electronic module as claimed in claim 1, the heat sink being formed by a housing (HSG) of the electronic module (TUN).
6. An electronic module as claimed in claim 1, the heat evacuation surface (HE) of the heat conductive coupling (HCC) being provided with a protrusion (PT) that passes through a hole (HOL) in the heat sink (HSG).
7. A heat-evacuation-prepared printed circuit board (PHA; PHS) comprising:
 - a printed circuit board (PCB) with solder pads (SP1, ..., SP10) for mounting a heat producing component (CMP) on the printed circuit board (PCB); and

- a heat conductive coupling (HCC) that passes through a hole (HOL) in the printed circuit board (PCB), the heat conductive coupling (HCC) having a heat reception surface (HR) that is substantially flush with the solder pads (SP1, ..., SP10) of the printed circuit board (PCB), and having a heat evacuation surface (HE) that is remote from the printed circuit board (PCB).

8. A method of manufacturing a heat-evacuation-prepared printed circuit board (PHA; PHS), the method comprising:

- an assembly step in which a heat conductive coupling (HCC) is placed in a hole (HOL) of a printed circuit board (PCB), which has solder pads (SP1, ..., SP10) for mounting a heat producing component (CMP) on the printed circuit board (PCB), the heat conductive coupling (HCC) being placed so that a heat reception surface (HR) of the heat conductive coupling (HCC) is flush with the solder pads (SP1, ..., SP10), whereas a heat evacuation surface (HE) of the heat conductive coupling (HCC) is remote from the printed circuit board (PCB).

9. An electronic apparatus (REC) comprising an electronic module (TUN) as claimed in claim 1.

10. An information rendering system (VDS) comprising an electronic module (TUN) as claimed in claim 1, the electronic module being part of a signal processing path (REC) arranged to retrieve an information (VID) from an input signal (RF), and an information rendering device (DPL) for rendering the information (VID) retrieved.

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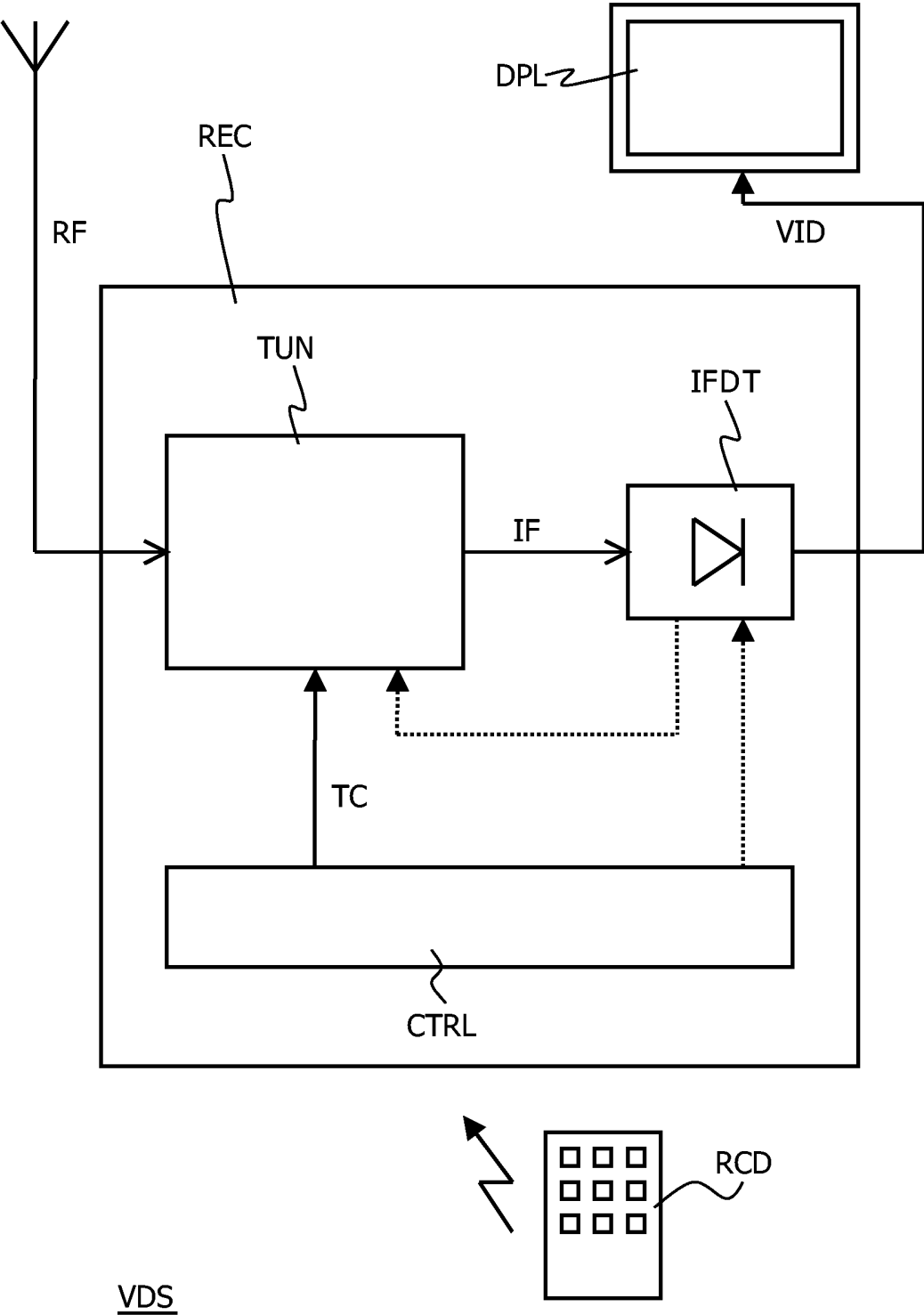
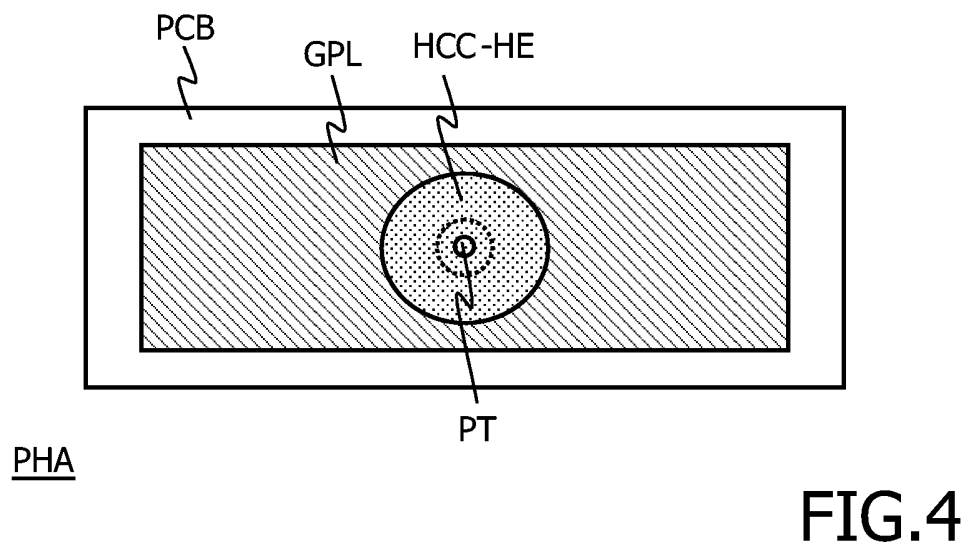
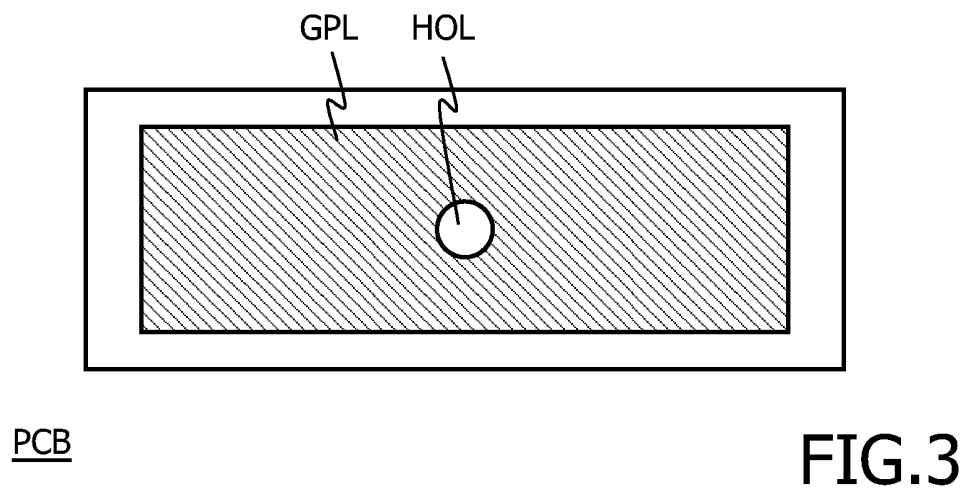
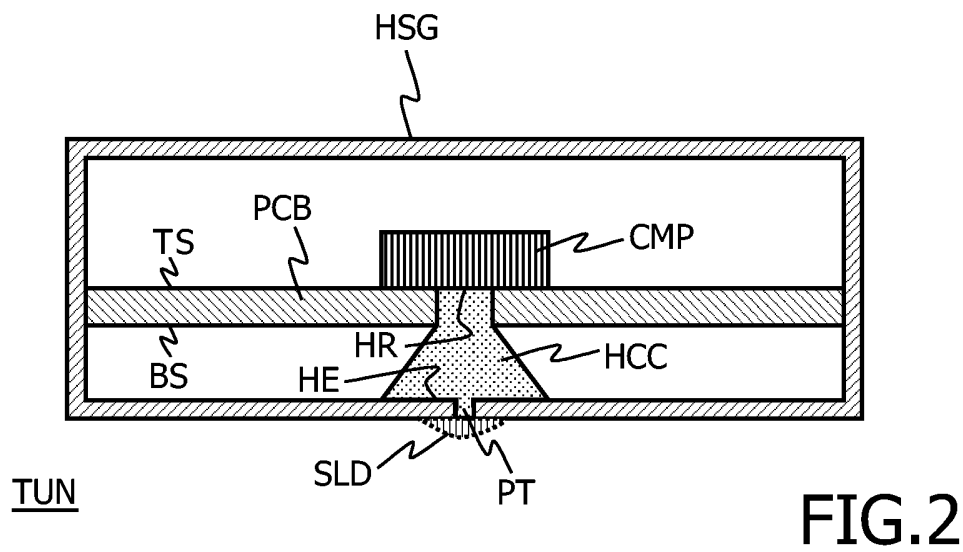
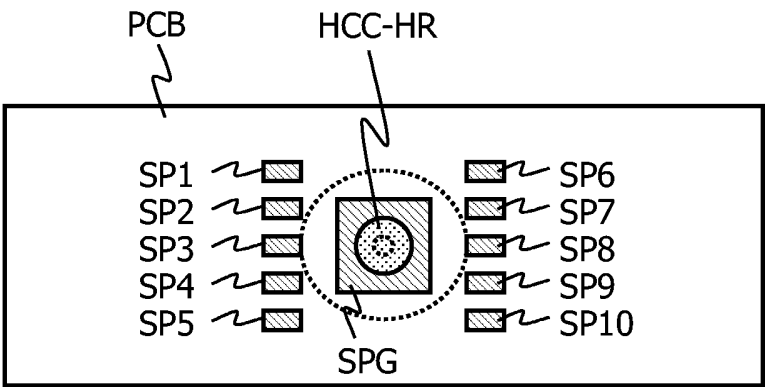


FIG.1

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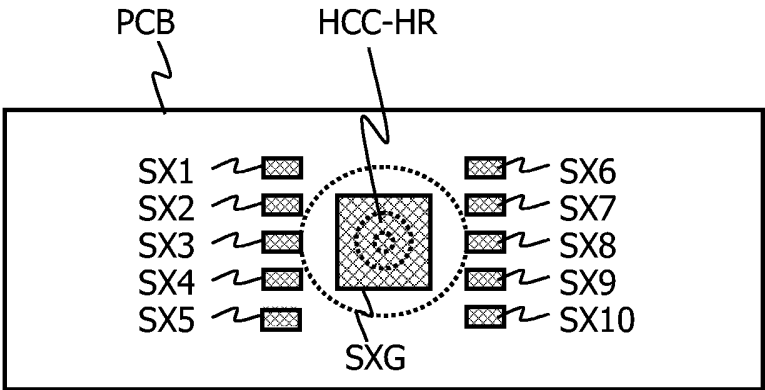


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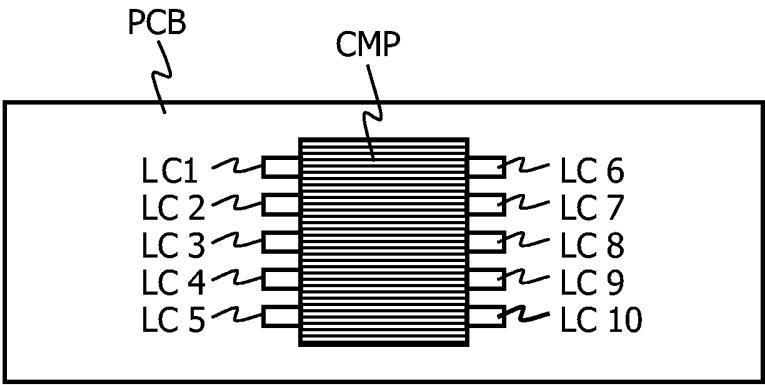
PHA

FIG.5



PHS

FIG.6



PHC

FIG.7