

## TITLE

Microstrip Antenna for Electromagnetic Radiation Dissipation Device

## FIELD OF INVENTION

5 This invention relates generally to antennas that receive electromagnetic radiation. This invention relates more specifically to antennas adapted to be placed in the vicinity of an active electromagnetic radiation emission source to reduce undesirable radiation that emanates from the active emission source.

## BACKGROUND

10 Many devices transmit electromagnetic radiation when in operation. For example, wireless communication devices intentionally emanate electromagnetic radiation when transmitting. Other devices transmit inadvertently, for example when a microwave oven is cooking, microwaves may inadvertently escape the oven. The  
15 widespread acceptance and use of hand-held, portable cellular telephones has been accompanied by increasing concern regarding possible harmful effects of such radiation. New hand-held cellular telephone typically have an elongated housing with an internal antenna, and older hand-held cellular telephones typically have an elongated housing with an antenna extending upward vertically from the housing.

20 When using either type of telephone, the user's head comes into close proximity to the antenna when his head is placed adjacent to the cellular telephone. The antenna emanates radiation when the cellular telephone is transmitting, and such an antenna is referred to herein as a transmitting antenna. Thus, when the user is talking, the device is emanating radiation from the transmitting antenna, and a substantial amount  
25 of electromagnetic energy is projected directly onto the user's head at close range.

Each cellular telephone has to meet certain government guidelines as to the amount of radiation the user is exposed to. The amount of RF radiation absorbed by the body is measured in units known as SARs, or specific absorption rates. It would be desirable to reduce the SARs without significantly adversely affecting the operation  
30 of the telephone.

There have been attempts to shield the body from the electromagnetic energy emanating from the transmitting antenna. For example, U.S. Patent 5,613,221 issued to Hunt discloses a conductive strip placed between the transmitting antenna and the

user's head, to conduct radiation away from the user's head. There have also been some attempts to move the source of electromagnetic energy away from the body by changing the transmitting antenna location or radiation pattern. For example, U.S. Patent 6,356,773 issued to Rinot removes the transmitting antenna from the phone and places it atop the user's head. An insulating shield is disposed between the transmitting antenna and the user's head, like a cap, for blocking emissions so that they do not penetrate through to the user. U.S. Patent 6,031,495 issued to Simmons et alia uses a conducting strip between two poles of a transmitting antenna to create an end fire bi-directional pattern away from the user's head. Others have tried to reduce exposure to harmful emission by canceling the radiation. For example, U.S. Patent 6,314,277 issued to Hsu et alia, is a cellular telephone antenna that cancels transmitted radiation of the cellular telephone with an absorbent directional shield by feeding the signal back into the cellular telephone.

One method of reducing electromagnetic radiation is to capture the radiation with an antenna, convert it to an electric current, and then dissipate the current, as described in U.S. Published Patent Application 2008/0014872. Antennas, however, are designed to receive RF signals in particular frequency bands, and cellular telephones operate generally in one or more of four different bands. For example, in Europe, GSM cellular telephones operate in the 900 MHz and 1800 MHz bands. In the United States, GSM and CDMA cellular telephones operate in the 850 MHz or 1900 MHz bands. It would be desirable to design an antenna for electromagnetic dissipation devices that is capable of capturing radiation across most or all of the cellular telephone frequency bands.

Meander antennas have become popular for receiving cellular telephone signals due to their small size, lightweight, ease of fabrication, and omni-directional radiation patterns. Meander antennas generally comprise a folded wire printed on a dielectric substrate such as a printed circuit board (PCB). Meander antennas have resonance in a particular frequency band in a much smaller space than many other antenna designs. The resonant frequency of a meander antenna decreases as the total wire length of the meander antenna element increases. In addition, if the turns in the meander antenna are very close so as to have strong coupling, there can also be capacitive loading of the antenna, which will increase bandwidth. Total antenna geometry, wire length, and layout must be optimized for each given antenna's

purpose. It would be desirable to design a meander antenna for use with an electromagnetic radiation dissipation device that is effective across the cellular telephone frequency bands.

Therefore, it is an object of this invention to provide an antenna design to be used with a device that decreases the SARs to the user of an active emission source without significantly adversely affecting the desired performance of the emission source. It is a particular object to provide an antenna design specifically tuned for reducing the undesirable radiation a user is exposed to from a cellular telephone. It is a further object to provide an antenna design that can capture electromagnetic radiation from a cellular telephone operating in any of the four predominant frequency bands allotted for cellular telephone communication.

### SUMMARY OF THE INVENTION

The present invention relates to a microstrip antenna, in particular a microstrip antenna to be used with an electromagnetic radiation dissipation device that reduces exposure to undesirable electromagnetic radiation or with a device for indicating the presence of known or unknown electromagnetic radiation. The dissipation device uses an antenna to capture radiation from an active emission source, such as a cellular telephone when it is transmitting. The device converts the captured radiation into an electric current and dissipates the collected current by spending it to operate a current-using device, which may be a thermal, mechanical, chemical or electrical device, or combination thereof.

The microstrip antenna according to the invention comprises several serially connected meandering segments wherein each meandering segment comprises at least two parallel adjacent conductive portions serially connected by two successive bends; one or more meandering segments have bends with angles which differ from  $90^\circ$  by less than  $5^\circ$ ; and one or more meandering segments have bends with angles which differ from  $90^\circ$  by more than  $5^\circ$ . It has been found that this antenna presents particularly advantageous properties for reducing exposure to undesirable electromagnetic radiation.

Advantageously, the antenna according to the invention may be a monopole antenna.

Advantageously, said bends may be sharp bends. By "sharp bends" it is meant that they do not present any significant taper or rounding.

Advantageously, the microstrip may be between 0.005 and 0.035 inches wide.

Advantageously, the microstrip may be between 0.5 and 5 inches long.

5 Advantageously, said parallel adjacent conductive portions may be spaced with a pitch between 0.03 and 0.7 inches.

Advantageously, the antenna may comprise at least two meandering segments or significantly different widths. By "width" of a meandering segment it is understood the distance between opposite ends of the parallel adjacent conductive portions of  
10 that segment. By including meandering segments of significantly different widths, the antenna achieves a better capture of electromagnetic radiation at various significantly different wavelengths.

Advantageously, the antenna may comprise a first meandering segment having bends with angles which differ from 90° by less than 5°; and a second  
15 meandering segment serially connected to the first meandering segment and having bends with angles which differ from 90° by more than 5°.

More advantageously, the antenna may further comprise a third meandering segment serially connected to the second meandering segment and having bends with angles which differ from 90° by less than 5°.

20 Even more advantageously, the antenna may further comprise a fourth meandering segment serially connected to the third meandering segment and having bends with angles which differ from 90° by more than 5°.

The antenna may also further comprise a fifth meandering segment serially connected to the fourth meandering segment and having bends with angles which  
25 differ from 90° by less than 5°.

In a preferred embodiment, said fifth meandering segment may be connected to an electrical contact, said first, third and fifth meandering segments may have substantially parallel edges, and said third meandering segment may have a substantially narrower width than said first and fifth segments. By "edge" of a  
30 meandering segment, it is understood a line connecting adjacent ends of the parallel adjacent conductive portions of that segment. This configuration further improves capture of electromagnetic radiation at various significantly different wavelengths.

Advantageously, two edges of said second meandering segment converge with an angle of more than  $1^\circ$ , but less than  $90^\circ$ , and an upper and a lower edge of said fourth meandering segment diverge with an angle of more than  $90^\circ$ . If looking at the footprint of the meandering segment, where "footprint" is understood to be an outline of the perimeter of the segment, the footprint of second meandering segment tapers from the width of said first meandering segment to the width of said third meandering segment, and the footprint of said fourth meandering segment tapers from the width of said third meandering segment to the width of said fifth meandering segment.

The present invention also relates to a device comprising a microstrip antenna according to the invention and a dissipation assembly connected to said microstrip antenna, as well as to a method of reducing exposure to electromagnetic radiation emanating by an active emission source, the method comprising receiving electromagnetic radiation from the active emission source at a microstrip antenna according to the invention whereby current is induced in said antenna, conducting the current to a dissipation assembly, and operating the dissipation assembly with the current.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram illustrating the antenna of the present invention in cooperation with an electromagnetic radiation dissipation device.

Fig. 2 is block diagram illustrating an electromagnetic radiation dissipation device incorporating the antenna of the present invention positioned near an emission source.

Fig. 3 is a block diagram of a printed circuit board incorporating the antenna of the present invention for use with a cellular telephone.

Fig. 4 depicts the preferred dimensions of the antenna.

Fig. 5 is a perspective view of a cellular telephone with the electromagnetic radiation dissipation device adhered to the outside shell.

#### DETAILED DESCRIPTION OF THE INVENTION

The present invention is a microstrip antenna 14, in particular a microstrip antenna 14 to be used with an electromagnetic radiation dissipation device 10 for

reducing exposure to undesirable radiation or with a device for indicting the presence of known or unknown electromagnetic radiation. Dissipation device 10 comprises antenna 14 and a dissipation assembly 17, as illustrated in Figure 1. When an emission source 11, as shown in Figure 2, is in operation it transmits electromagnetic radiation. When antenna 14 is bombarded by the radiation, electrons are stirred up in the antenna 14, generating an electron flow (current). To continue to absorb the electromagnetic radiation, the current eventually must be drained from the antenna. This current is drained from the target antenna 14 with a conductor 12 and moved to a dissipation assembly 17, which spends the current by operating an electrical, mechanical or thermal device. For small emission sources, the current is small and the conductor may be as simple as a wire or printed circuit board lead. For larger emission sources, a heavier-duty conductor may be required.

Figure 3 illustrates a PCB 30 incorporating the antenna 14 of the present invention. As is known in the art, an antenna is any conducting mass that functions as a receiver or collector of electromagnetic energy. Additionally, antennas have a number of important parameters; those of most interest include the gain, radiation pattern, bandwidth and polarization. In a receiving antenna, the applied electromagnetic field is distributed throughout the entire length of the antenna to receive the undesirable radiation. If the receiving antenna that the signal strikes has a certain length relative to the wavelength of the received radiation, the induced current will be much stronger. The desired length of the antenna can be determined by using the well-known equation:

$$(\lambda)(f) = c$$

where  $\lambda$  is the wavelength of the incident radiation,  $f$  is the frequency of the incident radiation, and  $c$  is the speed of light. For example, if a signal at 1900 MHz travels through the air, it completes a cycle in approximately 32 cm. If the signal strikes a 32 cm antenna or certain fractions of it (1/2 or 1/4 or 1/16 wavelength), then the induced current will be much higher than if the signal struck a target antenna that was not some appreciable fraction of the wavelength.

Typically, cellular phones and other wireless communications technologies such as PCS, G3 or Bluetooth® emit radiation in the radio or microwave ranges, or both,

when transmitting. These and other consumer products often emit multiple wavelengths (frequencies). Cellular telephones, in particular, emit radiation in the 450 MHz, 850 MHz, 900 MHz, 1800 MHz, and 1900 MHz ranges when transmitting. This means that the microstrip antenna 14 must perform well over a range of frequencies.

- 5 The corresponding wavelengths for cellular telephone frequencies are summarized below:

| f        | $\lambda$ | $1/2 \lambda$ | $1/4 \lambda$ | $1/16 \lambda$ |
|----------|-----------|---------------|---------------|----------------|
| 450 MHz  | 64 cm     | 32 cm         | 16 cm         | 4 cm           |
| 850 MHz  | 33.88 cm  | 16.9 cm       | 8.47 cm       | 2.12 cm        |
| 900 MHz  | 32 cm     | 16 cm         | 8 cm          | 2 cm           |
| 1800 MHz | 16 cm     | 8 cm          | 4 cm          | 1 cm           |
| 1900 MHz | 15.16 cm  | 7.58 cm       | 3.79 cm       | 0.95 cm        |

- 10 The microstrip antenna 14 herein is a receiving antenna and does not intentionally transmit electromagnetic energy. Microstrip antenna 14 can be any type of microstrip antenna such as a PCB trace antenna, a wire antenna, a conductive ink antenna, or an antenna of any other conductive material, as is known in the art. Microstrip antenna 14 is preferably a monopole PCB trace antenna comprised of a 1
- 15 oz copper microstrip arranged in a serpentine or meandering pattern. PCB trace antennas, microstrips, and methods for making them are well known in the art. PCB 30 has a top surface that includes the microstrip. In the preferred embodiment, the PCB is a standard 0.8 mm FR4 substrate material that is nonconducting at 1.8 GHz. For increased flexibility, a 0.5 mm substrate may be substituted. For example, to
- 20 allow the PCB antenna to mount to an irregular or rounded cellular telephone or other device, a PCB thickness of 0.5 mm or less is desirable. In the preferred embodiment, the PCB is shaped like a bottle or a modified hourglass as shown in Figure 3, and rather than using a ground plane for the antenna, the antenna is connected to a bridge rectifier to turn alternating current into direct current for lighting an LED.
- 25 The microstrip on the top surface of the PCB 30 is preferably between 0.005 and 0.035 inches wide and more preferably 0.020 inches wide as shown in Figure 4. The overall length of the microstrip from one end to the other is preferably between 0.5

and 5 inches and more preferably 3.86165 inches as shown in Figure 4. The preferred overall antenna area of copper is 0.0798 inches squared, and the preferred circumference of the antenna is 7.9349 inches. The general pattern of the microstrip antenna according to the invention comprises several serially connected meandering segments wherein each meandering segment comprises at least two parallel adjacent conductive portions serially connected by two successive bends; one or more meandering segments have bends with angles which differ from  $90^\circ$  by less than  $5^\circ$ ; and one or more meandering segments have bends with angles which differ from  $90^\circ$  by more than  $5^\circ$ . Preferably, each of the bends is a sharp bend, which does not present any significant taper or rounding. The distance between the parallel adjacent conductive portions is the pitch.

The antenna may comprise at least two meandering segments or significantly different widths. The width of a meandering segment is the distance between opposite ends of the parallel adjacent conductive portions of that segment.

Preferably, the antenna comprises a first meandering segment having bends with angles which differ from  $90^\circ$  by less than  $5^\circ$ ; and a second meandering segment serially connected to the first meandering segment and having bends with angles which differ from  $90^\circ$  by more than  $5^\circ$ . The antenna may further comprise a third meandering segment serially connected to the second meandering segment and having bends with angles which differ from  $90^\circ$  by less than  $5^\circ$ . The antenna may further comprise a fourth meandering segment serially connected to the third meandering segment and having bends with angles which differ from  $90^\circ$  by more than  $5^\circ$ . The antenna may also further comprise a fifth meandering segment serially connected to the fourth meandering segment and having bends with angles which differ from  $90^\circ$  by less than  $5^\circ$ .

In a preferred embodiment, said fifth meandering segment may be connected to an electrical contact, said first, third and fifth meandering segments may have substantially parallel edges, and said third meandering segment may have a substantially narrower width than said first and fifth segments. The edge of a meandering segment comprises a line connecting adjacent ends of the parallel adjacent conductive portions of that segment.

Preferably, the two edges of said second meandering segment converge with an angle of more than  $1^\circ$ , but less than  $90^\circ$ , and an upper and a lower edge of said

fourth meandering segment diverge with an angle of more than 90°. If looking at the footprint of the meandering segment, where "footprint" is understood to be an outline of the perimeter of the segment, the footprint of second meandering segment tapers from the width of said first meandering segment to the width of said third meandering segment, and the footprint of said fourth meandering segment tapers from the width of said third meandering segment to the width of said fifth meandering segment.

Figure 3 shows a preferred pattern of the microstrip antenna with several meandering segments that incorporates several substantially 90-degree turns or bends in addition to several turns or bends of greater or lesser degree. The specific dimensions of the segments and angles of the preferred embodiment are shown in Figure 4 and described below. For the sake of convenience and with respect to Figures 3 and 4, the portions of microstrip antenna 14 that extend in the y direction will be considered vertical portions (or vertically-oriented portions), and the portions of microstrip antenna that extend in the x direction will be referred to herein as horizontal portions (or horizontally-oriented portions). As is shown in Figures 3 and 4, all of the horizontal portions of microstrip antenna 14 are substantially parallel to one another. The vertical portions, however, can be substantially parallel or angled. As shown, the vertical portions are consistent in height (or y displacement) for each meander segment. As shown in Figure 4, they are uniform and 0.07 inches throughout (not all of the heights are shown but should be considered consistent throughout). Alternatively, the height of each vertical portion can vary within a meandering segment or can vary across different meandering segments. Also as shown, the pitch between adjacent parallel horizontal portion is 0.05 inches throughout. As with the height of each vertical portion, the pitch between adjacent parallel portions can vary within a meandering segment or can vary across different meandering segments. The horizontal portions and vertical portions are connected to one another at an angle or "bend angle." Bend angles can be any interior angle between 0 degrees and 180 degrees. The bends, as shown in Figures 3 and 4, are preferably sharp bends that do not present any significant taper or rounding.

Figure 3 illustrates that microstrip antenna 14 can be broken into several serially connected microstrip segments 31-35. Microstrip segment 31 includes a vertical portion that is coupled at its proximal end to capacitors 15. Segment 31 then bends 90 degrees at bend 31a to a horizontal portion 31b that is half the overall width of the

footprint of segment 31. Segment 31 then meanders back and forth and includes another four 90-degree bends. In segment 31, the vertical portions are parallel to one another. The distal end of segment 31 is coupled to the proximal end of second microstrip segment 32 bend 32a that is less than 90 degrees. The footprint of segment 32 tapers from the overall width of segment 31 to a smaller width and includes a meander pattern involving bends greater and less than 90 degrees, such that each vertical portion is angled toward the centerline along the y axis of the antenna. The distal end of segment 32 is coupled to the proximal end of third microstrip segment 33 at bend 33a. Segment 33 is narrower than segment 31 but includes six more 90-degree bends. In segment 33, the vertical portions are parallel to one another. The distal end of segment 33 is coupled to the proximal end of fourth microstrip segment 34 at bend 34a. The footprint of segment 34 tapers from the width of segment 33 to a larger width and includes bends greater and less than 90 degrees, such that the vertical portion is angled away from the center. Finally, the distal end of segment 34 is coupled to the proximal end of fifth microstrip segment 35 at bend 35a. Segment 35 is the same overall width as segment 31 and includes eight 90-degree bends. The final portion of segment 35 is horizontal and is one the overall width of the footprint of segment 35. The vertical portions of section 35 are parallel to one another. For the preferred embodiment, there are 21 angles of 90 degrees, 3 angles of less than 90 degrees, and 3 angles of more than 90 degrees. Alternative embodiments can have varying numbers of angles, however the general shape of a modified hourglass or bottle as shown in Figures 3 and 4 that incorporating bends of various angles gives the broadest range of reception.

Figure 4 illustrates the dimensions of the preferred embodiment of microstrip antenna 14. All of the measurements are in inches in Figure 4, and the tolerances are  $\pm 0.5^\circ$  for angular measurements and  $\pm 0.015$  for linear measurements. Microstrip antenna 14 comprises a first meandering segment having a first vertical portion 0.07 inches in height, a first horizontal portion 0.18 inches in width connected at a  $90^\circ$  angle to the first vertical section, a second vertical portion 0.07 inches in height connected at a  $90^\circ$  angle to the first horizontal portion; a second horizontal portion 0.32 inches in width connected at a  $90^\circ$  angle to the second vertical portion; a third vertical portion 0.07 inches in height connected at a  $90^\circ$  angle to the second

horizontal portion; and a third horizontal portion 0.32 inches in width oriented at a 90° angle from and connected to the third vertical portion.

5 Microstrip antenna 14 as shown in Figure 4 comprises a second meandering segment serially connected to the first microstrip segment and having a first vertical portion with a vertical displacement of 0.07 inches connected at a 65.83° angle to the third horizontal portion of the first meandering segment; a first horizontal portion connected at a 114.17° to the first vertical portion; a second vertical portion with a vertical displacement of 0.07 inches connected at a 65.83° angle; and a second horizontal portion connected at a 114.17° angle to the second vertical portion.

10 Microstrip antenna 14 as shown in Figure 4 further comprises a third meandering segment serially connected to the second meandering segment and having a first vertical portion 0.07 inches in height and connected at a 90° angle to the second horizontal portion of the second meandering segment; a first horizontal portion 0.20 inches in width connected at a 90° angle to the first vertical section, a second vertical portion 0.07 inches in height connected at a 90° angle to the first horizontal portion; a second horizontal portion 0.20 inches in width connected at a 90° angle to the second vertical portion; a third vertical portion 0.07 inches in height connected at a 90° angle to the second horizontal portion; and a third horizontal portion 0.20 inches in width connected at a 90° angle from the third vertical portion; and a fourth vertical portion 0.07 inches in height connected at a 90° angle to the third horizontal portion; and a fourth horizontal portion 0.20 inches in width connected at a 90° angle from the fourth vertical portion.

25 Microstrip antenna 14 as shown in Figure 4 further comprises a fourth meandering segment serially connected to the third meandering segment and having a first horizontal portion 0.20 inches in width and connected at 90° to the fourth horizontal portion of the third meandering segment; a first vertical portion with a vertical displacement of 0.07 inches connected at a 146.71° angle to the first horizontal portion; and a second horizontal portion 0.32 inches in width connected at a 33.29° to the first vertical portion.

30 Microstrip antenna 14 as shown in Figure 4 also comprises a fifth meandering segment serially connected to the fourth meandering segment and having a first vertical portion 0.07 inches in height and connected at a 90° angle to the first horizontal portion of the fourth meandering segment; a first horizontal portion 0.32

inches in width connected at a 90° angle to the first vertical section, a second vertical portion 0.07 inches in height connected at a 90° angle to the first horizontal portion; a second horizontal portion 0.32 inches in width connected at a 90° angle to the second vertical portion; a third vertical portion 0.07 inches in height connected at a 90° angle to the second horizontal portion; and a third horizontal portion 0.32 inches in width connected at a 90° angle from the third vertical portion; a fourth vertical portion 0.07 inches in height connected at a 90° angle to the third horizontal portion; and a fourth horizontal portion 0.16 inches in width connected at a 90° angle from the fourth vertical portion.

Microstrip antenna 14 cooperates with dissipation assembly 17 of dissipation device 10 to effectively decreasing the SARs to the user of a cellular telephone without significantly adversely affecting the transmission from the cellular telephone to the cell tower, or base station. As shown in Figure 3, microstrip antenna 14 is connected to capacitors 15 and diodes 16, to drive the LED 18. This further permits the dissipation device to also indicate to its user that electromagnetic radiation is present. The capacitors and diodes act as a voltage multiplier to generate sufficient voltage to drive the LED 18. For example, in this low-level application, four capacitors 15 are used with two diodes 16. Preferably the diodes 16 are high-frequency RF Schottky diodes, which have a very low forward voltage of about 0.2-0.3 V. Such diodes are available commercially from, for example, Aeroflex / Metelics, Inc. of Sunnyvale, California. Preferably the capacitors are 1.0  $\mu$ f, 6 VDC ceramic capacitors such as the AVX 0603ZD105KAT2A available from AVX of Myrtle Beach, South Carolina. Additionally, the LED is preferably a low current 632 nm red LED such as the APT1608SEWE available from Kingbright Corp. of City of Industry, California.

The number of capacitors and diodes can be increased or decreased as necessary when cooperating with emission sources of different levels of radiation. For example, when reducing undesirable emission from an emission sources emanating higher energy, such as short-wave radio, the number of capacitors can be reduced because the voltage draining off the antenna is itself sufficient to drive a dissipater assembly.

The collected current can be used to operate any dissipation assembly 17, which is defined as one or more users of current. For example, the dissipation assembly 17 can be one or more of a buzzer, bell or any other transducer that converts electrical

energy to sound; motor or any other transducer that converts electrical energy to motion; heater or any other transducer that converts electrical energy to heat; lamp or any transducer that converts electrical energy to light; or a combination thereof. The current may be used to catalyze a chemical reaction. In the preferred embodiment, the current is directed to an LED that lights up when supplied with the current, serving a secondary purpose of showing the user when the device 10 is working or when electromagnetic radiation is present. In another embodiment, the current is directed to an LCD display. The dissipation assembly 17 may be used to operate one or more users of current within the emission source 11.

Figure 5 illustrates device 10 incorporating microstrip antenna 14 as it is applied to a cellular telephone 50. Cellular telephone 50 is the electromagnetic emission source 11. Dissipation device 10 does not have to be connected in any way to the emission source 11. For example, in the preferred embodiment, the dissipation device 10 is not connected electrically to the cellular telephone 50. Additionally, dissipation device 10 can simply rest near cellular telephone 50 by being worn on a persons clothing or integrated into accessories, such as jewelry, lanyards, hats or scarves. Preferably, however, dissipation device 10 is connected physically to the emission source 11, simply so that dissipation device 10 does not inadvertently get separated from the emission source 11 and stop functioning as intended. For example, dissipation device 10 may be adhesively attached to the outer housing 51 of the cellular telephone 50, as shown in Fig 5. Dissipation device 10 may be attached to the emission source 11 using other mechanisms, such as a screw, pin, compression or friction fit, for example, or dissipation device 10 may be integrally formed with the emission source 11. Regardless of whether dissipation device 10 is physically attached to emission source 11, it must be within a certain distance to capture the undesirable radiation. This distance depends on a number of factors, including the emission frequency, power, medium through which the radiation is traveling, etc. The acceptable distance 20 is symbolically indicated in Figure 2 with the dotted line. Preferably, the dissipation device 10 is positioned within 6 inches of a cellular telephone or other emission source.

The following comparative table shows the reduction in specific absorption rate (SAR) values obtained with a dissipative device with an example of an antenna

according to the invention (RF Raider), compared with those obtained with a dissipative device with a conventional meandering microstrip antenna:

| <b>Comparison Table of SAR Reducing Chips Tested</b> |                        |                       |                  |               |          |
|------------------------------------------------------|------------------------|-----------------------|------------------|---------------|----------|
| Handset Tested                                       | SAR Reducing Chip Used | Frequency Band Tested | SAR without Chip | SAR with Chip | Decrease |
| Nokia 2680                                           | RF Raider              | 1800 MHz              | 0.589            | 0.306         | 48.0%    |
| Nokia 2680                                           | Chip with Antenna      | 1800 MHz              | 0.561            | 0.533         | 5.0%     |

Note: All testing was conducted at the mid channel in the band.

5 In addition to use with cellular telephones, the present invention may be used with other emission sources such as other wireless communication devices such as satellite phones, BlackBerry® and other email-transmitting devices; wide area wireless local area networks; microwave ovens; portable radios, music players, and video players; automatic garage door and building door openers; police radar guns; short-wave and other ham radios; televisions or other cathode ray tube and plasma displays; power transmission lines; radioactive chemicals; or any other emission source. The present invention may also be used to indicate when electromagnetic radiation is present yet the emission source is unknown.

10 While there has been illustrated and described what is at present considered to be the preferred embodiment of the present invention, it will be understood by those

skilled in the art that various changes and modifications may be made and equivalents may be substituted for elements thereof without departing from the true scope of the invention. Therefore, it is intended that this invention not be limited to the particular embodiment disclosed, but that the invention will include all embodiments  
5 falling within the scope of the appended claims.

**CLAIMS**

We claim:

1. A microstrip antenna comprising at least three serially connected meandering segments wherein:
  - 5 - each meandering segment comprises at least two parallel adjacent conductive portions serially connected by two successive bends;
  - one or more meandering segments have bends with angles which differ from 90° by less than 5°;
  - one or more meandering segments have bends with angles which  
10 differ from 90° by more than 5°;
  - each meandering segment having bends with angles which differ from 90° by more than 5° is serially connected to at least one meandering segment having bends with angles which differ from 90° by less than 5°; and  
15 - each meandering segment having bends with angles which differ from 90° by less than 5° is serially connected to at least one meandering segment having bends with angles which differ from 90° by more than 5°.
2. The antenna of claim 1, wherein said antenna is a monopole antenna.
- 20 3. The antenna of claim 1, wherein said bends are sharp bends.
4. The antenna of claim 1, wherein the microstrip is between 0.005 and 0.035 inches wide.
5. The antenna of claim 1 wherein the microstrip is between 0.5 and 5 inches long.
- 25 6. The antenna of claim 1, wherein said parallel adjacent conductive portions are spaced with a pitch between 0.03 and 0.7 inches.
7. The antenna of claim 1, having at least two meandering segments of significantly different widths.
8. The antenna of claim 1 comprising:
  - 30 - a first meandering segment having bends with angles which differ from 90° by less than 5°;

- a second meandering segment serially connected to the first microstrip segment and having bends with angles which differ from  $90^\circ$  by more than  $5^\circ$ ; and
  - a third meandering segment serially connected to the second meandering segment and having bends with angles which differ from  $90^\circ$  by less than  $5^\circ$ .
- 5
9. The antenna of claim 8 further comprising a fourth meandering segment serially connected to the third meandering segment and having bends with angles which differ from  $90^\circ$  by more than  $5^\circ$ .
- 10 10. The antenna of claim 9 further comprising a fifth meandering segment serially connected to the fourth meandering segment and having bends with angles which differ from  $90^\circ$  by less than  $5^\circ$ .
11. The antenna of claim 9, wherein said first meandering segment is connected to an electrical contact, said first, third and fifth meandering segments have substantially parallel edges, and said third meandering segment has a substantially lower width than said first and fifth segments.
- 15
12. The antenna of claim 11, wherein two edges of said second meandering segment converge with an angle of more than  $1^\circ$  but less than  $90^\circ$ , and an upper and a lower edge of said fourth meandering segment diverge with an angle of more than  $90^\circ$ .
- 20
13. A device comprising:
- a microstrip antenna according to any one of the preceding claims; and
  - a dissipation assembly connected to said microstrip antenna.
- 25
14. The device of claim 13, wherein the dissipation assembly comprises one or more of an electrical, mechanical or thermal device.
15. The device of claim 13 wherein the dissipation assembly comprises a light emitting diode.
- 30 16. The device of claim 13, wherein the microstrip antenna is physically connected to an active emission source.

17. The device of claim 13, wherein the microstrip antenna is not physically connected to an active emission source.
18. The device of claim 13, wherein the microstrip antenna is tuned to the wavelength of a handheld transceiver, such as a cellular telephone.
- 5 19. A method of reducing exposure to undesired electromagnetic radiation emanating from an active emission source, the method comprising:
- receiving electromagnetic radiation from the active emission source at a microstrip antenna whereby current is induced in said antenna;
  - conducting the current to a dissipation assembly; and
  - 10 - operating the dissipation assembly with the current;
- wherein the microstrip antenna comprises at least three serially connected meandering segments wherein:
- each meandering segment comprises at least two parallel adjacent conductive portions serially connected by two successive bends;
  - 15 - one or more meandering segments have bends with angles which differ from 90° by less than 5°;
  - one or more meandering segments have bends with angles which differ from 90° by more than 5°;
  - each meandering segment having bends with angles which differ from 90° by more than 5° is serially connected to at least one meandering segment having bends with angles which differ from 90° by less than 5°; and
  - 20 - each meandering segment having bends with angles which differ from 90° by less than 5° is serially connected to at least one meandering segment having bends with angles which differ from 90° by more than 5°.
- 25 20. The method of claim 19, wherein the dissipation assembly comprises one or more of an electrical, mechanical, or thermal device.
21. The method of claim 19, wherein the dissipation assembly comprises a light emitting diode.
- 30 22. The method claim 19, wherein the microstrip antenna is physically connected to an active electromagnetic emission source.

23. The method of claim 19, wherein the microstrip antenna is not physically connected to an active electromagnetic emission source.
24. The method of claim 19, wherein the microstrip antenna is tuned to the wavelength of a handheld transceiver, such as a cellular telephone.