

United States Patent

Simopoulos et al.

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[54] MULTIBAND ANTENNA WITH ASSOCIATED R.F. AMPLIFIER

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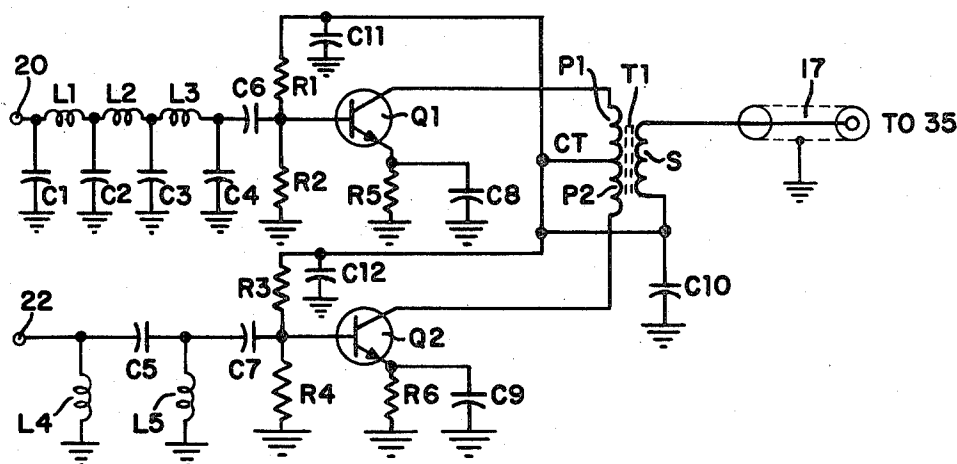
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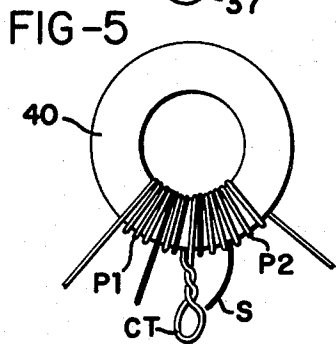
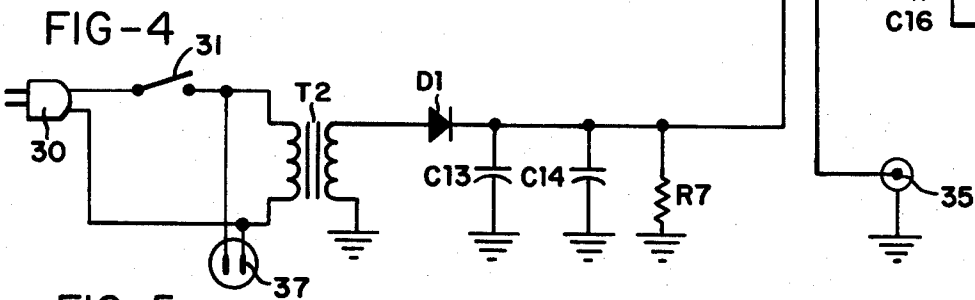
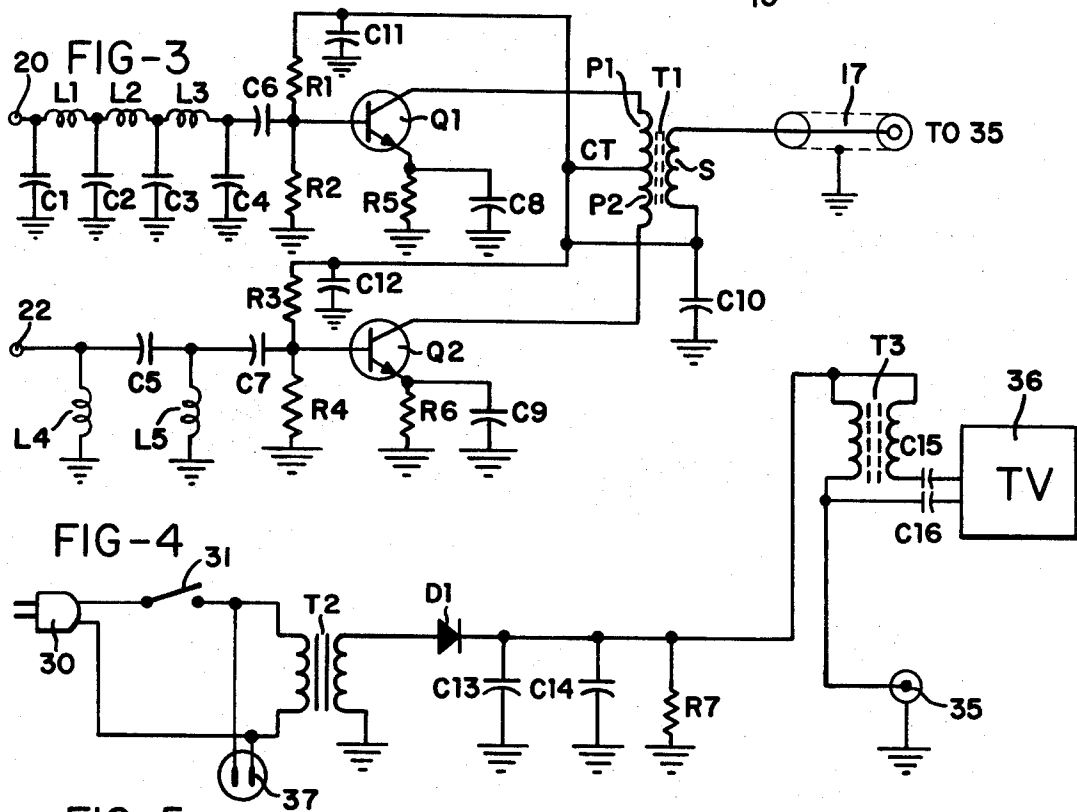
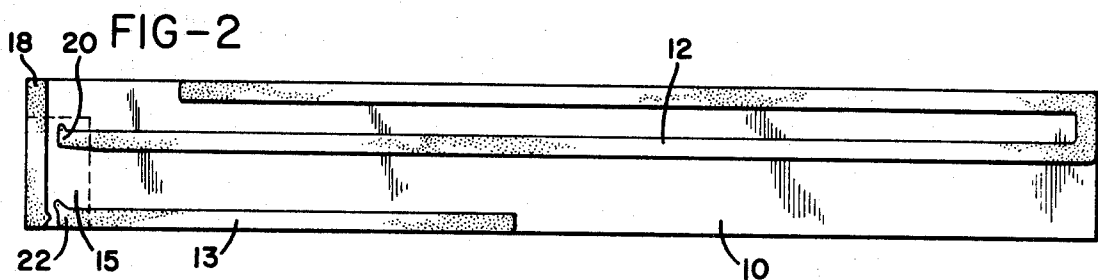
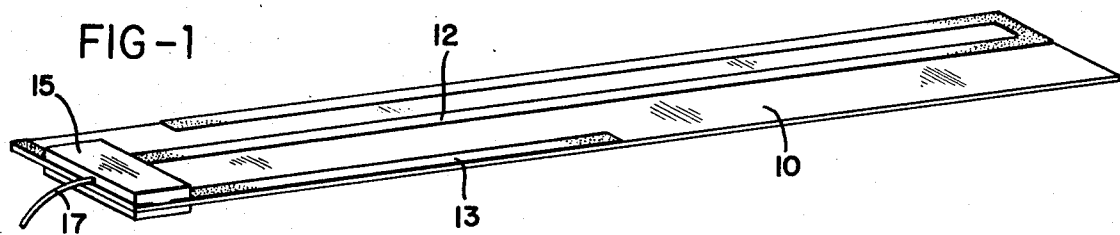
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[57] ABSTRACT

An improved VHF television antenna includes a pair of elongated antenna elements mounted on a base member and a noise matched amplifier connected directly to each element to amplify the received signal which is then transferred by a low impedance cable to a television set. The input impedance of each amplifier is noise matched to the impedance of its corresponding element at the center of the band of wavelengths for which the element is designed to receive.

1 Claim, 5 Drawing Figures





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MULTIBAND ANTENNA WITH ASSOCIATED R.F. AMPLIFIER

BACKGROUND OF THE INVENTION

Commercial television broadcasting in the United States in the very high frequency (VHF) range is divided into a lower band extending between 54 and 88 mHz (channels 2-6) and a higher band extending between 174 and 216 mHz (channels 7-13). The total band width for the VHF television channels is therefore in the order 4:1.

When using a single antenna to accommodate this entire frequency range of the VHF spectrum, it is generally necessary to apply filtering techniques to reduce the unwanted effects of high intensity signals occurring in the non-TV portion of the spectrum, i.e., from 88 to 174 mHz. Another technique is to employ two antennas, one designed to receive the low band and the other the high band. These conventional antennas are either flat dipole or a multimode dipole and are quite large since they are usually one-half wavelength in length.

SUMMARY OF THE INVENTION

This invention relates to an integrated transistorized television receiving antenna which is smaller in dimension than conventional antennas and may employ monopole elements as well as dipoles. The end of each element is connected directly to an integrally connected noise matched amplifier which is mounted on the antenna structure. The impedance of each amplifier is noise matched to the impedance of its corresponding element at approximately the center frequency for which the element is designed to receive, and since the impedance is noise matched, high signal to noise ratios are obtained. Also, since the antenna may employ monopoles and does not require the use of dipoles, the length of the antenna may be at least half that of conventional devices.

The output from the two integrally connected noise matched amplifiers are coupled together through a high frequency transformer and this combined signal is carried by a coaxial cable to the television receiver. The coaxial cable also serves the dual purpose of supplying DC power to the transistors, and consequently means to separate the DC power supply from the television signals are employed.

In a preferred embodiment, the antenna elements are mounted on a single base member with the element receiving the low band having a total length in the order of 56 inches, and the element receiving the high band having a length in the order of 15 inches. The 56 inch element is folded to about 29 inches in order to restrict the total length of the antenna assembly to about 30 inches. Also, the spacing between the elements is selected so that the longer antenna will act as a reflector for the shorter antenna, and the shorter antenna will act as a director for the longer antenna resulting in an improved front to back gain ratio.

Accordingly, it is an object of this invention to provide an improved small antenna system of the type described wherein integrally connected noise matched amplifier elements are mounted directly on the antenna supporting structure with their inputs connected directly to the ends of their respective elements; to provide an improved antenna system wherein the im-

pedance of each amplifier is adjusted to noise match the impedance of its respective element at approximately the center of the band of frequencies for which that element is designed thus to maximize signal to noise ratio and minimize noise from the active elements; and to provide an improved television receiving antenna system which occupies less space than conventional antennas but yet provides high gain and improved signal to noise ratios.

Other objects and advantages of the invention will be apparent from the following description, the accompanying drawings and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the improved VHF television antenna constructed according to this invention;

FIG. 2 is a plan view of the VHF television antenna showing particularly the configuration and relationship of the monopole elements to each other;

FIG. 3 is an electrical schematic diagram of the amplifier circuit which is mounted directly on the antenna structure; and

FIG. 4 is an electrical schematic diagram of a power supply which may be used with the circuit shown in FIG. 3;

FIG. 5 is a plan view of a transformer which combines the outputs from two transistor amplifier circuits mounted on the antenna structure.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now particularly to FIGS. 1 and 2, which show a preferred embodiment of a VHF television receiving antenna constructed according to this invention, the antenna includes a base member 10 which may be formed from phenolic or other electrically insulating material. Two monopole elements are formed on the base member 10, the first monopole element 12 having a length effective to receive signals in the lower band (channels 2-6), and a second monopole element 13 having a length effective to receive signals in the higher television band (channels 7-13).

The first monopole element 12 has a total length of approximately 56 inches, however this element is folded so that the total length of the base member itself is only 30 inches. The length of the second monopole element 13 is in the order of 14 inches and represents approximately one quarter wavelength.

The width of each antenna element is preferably one-half inch and the spacing between the center of elements 12 and 13 is $2\frac{3}{4}$ inch. This spacing is the minimum found to give an effective front to back ratio when the elements are mounted in a horizontal plane.

Also mounted on the base member 10 is a transistor amplifier, shown generally at 15, which amplifies the signals received by the monopole elements and transmits these signals to a television receiver by means of a low impedance line, preferably a coaxial cable 17. As shown in FIG. 2, the area occupied by the amplifier 15 is shown enclosed by dotted lines. Also formed on the base member 10 is a ground buss bar 18, the purpose of which will be described later.

The amplifier components are mounted directly on the base member 10 in the preferred embodiment, and

consequently the base member may be a printed circuit board on which the interconnecting leads between elements comprising the amplifier are formed. Also, the monopole elements 12 and 13 may be formed from the same material used as the conductor material on the printed circuit board for ease in construction. Thus, the entire antenna, as shown in FIGS. 1 and 2, is an elongated flat device having a total length of approximately 30 inches and a total width in the order of 4 inches and includes two monopole elements and the transistorized amplifier.

As is well known in the art, the impedance at the end of a monopole element will vary with frequency, and therefore two elements have been provided to cover the entire VHF television range, one for each of the bands identified above. In order to maximize the signal to noise ratio, the input impedance of the amplifier is noise matched to the impedance of the source or antenna. For any given amplifier, there is one source resistance which will provide the optimum noise match, and in the case of a transistor amplifier, the source resistance which minimizes the noise figure is given as follows:

$$R_s (\text{opt}) = (r_b' + r_e') \sqrt{1 + H_{FE} \frac{1 + (2r_b'/r_e')}{[1 + (r_b'/r_e')]^2}}$$

or

$$R_s (\text{opt}) \approx r_e' \sqrt{H_{FE}} \sqrt{1 + \frac{2r_b'}{r_e'}}$$

Where

R_s = Source resistance

r_e' = emitter resistance

r_b' = base resistance

H_{FE} = forward current gain common emitter

Further discussion of this noise matching technique may be found in "Vacuum Tube Amplifiers", edited by G. E. Valley, Jr. and H. Wallman, published by Dover Publications, Inc., 1965, pages 496-694, and in particular, pages 619 and 681. With respect to transistors, reference is made to the "Handbook of Semiconductor Electronics", Second Edition, edited by L. P. Hunter, published by McGraw-Hill Book Company, Inc., 1956, pages 12-23 through 12-29.

The transistor amplifier 15 includes two separate amplifier circuits, each having an input connected to the end of its corresponding monopole element. Thus, the base of transistor Q1 is connected electrically to the end 20 of monopole element 12 while the base of transistor Q2 is connected electrically to the end 22 of monopole element 13. As shown in FIG. 3, a low pass filter is connected between the antenna element 12 and transistor Q1 in order to prevent FM and high band TV signals from causing cross modulation. The filter includes capacitors C1, C2, C3 and C4 and inductors L1, L2, and L3. Each of the inductors is an air coil of No. 22 wire wound on an one-eighth inch inside diameter form. Similarly, a high pass filter circuit including inductors L4 and L5 and capacitor C5 is placed in the input circuit of transistor Q2 to prevent FM and other signals of lower frequency from causing cross modulations. The outputs from the low and high pass filters are connected to the base elements of transistors Q1 and Q2 through capacitors C6 and C7, respectively.

A source of DC voltage is applied through the coaxial cable 17 to both transistor amplifier circuits. The shield of the cable 17 is connected to the buss bar 18 which forms a common ground for all components of the system. In the preferred embodiment, this DC supply is in the order of 20 volts. Resistors R1 and R2 provide a voltage dropping network which biases the base of transistor Q1 and resistors R3 and R4 similarly providing a biasing voltage for the base of transistor Q2.

The DC supply voltage is also applied through the center tap CT of the primary windings P1 and P2 of transformer T1 to the collector elements of both transistors. The transistor circuits are completed by emitter resistors R5 and R6 and radio frequency bypass capacitors C8 and C9. The center tap CT and one side of the secondary winding S of transformer T1 are connected to radio frequency ground through capacitors C10 while allowing them to remain above direct current ground. Capacitors C11 and C12 also insure a radio frequency ground near each transistor.

FIG. 4 shows a power supply particularly suited for use with the preferred embodiment. 115 volts AC is applied through connector 30 and switch 31 to a power transformer T2. The output of this transformer is applied through rectifier D1 to a filtering circuit including capacitor C13. A bleeder resistor R7 provides a constant load to the power supply and also prevents a charge from remaining on capacitor C13 after the unit has been disconnected from the AC source. The DC supply is then connected to a coaxial connector 35 to which is attached the coaxial cable 17. Capacitor C14 insures that no radio frequency (television) signals are fed through the power supply to the AC service line and prevents interference with other television receivers.

An impedance matching transformer T3 is connected to the television set 36 through capacitors C15 and C16, and between the power supply and the coaxial cable 17. This transformer matches the low impedance of the coaxial cable 17, which is typically in the order of 52 to 75 ohms, to the 300 ohm input normally provided on commercially available television receivers.

The transformer T1 combines the output from both transistors Q1 and Q2 onto a single low impedance line for transmission to the television set. In the preferred embodiment, the transformer includes a toroidal ferrite core 40, shown in FIG. 5, and primary windings P1 and P2 which consists of 12 turns of No. 30 wire, six turns on either side of the center tap CT. The secondary winding S is wound directly over the primary winding and includes four turns of No. 30 wire, two turns on either side of the center tap. The total diameter of the ferrite core 40 is approximately 0.375 inch.

The impedance matching transformer T3 is wound on a similar toroidal ferrite coil, however, other types of impedance matching transformers or baluns may be employed with equal effectiveness.

As shown in FIG. 4, an AC convenience receptacle 37 is provided into which the television set may be plugged. When the power supply for the antenna is turned on, the television is also turned on.

The following table lists the values for the various components employed in the preferred embodiment.

R1	3.3 K ohms	C6	910 pf
R3	33 K ohms	C7	12 pf
R2	1 K ohms	C8 through C12 and C14 through C16	0.01 mfd
R4	12 K ohms	C13	250 mfd
R5	120 ohms	Q1	type 2 N3866 (RCA)
R6	510 ohms	Q2	type 40235 (RCA)
R7	2.7K ohms	D1	type 1N2069
C1	75 pf	L1	0.08 UH
C2,C3	220 pf	L2,L5	0.02 UH
C4	150 pf	L3,L4	0.04 UH
C5	15 pf		

It is obvious that the transistors used as amplifiers need not be limited to bi-polar devices. Newer devices such as field effect transistors may be substituted which may provide higher gain, lower noise and minimize the possibilities of cross modulation, intermodulation, etc.

Thus, an improved VHF type television antenna has been described in which monopole elements, or dipoles if desired, are employed to capture the signal radiated from a television transmitting station, with a noise matched amplifier connected directly to each of the antenna elements to provide maximum signal to noise ratio. The antenna constructed according to this invention also provides a front to back gain ratio due to the spacing of the elements thus providing desirable directional characteristics.

While the preferred embodiment of this invention has been described as a VHF television antenna, the principles employed in this invention could also be applied to other multiband antennas where it is desired to have antenna systems of lengths substantially shorter than conventional antennas. Thus, in its broad concept this invention contemplates a multiband antenna employing receiving elements, such as rabbit ears, with each element connected directly to a noise matched amplifier.

This invention also contemplates the use of two or more antennas tuned to the same frequency, and an integrally noise matched amplifier connected to the end of each element. The outputs of the amplifiers are connected so that they add together. Since the received signals are coherent and the noise from the transistors are incoherent, the signal-to-noise ratio will be increased. If there are N such units tuned for the same frequency, the output signal is directly proportional to N, the output noise is proportional to $\sqrt{N}$. Therefore, the signal-to-noise ratio is improved by the factor of $\sqrt{N}$, ideally. As an example, when four antennas are connected in this fashion, the signal-to-noise ratio will increase by a factor of two.

The techniques of this invention have been directly

applied to the design of arrays wherein one section of two elements was used for the low frequency TV band (55-88mHz) and another section of two elements was used for the high frequency band (174-216 mHz). For the low frequency band, this application permits one element to be peaked to Channel 3 (63 mHz) while the other element was peaked to Channel 5 (79 mHz). By this means, an additional antenna efficiency was obtained because the effective bandwidth of each element was reduced by another factor of two. The second section of the array is then treated in the same manner for the high frequency TV band using Channels 8 (183 mHz) and 12 (207 mHz). The resulting array disclosed that the techniques of this invention provide a basic designer's tool for application to a wide variation of uses to obtain extremely high efficiency for specific situations.

While the form of apparatus herein described constitutes a preferred embodiment of the invention, it is to be understood that the invention is not limited to this precise form of apparatus, and that changes may be made therein without departing from the scope of the invention.

What is claimed is:

1. An improved multiband antenna comprising a pair of elongated antenna elements, one of said elements tuned to a first frequency and the other of said elements tuned to a second frequency different from said first frequency, said elements arranged substantially parallel to each other; an amplifier integrally connected to said elements, said amplifier including a first transistor having its base electrode electrically connected to said first element and a second transistor having its base electrode electrically connected to said second element, the input impedance of each of said transistors being adjusted to equal approximately the optimum noise matching impedance of its corresponding antenna element at the frequency for which it is tuned; a single radio frequency transformer having its primary winding the ends of which are connected to the collector elements of both said transistors and a center tap connection through which DC voltage is applied to said transistors; means providing a radio frequency ground for said center tap connection; said transformer including a single secondary winding which combines the outputs of both said transistors into a single output.

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