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PATENT SPECIFICATION

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(54) IMPROVEMENTS IN OR RELATING TO DIGITAL FREQUENCY INDICATION IN COMMUNICATIONS RECEIVERS

(71) We, LICENTIA PATENT-VER-
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BESCHRANKTER HAFTUNG, a com-
pany organised under the laws of Germany,
of Theodor-Stern Kai 1, 6 Frankfurt/Main
70, Germany, do hereby declare the inven-
tion, for which we pray that a patent may be
granted to us, and the method by which it is
to be performed, to be particularly described
in and by the following statement:—

This invention relates to a circuit arrange-
ment for the digital indication of frequency
in a communication receiver, for example a
radio receiver, for use with amplitude modu-
lated (AM) and frequency modulated (FM)
signals.

The frequency to which such a radio re-
ceiver is tuned is frequently indicated by
mechanical linkages from the tuning member,
usually a rotary condenser. However, indica-
tions produced in this way are subject to
errors which may be as large as several kHz
in the short wave range, making accurate
visual adjustment of tuning difficult.

It has been proposed (Funk-Technik 1971
Vol. 5 pp 157—159 and Radio Mentor 1973
Vol. 9 pp 389—391) to provide a digital indi-
cation of the tuning frequency by counting
the number of oscillations of the AM or FM
oscillator, by means of an electronic counter,
and presenting the result optically after sub-
traction of the intermediate frequency. How-
ever the signals taken from the AM or FM
oscillator are too weak to control the counting
circuits. For that reason a wide band ampli-
fier is associated with each oscillator and the
oscillations after amplification are converted
into pulses of the same basic frequency, suit-
able for controlling the counting circuits.

Such frequency measuring circuits are com-
plex and it is an object of the present inven-
tion to provide a simpler arrangement.

According to the invention there is pro-
vided a circuit arrangement for the digital
indication of frequency in a communications
receiver capable of receiving AM and FM

transmissions, including AM and FM local
oscillators an amplifier, common to both oscil-
lators and of sufficient bandwidth to be cap-
able of amplifying the oscillations provided by
each of said oscillators, electronic counter
means arranged to determine the frequency
of the amplified oscillations, and display
means arranged to cooperate with said counter
means to indicate a frequency to which said
receiver is tuned, wherein the coupling of
said amplifier to said oscillators is such that
said oscillators are not substantially detuned
by changes in the capacitance of said
amplifier.

In order that the invention may be clearly
understood and readily carried into effect
examples thereof will now be described with
reference to the accompanying drawings, of
which:—

Figures 1 and 2 each show a practical ex-
ample of a circuit arrangement in accordance
with the invention.

Figure 3 and 4 each show a wide band
amplifier suitable for use in a receiver in
accordance with the circuit arrangement of
the invention and

Figure 5 shows a block diagram of a cir-
cuit for the generation of various division
ratios for use with the circuit arrangement
according to the invention.

Referring to the drawings Figure 1 shows
an FM local oscillator 1 and an AM local
oscillator 3 of a radio receiver which is not
fully shown.

According to the range of the received
waves only the FM oscillator 1 or the AM
oscillator 3 is in operation, in response
to a maintaining voltage U which is applied
to the particular oscillator required. The AM
oscillator 3 extends, during tuning, over a
frequency range of about 0.5 to 25 MHz,
whilst the frequency range of the FM oscil-
lator is about 100 to 120 MHz. A wide
band amplifier 8 is common to the two oscil-
lators and therefore has a band width of 0.5
to 120 MHz. In order to keep the loading

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of the oscillators 1, 3 low and to obtain adequate decoupling, high amplification is provided for the wide band amplifier 8, for example 1000 times.

5 The wide band amplifier amplifies the oscillations concerned and at the same time converts them into rectangular oscillations which are required for a digital switching circuit beginning with a divider 9. The input
10 signal for the divider 9 must for example possess a minimum level of 2.4 V for a logical 1 and must not exceed a maximum level of 0.4 V for a logical 0. The minimum requirement is a signal voltage which consists
15 of a direct component of 1.4 V and a superimposed alternating component of 2 V peak to peak. Furthermore, it is to be noted that in order to obtain steep flanks of the alternating component a limiter stage must have
20 already been passed through. A flank steepness of the rectangular oscillations suitable for control of the subsequent divider can be achieved by full modulation or slight overmodulation of the amplifier, whilst at low
25 frequencies e.g. 500 kHz a suitably higher over modulation is necessary for the same flank steepness. This corresponds on the one hand to reduction of amplification for the upper limiting frequency, and it can be taken
30 care of in the design of the coupling circuit by making the coupling somewhat looser for the VHF range.

35 The divider 9 may consist of a plurality of flip-flops in integrated transistor-transistor logic (TTL). For a negative flank of an input pulse the output condition of a flip-flop changes from logical 0 to 1 or conversely. In this way the input beat sequence and hence
40 the frequency is halved. By the connection in succession of a plurality of flip-flops there can be generated $1/4$, $1/8$, $1/16$ and so on of the input frequency. From four flip-flops suitably connected a decimal divider is obtained.

45 There is applied to the divider 9 a control voltage U_{sz} in order to enable the input frequency to be subdivided to different extents according to the type of the range of waves received (AM or FM). This is necessary when
50 using the invention, since only one amplifier output is available, whilst in the case of known circuit arrangements having separate wide band amplifiers different amplifiers are used at different times and are switched over,
55 or the amplifier outputs must be switched over. Whereas in the case of known circuit arrangements having separate wide band amplifiers a pre-divider is necessary in each case, when using the invention only one pre-divider 9 is required since only one wide
60 band amplifier 8 is present. The pulses at the output of the divider 9 are let through by a gate 10, only during predetermined periods. For this purpose the gate 10 is controlled by
65 a time base 11. The pulses let through by the

gate 10 are counted by a counter 12. Since however it is not the oscillator frequency but the received frequency that is of interest, a correction is made to the extent of the particular intermediate frequency (IF) in use. The result is converted into direct current signals and fed to an indicator 13 for optical
70 indication. The time base 11 supplies to the counter 12 signals which prepare it again for a new counting operation and have the effect that the last result remains indicated until the occurrence of the next result.
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Conveniently the wide band amplifier and the counter 12 can be arranged to have the same working voltage so that the power
80 supply can be common.

For coupling the FM oscillator 1 and the AM oscillator 3 to the common input of the wide band amplifier 8 there are provided
85 two condensers 5 and 6 and a common lead 14 which is typically a coaxial lead. This lead 14 has a capacity to ground 7 indicated in broken lines, which can be further increased by the connection of a fixed capacitance so that coupling is effected via the
90 capacitive voltage dividers 5, 7 or 6, 7. The coupling of the common wide band amplifier 8 to the two oscillators 1, 3 is so loose that the oscillators 1, 3 are not appreciably detuned by variations in the capacity of the wide
95 band amplifier 8.

The oscillator voltages of the oscillators 1, 3 are typically about 1 V for AM and FM. The voltage value that can be coupled
100 out of the oscillator circuits 2 and 4 is limited by the value of the condensers 5 and 6 respectively and by the capacitance 7 of the lead 14 between the oscillators 1, 3 and the common input of the wide band amplifier 8. The capacitances of the condensers 5 and 6
105 must be kept small in order to keep low the detuning of the oscillator circuits 2, 4 and the associated compression of the particular range of reception, whilst the capacity 7 of the lead 14 may not be reduced below a minimum value determined by the length of
110 the lead. Typical values of capacity are for example 1 pF for the condenser 5 and 2 pF for the condenser 6. Between the condensers 5 and 7, and between the oscillator voltage of the wide band amplifier 8 there is the
115 relationship that the ratio of the capacitance of condenser 7 to that of the condenser 5 is equal to the ratio of the actual oscillator voltage to the theoretical oscillator voltage if the input resistance is ignored. From this, for a given input voltage of, for example, 30 mV
120 the capacitance indicated at 7 is calculated at 30 pF. The realisation of this low lead capacitance is possible by a short high-ohmic cable between the oscillators 1, 3 and the wide band amplifier within the ratio apparatus. For the input voltage of the wide band amplifier 8, with the AM oscillator 3 in operation, there is then given a value of about 120 mV.
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Whilst in Figure 1 there is a high-ohmic coupling, the FM oscillator 1 and the AM oscillator 3 being in parallel in relation to the counting, the practical example in Figure 2 shows a low-ohmic inductive coupling. In this case the lead 19 may be relatively long (e.g. 50 cm). This is of advantage if from reasons of construction the wide band amplifier 8 cannot be arranged in the direct vicinity of the oscillators 1, 3. The oscillations of the oscillator circuits 2 and 4 are coupled inductively to series coupled inductances 17 and 18 respectively and pass via the lead 19 to the common wide band amplifier 8, to which a divider gate and so on are connected as in Figure 1. Furthermore, mixed couplings of coupling coils and condensers are possible.

In Figure 3 and Figure 4 are illustrated two practical examples of the common wide band amplifier 8. In Figure 3 the oscillations of the AM or FM oscillator pass from an input E via a resistor 20 and a condenser 21 to the base of transistor 24. The collector of transistor 24 is connected via an inductance 23 and a resistor 22 to the operating voltage $+U_B$, whilst the emitter is grounded. The inductance 23 opposes a reduction in amplification at high frequencies. From the collector of the transistor 24 a connection leads to the base of a further transistor 25, the collector of which is connected directly to the operating voltage $+U_B$ and the emitter of which is connected to ground via a resistor 26. This transistor 25 acts as an impedance changer and ensures a low-ohmic coupling to the following amplifying stage which is formed by a transistor 33. For the purpose of bridging the direct voltage difference and for coupling purposes the emitter of the transistor 25 is connected to the base of the transistor 33 via one or more diodes such as 28. At the base of the transistor 33 only a low direct voltage is required, the emitter of the said transistor likewise having a low voltage relative to ground to enable following transistor 34 to be fully controlled. An inductance 30 in series with a resistor 29 in the collector lead of the transistor 33 is again for preventing a reduction in amplification at high frequencies.

The emitter of the transistor 33 is connected to ground via a resistor 32, in parallel with which is connected a condenser 31 for bypassing alternating current. Furthermore, the emitter is connected via a resistor 27 to the base of the transistor 24 for the purpose of current stabilising feedback. Finally, there is connected to the transistor 33 a further impedance changer which is formed by the transistor 34. The collector of transistor 34 is connected directly to the operating voltage $+U_B$, whilst its emitter is connected to ground via a resistor 37. On the amplified oscillations derived from the emitter via condenser 38 a direct current component is

superimposed by means of a voltage divider comprising resistors 36 and 39. A condenser 35 serves for additional filtering of the operating voltage $+U_B$, which advantageously is also the operating voltage for the digital switching circuit.

In the four-stage wide band amplifier of Figure 4 the oscillations from the AM or FM oscillators are input via resistor 42 and condenser 41 to a circuit employing transistors 43, 46, 52 and 55 corresponding to the transistors of Figure 3. Components 44, 45, 49, 53, 54, 58, 59 and 60 have the same functions as 22, 23, 26, 29, 30, 38, 39 and 35 respectively in Figure 3. However in contrast to Figure 3 an R.C coupling 48, 50 is provided between transistors 46 and 52. Furthermore there are provided two current stabilising feedback couplings, a T-member, comprising resistors 47 and 61 and a condenser 62, between transistors 46 and 43 and a resistor 51 between transistors 55 and 52. An inductance 57 compensates for the capacitance of the output load (the following digital switching circuit) and serves to decouple emitter resistor 56 which is necessary for determining the value of the direct current.

The stages of the wide band amplifier shown in Figure 3 and Figure 4 are so designed that in addition to the amplification of the oscillations of the oscillator these are also converted into the necessary rectangular oscillations, shown at 40, at the output of the wide band amplifier, in that over-modulation, i.e. limiting already takes place at the second stage (transistor 25, or transistor 46).

By way of example only typical values of the components of the circuits of Figures 3 and 4 are:—

Figure 3:

Supply voltage $+U_B$	=5V	
Transistors 24, 25, 33	=BF 240	
Transistor 34	=BF 523	
Resistor 20	=100 Ω	
Resistors 22, 29, 37, 39	=333 Ω	110
Resistor 26	=470 Ω	
Resistor 27	=1 k Ω	
Resistor 32	=120 Ω	
Resistor 36	=1.5 k Ω	
Condenser 21	=20 nF	115
Condensers 31, 35	=0.1 μ F	
Condenser 38	=50 nF	
Inductances 23, 30	=1 μ H	

Figure 4:

Supply voltage $+U_B$	=5V	
Transistors 43, 46, 52	=BF 241	120
Transistor 55	=BF 523	
Resistors 42, 51	=4.7 k Ω	
Resistors 44, 53	=330 Ω	
Resistor 47	=4.7 k Ω	125
Resistor 49	=470 Ω	
Resistor 50	=2.2 k Ω	
Resistor 56	=180 Ω	

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Resistor 59	=560 Ω
Resistor 61	=4.7 k Ω
Condensers 41, 48	=50 nF
Condenser 60	=0.1 μ F
Condenser 62	=50 nF
Inductances 45, 54	=0.25 μ H
Inductance 57	=1 μ H

Figure 5 shows how the different division ratios for AM and FM operation can be obtained although only one wide band amplifier 8 is used for both types of operation. For a first pre-divider 63 following the wide band amplifier 8 there is preferably used a simple divider having a frequency dividing ratio of 1:2 or 1:4 (one or two flip-flops respectively), since the pre-divider 63 must have a high limiting frequency, e.g. 120 MHz at FM, and hence is relatively expensive. For the subsequent pre-dividers 64 and 66 (according to the frequency range) decimal dividers may be provided, the input signals (rectangular oscillations) being applied in a suitable manner to the input of a first stage (flip-flop) and taken from the output of a second stage. In this way, at the same time the normally higher limiting frequency of a first flip-flop stage can be used in the decimal divider and division ratios of 1:5 or 1:25 obtained, so that total division ratios of e.g. 1:10 or 1:100 result; the gating period again being divided in decades and being for example 10 ms. A switch 65 has the effect that in AM operation the signals from pre-divider 63 bypass predivider 64 and pass directly to predivider 66, which also includes the gate shown at 10 in Figure 1. In contrast, in FM operation path 67 for the signals is closed and pre-divider 64 is brought into use for division. The resulting different division ratios for AM and FM operation are necessary if, for example, the indication of frequency in AM operation is required to five places and in FM operation to four places.

WHAT WE CLAIM IS:—

1. A circuit arrangement for the digital indication of frequency in a communications receiver capable of receiving AM and FM transmissions, including AM and FM local oscillators an amplifier, common to both oscillators and of sufficient bandwidth to be capable of amplifying the oscillations provided

by each of said oscillators, electronic counter means arranged to determine the frequency of the amplified oscillations, and display means arranged to cooperate with said counter means to indicate a frequency to which said receiver is tuned wherein the coupling of said amplifier to said oscillators is such that said oscillators are not substantially detuned by changes in the capacitance of said amplifiers.

2. A circuit arrangement according to Claim 1 wherein the oscillations of the AM and FM oscillators are fed to the input of the amplifier via a respective capacitance and a common coaxial lead and/or capacitance.

3. A circuit arrangement according to Claim 1 wherein the oscillations of the AM and FM oscillators are fed to the input of the amplifier by means of respective inductances connected in series with one end of the series connection connected to the input of the said amplifier.

4. A circuit arrangement according to any of the preceding claims wherein the amplifier is arranged to convert the said oscillations into rectangular oscillations by limiting.

5. A circuit arrangement according to Claim 4 wherein the amplifier is arranged to superimpose a direct current component on the said rectangular oscillations.

6. A circuit arrangement according to any of the preceding claims wherein the amplifier and the counter means are arranged to have substantially the same operating voltage.

7. A circuit arrangement according to any of the preceding claims including first divider means arranged to divide the output of the wide band amplifier in the ratio 1:2 or 1:4 and second divider means arranged to further divide the output in the ratio 1:5 or 1:25 to obtain a total division ratio of 1:10 or 1:100.

8. A circuit arrangement according to Claim 7 wherein said second divider means comprises decimal dividers arranged such that the oscillations are applied to a first stage and derived from a second stage.

9. A circuit arrangement substantially as herein described with reference to the accompanying drawings.

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Resistor 59	=560 Ω
Resistor 61	=4.7 k Ω
Condensers 41, 48	=50 nF
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Condenser 62	=50 nF
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Figure 5 shows how the different division ratios for AM and FM operation can be obtained although only one wide band amplifier 8 is used for both types of operation. For a first pre-divider 63 following the wide band amplifier 8 there is preferably used a simple divider having a frequency dividing ratio of 1:2 or 1:4 (one or two flip-flops respectively), since the pre-divider 63 must have a high limiting frequency, e.g. 120 MHz at FM, and hence is relatively expensive. For the subsequent pre-dividers 64 and 66 (according to the frequency range) decimal dividers may be provided, the input signals (rectangular oscillations) being applied in a suitable manner to the input of a first stage (flip-flop) and taken from the output of a second stage. In this way, at the same time the normally higher limiting frequency of a first flip-flop stage can be used in the decimal divider and division ratios of 1:5 or 1:25 obtained, so that total division ratios of e.g. 1:10 or 1:100 result, the gating period again being divided in decades and being for example 10 ms. A switch 65 has the effect that in AM operation the signals from pre-divider 63 bypass predivider 64 and pass directly to predivider 66, which also includes the gate shown at 10 in Figure 1. In contrast, in FM operation path 67 for the signals is closed and pre-divider 64 is brought into use for division. The resulting different division ratios for AM and FM operation are necessary if, for example, the indication of frequency in AM operation is required to five places and in FM operation to four places.

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by each of said oscillators, electronic counter means arranged to determine the frequency of the amplified oscillations, and display means arranged to cooperate with said counter means to indicate a frequency to which said receiver is tuned wherein the coupling of said amplifier to said oscillators is such that said oscillators are not substantially detuned by changes in the capacitance of said amplifiers.

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7. A circuit arrangement according to any of the preceding claims including first divider means arranged to divide the output of the wide band amplifier in the ratio 1:2 or 1:4 and second divider means arranged to further divide the output in the ratio 1:5 or 1:25 to obtain a total division ratio of 1:10 or 1:100.

8. A circuit arrangement according to Claim 7 wherein said second divider means comprises decimal dividers arranged such that the oscillations are applied to a first stage and derived from a second stage.

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