

Radio receiver with search tuning.

The invention relates to a radio receiver with automatic change-over between different stations transmitting the same programme. The invention is particularly relevant to car radio receivers.

5 A car radio receiver is known in which six program-select keys can each be assigned to ten different transmitters transmitting the same program by keying in the transmission frequencies. When a program-select key is actuated, the microprocessor-controlled receiver searches
10 automatically for the strongest transmitter associated with this key and switches it through for reception. If the field strength of the selected transmitter decreases, then the receiver again searches automatically for the strongest transmitter. (VDI-Nachrichten, 12.10.79, page 4; Funktechnik, No. 10/1979, pages T475-476).

15 Compared with simpler receivers which do not have such an automatic search tuning facility, the above-described receiver has indeed certain advantages, but the transmitters transmitting a certain program must first
20 be found from frequency tables and manually fed-in. When all the six program select keys have different stations assigned to them, and when in a particular region the greater part of the stations assigned to a particular program-select key can not or can only partly be received but
25 in which other stations which have not been stored in the memory can be received, the receiver must be manually tuned to the radio station, or to one or more of the program select keys there must be assigned a group of new radio stations. All this must be done manually and of course is
30 undesirable when such a storing of a new group of radio stations is only desired for a relative short time.

The object of the invention is to provide a radio receiver of the type described in the preamble which

automatically tunes to the strongest station of the group of stations transmitting the same program, and in which, however, no previous manual feed-in of the different frequencies of the radio stations of said group is necessary.

5 This radio receiver is therefore characterized in that the receiver is tunable within a predetermined receiving range to a reference station transmitting a desired program the receiver also being tunable by a search tuning action through the receiving range to a relay station or stations also transmitting
10 the desired program, the signal for each received relay station being compared with the reference station signal to check for equal program content, the tuning data for the reference station and the tuning data for each relay station of equal program content being stored in a memory and from the tuning data thus
15 stored the data which correspond to the station having the strongest received field strength being selected by means of the search tuning action, when the field strength of the selected station decreases to below a predetermined value the data from the stored data is selected which then corresponds to the station then having
20 the strongest received field strength. In addition to its simplicity of operation it has the further advantage that the automatic equipment can also operate perfectly on tuning to any new radio station, in which case all corresponding radio stations transmitting the same program are stored.

25 The invention will now be further explained by way of a non-limitative example with reference to the embodiments shown in the accompanying drawings, in which

 Figure 1 is the block schematic circuit diagram of an embodiment having two receiving sections,

30 Figure 2 is the schematic block circuit diagram of an embodiment having one receiving section,

 Figure 3 is the flow chart for the embodiment shown in Figure 2, and

35 Figure 4 is an extension of the flow chart of Figure 3.

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The radio-receiver shown in Figure 1 has to separate receiving sections 1 and 2 which are each connected to an aerial 18. The audio signal outputs 11 and 12, respectively, of the two receiving sections are connected to the inputs of a switch 7 and each time one of the two signals is applied to the loudspeaker 9 through amplifier 8. The two audio signals at the outputs 11 and 12, respectively, are further applied to the inputs of a program comparison circuit 6, the output signal of which is applied to a control unit 10 through a conductor 16. The receiving section 2 has furthermore a field strength output 14 which is also connected to the control unit 10. While the receiving section 1 can manually be tuned by means of tuning circuit 3, the receiving section 2 is tuned automatically. This receiving section 2 therefore forms part of an automatic search tuning circuit, including this receiver section 2, a tuning circuit 4, and the control unit 10. Reference numeral 5 denotes a control key.

The circuit arrangement shown in Figure 1 operates as follows: the receiving section 1 is tuned to a station by means of the manual tuning circuit 3. The audio signal output 11 is connected to the amplifier 8 through switch 7. When the program of this station must be received, the control key 5 is operated and the control unit 10 starts a search tuning action at the beginning of the selected range, and the receiving section 2 stops at the first station having a sufficient field strength. The program content of the audio signal at the outputs 11 and 12 are compared with each other in the program comparison 6. When the contents of the two programs are equal, an identity signal is applied to control unit 10 through conductor 16, and which in response thereof stores the frequency of the relay station received in receiving station 2, in a memory 13. Thereafter, the receiving station 2 continues the search tuning action until a new station is received. A program content comparison operation is performed also for this transmitter and when the program con-

tents are found to be equal, the frequency of this relay station is also stored in store 13. The search for relay stations transmitting the same program as the station at which by receiving section 1 is tuned, is continued until
5 the end of the selected range has been reached. The frequencies of all the stations which transmit the same program as the station at which the receiving section 1 is tuned are then stored in memory 13 of control unit 10.

Thereafter, the stations stored in memory 13 of
10 control unit 10 are retrieved one after the other for tuning the receiving section 2 using the frequency tuning circuit 4. The field strength signal produced by each such station at the conductor 14 is measured in an amplitude measuring circuit 15. Now the field strength of all the
15 stored stations is measured and the receiving section 2 is tuned to that station having the strongest field strength. The audio signal at the output 12 is now applied to the amplifier 3 through switch 7 which is operated under the control of the control unit 10. The field strength of the
20 station to which receiving section 2 is tuned, is continuously controlled by amplitude measuring circuit 15. If the field strength decreases to below a predetermined value, then a new field strength measurement of all the stored stations is performed, and receiving section 2 is again
25 tuned to the strongest station automatically. It is, however, alternatively possible to accomplish, after such a decrease in field strength, a new series of search tuning actions for a new set of relay stations for tuning receiving section 2 to a station of this new set of relay stations.

30 The embodiment shown in Figure 2 will now be described.

To save component and cost, only one receiving section 20 has been provided, in contradistinction to the embodiment shown in Figure 1. The audio signal on the out-
35 put 42 is applied to loudspeaker 9 through amplifier 8. The tuning of tuning circuit 21 is controlled by control unit 30, when performing an automatic search tuning action or

when one of the program-select keys 39 is operated. In the circuit arrangement of Figure 1 the audio signals of the two receiving sections 1 and 2 are continuously compared in signal comparator 6. In the circuit arrangement of Figure 2 the receiver 20 is operated in a time-division multiplex format. To that end this receiver is alternatively tuned to a first and a second station. The output signals on output 42 are sampled in sampler 24 and the samples thus obtained are applied to program comparison circuit 27 through interpolating filter 25 and 26. The field strength signal is applied to the control unit 30 through output 43 and an amplitude measuring circuit 22.

The control unit 30 is constituted by a micro-processor and comprises in addition to the usual units the following special assemblies, which may however be separated from the usual units of the microprocessor by adequate addressing: a frequency memory 31 in which the relay station frequencies which were found during search tuning and which transmit the same program are stored. An address counter 33, associated with memory 31 which is advanced one position for each detected relay station transmitting the same program. A program-select key frequency memory 32 in which the frequencies assigned to the program-select keys 39 are stored. An address counter 34 associated with the program-select key frequency memory 32. A loop counter 35 for counting the number of tuning operations necessary to find the strongest station from the set of stations stored and transmitting the same program. The control unit 30 comprises a search tuning key 37, a manual/automatic tuning selection key 38 and a program-store key 40 and applies a signal to a program-select key occupied lamp 41 when all memories of the program-select keys are occupied.

The operation of the circuit arrangement shown in Figure 2 will now be further explained with reference to the flow chart depicted in Figure 3 and the accompanying associated table. When the receiver has been switched on, it is first checked whether the field strength of the transmitter then received is suffi-

cient. If so, the frequency of this station is stored in the memory address "0" of the frequency memory 31 (Figure 2). Then the receiver amplifier 8 is muted through lead 19 and the search tuning circuit of receiver 20 is reset to the beginning of the range. Thereafter the address counter 33 is set to memory address "1".

The search tuning action is started, starting from the beginning of the range. A check is made whether the range end has already been reached. If not, the search tuning receiver stops at the next received station. The frequency of this station is stored in memory 31, more specifically in the memory address "1", which has already been appointed by the address counter 33. Then the receiver 20 is alternatively tuned to the frequencies stored in the memory addresses "0" and "1". Synchronously therewith the sampler 24 is operated which distributes samples of the audio signals at the output 42, among the inputs of the low-pass filters 25 and 26, respectively. Continuous signals which are compared with each other in the program comparison circuit 27 are then produced at the outputs of the low-pass filters. If the two signals are not equal, the search tuning action is continued and the station found next is stored in the same memory address "1", which means that the previous station is erased. If the two signals are equal, the address counter 33 is advanced one position (so to memory address "2") and the search tuning action is continued. The next station is then stored in memory address "2". Then the signals of the stations stored in the memory addresses "0" and "2" are compared with each other, etc. This process is repeated and the frequencies of the relay stations are stored in memory 31, until the end of the range has been reached.

On reaching the end of the range, the loop counter 35 is reset to zero and the receiver 20 is tuned to all stations stored in memory 31 at the addresses "0" to "n". The field strength signals appearing at output 43 and which are associated with these stations are measured by the

amplitude measuring circuit 22 and compared with each other in the control unit 30. The strongest station is stored in memory 31 at address "0". Each of the other stations, is stored in memory 31 at one of the addresses "1" to "n".
5 The receiver 20 is then tuned to the frequency stored at memory address "0" and the muting is lifted. Furthermore, the loop counter 35 is advanced one position. When the loop counter 35 has not yet reached the position "m" it is checked whether the field strength of the station then received is sufficient. If so, it is checked whether the key 38 is actuated. If not, it is checked whether one of the program-select keys 39 is actuated. If none of these program-select keys is actuated it is checked whether the search tuning key 37 is actuated. If not, the field
10 strength of the tuned station and the actuation of the keys 37, 38, 39 is checked.

When the field strength of the received station has in the meantime decreased to a value which does no longer permit a perfect reception, the receiver is tuned
20 to another station stored in memory 31 which thus transmits the same program, but which has a field strength which is higher than the field strength of the station stored in memory 31 at address "0". The station thus selected can then be stored in memory 31 at address "0". Loop
25 counter 35 is now advanced one count.

When the last-mentioned loop has been passed through more than "m"-times, this indicates that the receiving conditions have apparently changed considerably. The receiver is muted, that is to say no further check is
30 made whether the field strength of the station is still sufficient, but a new series of search tuning actions for new relay stations which correspond to the station in the memory address "0" is performed. This series of search tuning actions is immediately followed by resetting the
35 loop counter 35 to zero and by the selection of the strongest station among the stations found.

The quantity "m" of the loop counter has been

chosen so that a new series of search tuning actions for relay stations is started at the proper moment, before the receiving conditions have changed so that no strong relay station among the stations stored during the previous series of search tuning actions is available any longer. This quantity "m" may, for example, be equal to 3, which means that a new series of search tuning actions for new relay stations and selection of the strongest station of the stored stations is not performed until the fourth cycle through the loop has ended.

A new series of search tuning actions for relay stations may also be initiated manually, when key 38 is actuated. When after turning on the receiver (start of program) the field strength of the received station is not sufficient the receiver is muted here already and the station search tuning action is reset to the beginning of the range. Thereafter, the search tuning action starts and the receiver stops at the next station. If the field strength of the station thus found is sufficient, the frequency of this station is stored in the memory 31 at the address "0" and a series of station search tuning actions for searching relay stations having the same program and selection of the strongest station etc. is performed.

When the station to which the receiver is tuned should not transmit the desired program, the search tuning key 37 may then be operated and the search tuning action continues from the previous position and stops at the next station. After checking of the station field strength and frequency storage in the memory address "0" a series of search tuning actions for a set of relay stations is performed in the way as described above.

With each program-select key 39 there is associated the frequency of a station transmitting one specific program. When one specific program-select key is actuated this causes the address counter 34 to be set to one specific address and the frequency stored in memory 32 at that address tunes the receiver 20 to that frequency.

Subsequently, the field strength of the station is checked and the frequency is stored in the memory address "0" of the frequency memory 31. In the manner described in the foregoing, the series of search tuning actions to identify a set of relay stations having the same program is then performed.

Figure 4 shows an extension of the flow chart of Figure 3. When appropriate in the program shown in Figure 3 there can be introduced a subroutine at point 52, between points 50 and 51. This subroutine is depicted in Figure 4 the functions of which are given in the accompanying associated table and is used when by automatic tuning, a station is found whose frequency we want to store in a particular program-select key 39. This is done as follows:

As long as the program-select key is not actuated the program is returned over point 51 to the normal loop of Figure 3. However, as soon as the program store key 40 is actuated, the amplifier 8 is muted and the search tuning action is started at the beginning of the range. In addition, the address counter 34 is set to the addressed assigned to the first program-select key. The range is scanned and the search tuning receiver stops at a station, the modulation frequency of which is stored in the first program-select key 39, that is to say this frequency is stored in the program-select key frequency memory 32 at address "1". Then receiver 20 is alternately tuned to the last said station and to the stations stored in the other program-select keys. If the program of the station found differs from the programs of the stations of all the other program-select keys, then the address counter 34 is advanced to the next position.

As soon as the address counter 34 is set to the next address it is checked whether a further program-select key is still available. If so, the search tuning action is continued and the action stops at the next station when the end of the range has not yet been reached. The subroutine is then passed through, and that until all the program-select keys have associated therewith a different station.

If, however, no further program-select key is available while the end of the range has not yet been reached, a program-select key engaged lamp 41 lights up. Then, after the muting has been lifted again, the program returns to point 51 of the program of Figure 3. This is also the case when the end of the range has been reached.

If during the comparison of the programs it appears that the program of the stations found do not differ from the programs of all the programs stored in memory 32 then the address counter 34 is not advanced but the search tuning action is continued until a new station is found which is stored in the memory 32 at the address.

Using the subroutine depicted in Figure 4 it is possible to use the signal comparison circuit 27 not only for finding relay stations transmitting the same program but it is alternatively possible to associate automatically at any desired moment with the program-select keys 39 different programs, without the necessity of listening to these stations. If now one of the program-select keys 39 which has been engaged in this manner is actuated, the receiver is tuned to the associated frequency and a series of automatic search tuning actions is carried out to find the set of relay stations transmitting the same program and a subsequent tuning to the strongest of the stations thus found is performed.

The signal comparison circuit 6 (Figure 1) and 27 (Figure 2) may be of any optional construction. As regards the circuit of Figure 2', the audio signal on the output 42 is sampled by means of the switch 24 in synchronism with the tuning frequency change of the receiver and the samples thus obtained are applied to the inputs of the signal comparison circuit 27 through the two low-pass filters 25 and 26. The low-pass filters have for their effect that the signal samples are again converted to continuous signals. It is then of course a requirement that the frequency at which switch 24 is operated must be twice as high as the

frequency in the signal to be compared. In order to perform a signal comparison it is however not necessary to evaluate the highest frequencies in the signal, but low-frequency portions may be evaluated. The program comparison circuit 27 may so operate that
5 the continuous output signals of the low-pass filters 25 and 26 are sampled at predetermined instants, are stored in the control unit 30 and thereafter compared, and that after a predetermined number of samples the degree of agreement or deviation is evaluated as a criterion therefor, whether the programs are in agreement or not.

10 To check whether the relay station to which the receiver 2 has been tuned and the reference station to which the receiver 1 has been tuned transmit programs with equal contents, the comparison circuit 6 may be of such a construction that, for example, the audio
15 signal transmitted by the relay station is compared in this comparison circuit with the audio signal transmitted by the reference station. If the relay station and the reference station are both of a type transmitting in addition to the desired audio signal also a transmitter identification signal, then this comparison circuit 6
20 may be of such a construction that at least a portion of the transmitter identification signal transmitted by the relay station is compared in the comparison circuit with the corresponding portion of the transmitter identification signal transmitted by the reference station.

It should be noted that a transmitter comprising a transmitter
25 identification signal generator and a receiver which includes a device for recovering this transmitter identification signal, are extensively described in our Patent Application 7038/78 (Serial No. 1 579 985).

It should also be noted that this transmitter identification
30 signal may be a digital, but may also be an analog signal. This transmitter identification signal may, for example, be an indication of the name of the station tuned to, but may also or in addition, be an indication that the receiver is tuned to a station transmitting, for example, traffic information.
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FUNCTIONS OF THE BLOCKS IN FIG. 3

- 60 = power on
- 61 = station field strength sufficient yes/no
- 62 = store frequency in memory address "0"
- 5 63 = muting, reset of station search to beginning of the range,
set memory address to "1"
- 64 = continuation of station search
- 65 = range end, yes/no
- 66 = stop at next station, store frequency in memory
- 10 67 = alternating between relay station and reference station
- 68 = program contents equal/unequal
- 69 = advance memory address by "1"
- 70 = reset loop counter
- 15 71 = switching between frequencies of memory addresses "0" to "n"
putting the strongest station into memory address "0"
- 72 = tuning receiver to frequency of memory address "0"
muting lifted
- 73 = advance loop counter
- 20 74 = state of counter (loop counter)
"m"
- 75 = station field strength sufficient
- 76 = manual/automatic tuning selection
- 77 = program-select key actuated
- 25 78 = search-tuning key actuated
- 79 = station search start and stop at next station
- 80 = tuning of receiver to range beginning
- 81 = tuning of receiver to frequency of actuated program-select key
- 30 E = Equal
UNE = Unequal

FUNCTIONS OF THE BLOCKS IN FIG. 4

- 82 = program-store key actuated, yes/no
- 83 = muting lifted
- 5 84 = muting , reset of station search to range beginning set address counter 34 to first program-select key
- 85 = continuation of search tuning
- 86 = range end reached
- 87 = stop at next station, storing of found station into program-select key
- 10 88 = alternate tuning to found station and stations of other program-select keys
- 89 = all programs different
- 90 = advance of address counter 34 to next program-select key
- 91 = program-select keys engaged lamp
- 15 92 = any program-select keys left?

Y = Yes

N = No



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CLAIMS:-

1. A radio receiver with automatic change-over between different stations transmitting the same program characterised in that the receiver is tunable within a predetermined receiving range to a reference station transmitting a desired program the receiver also being tunable by a search tuning action through the receiving range to a relay station or stations also transmitting the desired program, the signal for each received relay station being compared with the reference station signal to check for equal program content, the tuning data for the reference station and the tuning data for each relay station of equal program content being stored in a memory and from the tuning data thus stored the data which correspond to the station having the strongest received field strength being selected by means of the search tuning action, when the field strength of the selected station decreases to below a predetermined value the data from the stored data is selected which then corresponds to the station then having the strongest received field strength.

2. A radio receiver as claimed in Claim 1, characterized in that after a predetermined number of decreases of the field strength and subsequent new selections of the stored tuning data for the station then having the strongest received field strength, a new search tuning action for a relay station of equal program content can then be resumed with the tuning data obtained in the new search tuning action also being stored and from the newly stored tuning data the data is selected which corresponds with the station having then the strongest received field strength.

3. A radio receiver as claimed in Claim 1, characterized in that for tuning the receiver to the reference station there is provided a first receiving section for producing a reference station signal, and for search tuning through the receiving range to the said relay station or stations a second receiving section for producing a comparison signal.

4. A radio receiver as claimed in Claim 1, characterized in that for tuning the receiver to the reference station and for



searching through the receiving range for the said relay station or stations a receiver section is provided which is tuned alternately to the reference station and to a relay station, the output signal from the receiving station being sampled in synchronism with the alternately tuning, the samples thus obtained being applied alternately to a first and to a second signal output.

5 5. A radio receiver as claimed in Claim 4, characterized in that the first and the second signal output each have a low-pass filter connected thereto for producing the reference station signal and the relay station signal, respectively.

10 6. A radio receiver as claimed in Claim 3 or Claim 5, characterized in that the reference station signal and the relay station signal are applied to a program comparison circuit.

15 7. A radio receiver substantially as herein described with reference to Figure 1 or Figure 2 of the accompanying drawings.

8. A radio receiver incorporating a microprocessor adapted to be operated as herein described with reference to the flow chart of Figure 3 or the flow charts of Figure 3 and 4.

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