SUPPRESSION OF RADIATED TRANSMITTER NOISE FOR PROTECTION OF A NEARBY LOCATED RECEIVING ANTENNA

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1.Introduction and summary

With mobile communication systems due to the small shelters or vehicles the receiving antenna cannot be installed far from the transmitting antenna but must be mounted at a distance of only some meters (fig.1). With a power-amplifier-stage (pa-stage) typically delivering a signal power of 1kW to the transmitting antenna (HF-range) two main problems are to solve: Field intensities up to 200V/m excite the receiving antenna which must not produce crossmodulation in the active antenna and in the receiver. By means of an extremely linear fast tunable highly selective active receiving antenna which has been presented in /1/ and /2/ this problem has been solved satisfactorily if the frequency of transmission is at least 10% apart from the receiving frequency. However, additionally, a broadband noise floor due to the synthesiser's noise and to the pa-stage's noise is radiated from the transmitting antenna. This noise floor desensitises the receiving system typically to an extent of 20 to 30dB. So far no solution has been presented for this problem.

The aim of the presented paper is to introduce a newly developed and tested transceiving system by means of which the radiated noise floor is reduced exclusively within the receiving channel with a bandwidth of 10kHz, for example, at a rate that the high sensitivity of the receiving system is preserved. This is obtained by means of a narrow band negative feedback circuitry connected in parallel to a standard pa-stage, being tuned to the actual receiving frequency (fig.1). In a prototype the time for tuning is less than 50 ms which is equivalent to the tuning time of the selective active receiving antenna. For further developements a ten times faster tuning seems to be possible to be realised. If more than one receiving system is to be used additional feedback loops are to be connected in parallel to the first feedback loop, each of the feedback loops being tuned to one of the actual receiving frequencies.

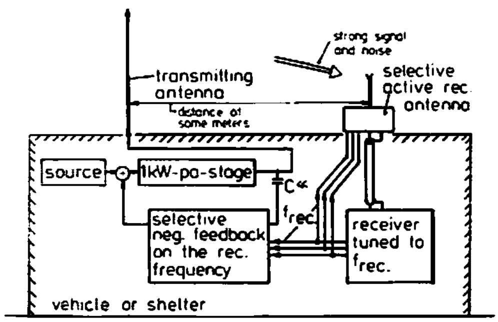

Fig.1: typical mobile transceiving system with feedback

2.Conventional solution to the problem

With transmitting systems of nowadays the transmitted noise floor typically is about 130dB below the desired strong transmitted signal if a bandwidth of 2kHz is considered. Taking a field intensity of 100V/m of the strong signal at the location of the receiving antenna and an equivalent noise fieldstrength E_{en} of 2uV/m of the receiving system for example the radiated noise floor typically is about 24dB above E_{en}. In consequence the radiated noise floor has to be reduced for at least 25dB at the frequency f_{rec} to which the receiving system actually is tuned.

A reduction of the radiated noise could be obtained by inserting filters at the pa-stage output. Bandpass filters to be tuned to the transmitting frequency or notch-filters to be tuned to the receiving frequency could be taken into acount. Those filters would have to be high power filters the tuning of which would only be possible by means of switching between a variety of fixed frequency filters since no electrically tunable high power elements are available. In consequence the technical effort would be extreme and other solutions are required.

3.Selective noise suppression by means of negative feedback

3.1 Principle of operation

The proposed solution completely avoids high power filtering; filtering is done in the feedback loop where the signals are weak. For tuning mainly a VCO has to be set to the required frequency, which can be done very fast. In consequence the technical effort is comparatively small. The aim of the feedback loop the block diagram of which is displayed in fig.2 is to diminish the amplification of the pa-stage around the frequency f_{rec} within at least the IF-bandwidth "B'" of the receiver. The amplification has to be reduced to an extent that the field intensity of the radiated noise exciting the receiving antenna is below the equivalent noise fieldstrength E_{en} of the receiving system (f.3).

The principle of operation is to be discussed by means of fig.2. By means of a loose coupling the output signal of the pa-stage is fed to a mixer which has to be of a extreme linearity due to the large level difference between the strong desired signal to be transmitted and the weak noise to be coupled back. Mixer of this kind are available and have been presented for example in /3/. With the prototype the frequency of the PLL-stabilised VCO used for converting the signal is choosen in a way that the frequency band around f_{rec} is transferred to a first IF of 45MHz. The aim of the IF-filter at 45MHz is to reduce the power of the strong transmitted signal in order to protect the SSB-demodulator. For stability reasons (see below) this filter is to be designed with minimum phase shift in the frequency band with feedback factor greater than unity. A single resonant LC-filter with a Q-factor of about 100 to 200 meets the requirements with respect to phase shifting and with respect to the required selectivity as well. The SSB-demodulator is required in order to avoid ambiguity since the noise in the frequency bands above and below the LO-frequency at 45MHz-B/2 is not correlated. "B" represents the cut-off frequency of the 1.order low-pass filter. In consequence at the output of the low-pass filter exclusively the bandlimited noise of one of the two frequency bands is available. This signal modulates the LO-signal at (45MHz-B/2) in a double-balanced mixer suppressing the LO-signal. The output signal is limited to the band around 45MHz, amplified, converted to f_{rec} in a further mixer and coupled to the input of the pa-stage.

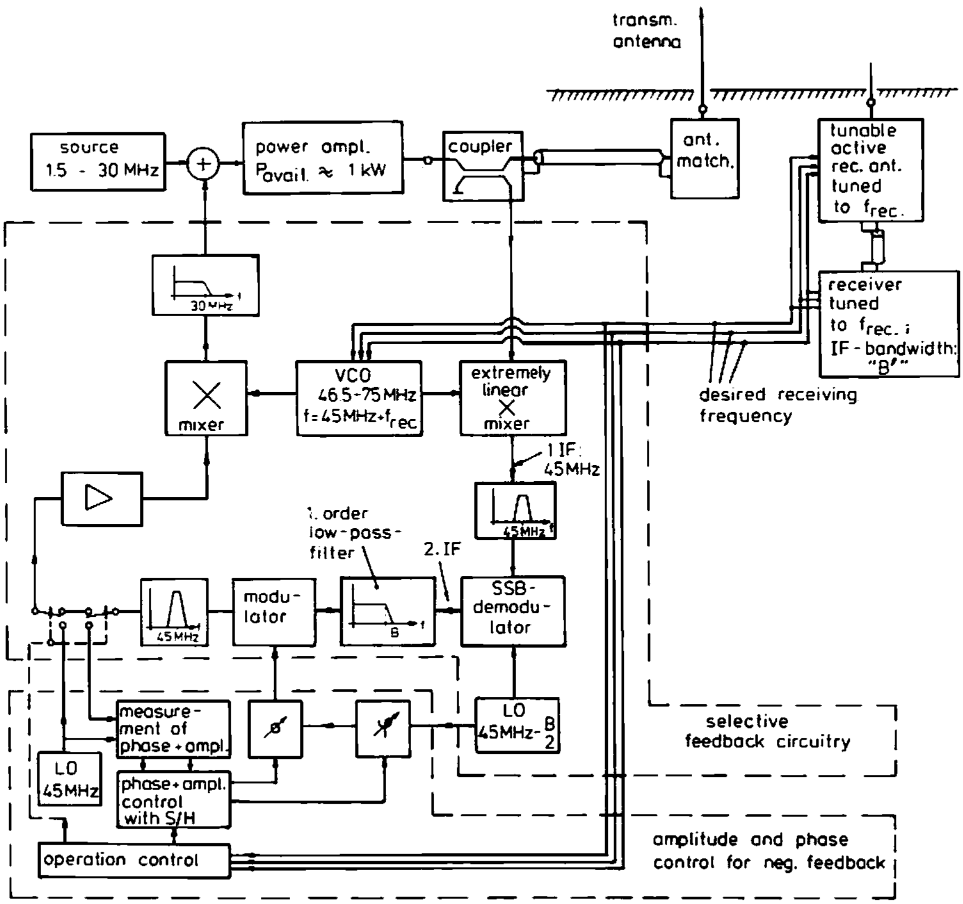

Fig.2: detailed block-diagram of the transceiving system

3.2 Stability of the feedback loop

In order to obtain a reduction of the amplification of about 20 to 40dB a feedback factor of about 10 to 100 is required. By means of a control-circuit as to be explained below at f_{rec} the open loop phase is adjusted to -180°, which means negative feedback. For stability reasons in the total frequency band with a feedback factor greater than unity the additional phase shift must not essentially exceed 90°. A good solution for filtering is a first order (RC) low-pass filter which leads to a maximum phase shift of 90° in combination with a feedback factor decreasing with 20dB/decade far beyond the cut-off frequency. Phase shift, however, not only occurs in this low-pass filter but in all other components as well, for example in the other filters and in the pa-stage and the feedback circuitry due to the inevitable electrical length of those devices. In consequence the obtainable narrow-band noise suppression depends on the total electrical length (l_{el}) of the feedback loop and on the cut-off frequency of the low-pass filter. Fig.4 shows the obtainable noise suppression, if an increase of 3dB close to the suppressed narrow band is tolerated in comparison to the pa-stage without feedback.

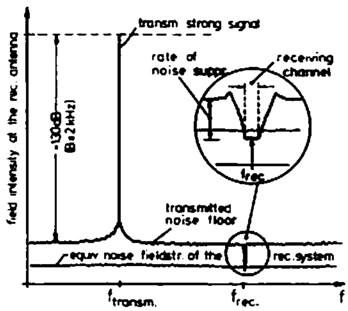

Fig.3: field at the rec. ant.

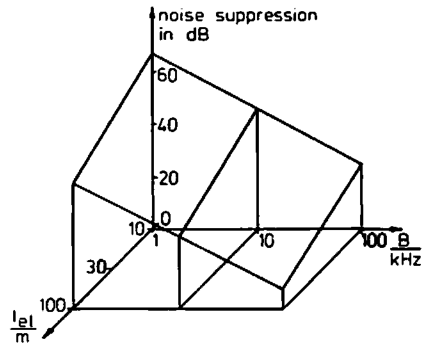

Fig.4: obtainable noise suppr.

With a standard pa-stage and the realised prototype of feedback circuitry l_{el} typically is about 60m. In consequence, within a bandwith of 10kHz the transmitted noise can be reduced for about 30dB, which corresponds to the measurements.

3.3 Automatic tuning to negative feedback

For adjusting the open loop phase to -180° for f_{rec} and the open loop gain to the required value an amplitude and phase control circuit as displayed in fig.2 is used. By means of an operation control circuit which is triggered if the receiving frequency is changed the loop is switched from the operational mode to the control mode at which a test signal at 45MHz is fed into the open feedback loop. By automatic control the amplitude and phase of the signal having passed the pa-stage and the feedback circuitry are adjusted to the desired values by means of amplitude and phase control elements. With the prototype the loop is adjusted within about 45ms. For tuning to negative feedback no switching off of the transmitted signal is required.

4. References

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/3/ Lindenmeier,H.K.; Reiter,L.M.: Noise and Linearity Problems in High-Freq. Mixer Circuits. Int.IEEE Symp. on Circuits and Systems, Rom, 1982, Vol.2