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METHOD AND DEVICE FOR EXTENDING THE DYNAMIC RANGE IN MEASUREMENTS CARRIED OUT WITH A DIRECTIONAL COUPLER

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(56) Prior Art Documents
US 4962359
EP 261828
DE 3317358

(57) Claim

1. A method for extending the dynamic range in measurements carried out with a directional coupler (DC1), such as antenna measurements, in which method

- a signal is supplied in a first direction towards the object (10) under analysis, such as an antenna, through a first port (3) of the measuring directional coupler, part of the signal leaking as a leak signal (A4) through a second port (4) of the measuring directional coupler in a second direction to a measuring line (11) towards measuring means (12), and

- the signal returning from the object (10) under analysis in said second direction is measured by the measuring means (12), c h a r a c t e r i s e d in that

- a spurious signal, such as said leak signal (A4), summing to the signal returning from the object is eliminated by supplying through a second directional coupler (DC2) to said measuring line (11) a phased

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compensation signal (B5) propagating in said second direction towards said measuring means with substantially the same amplitude as, but substantially opposite phase to, said spurious signal.



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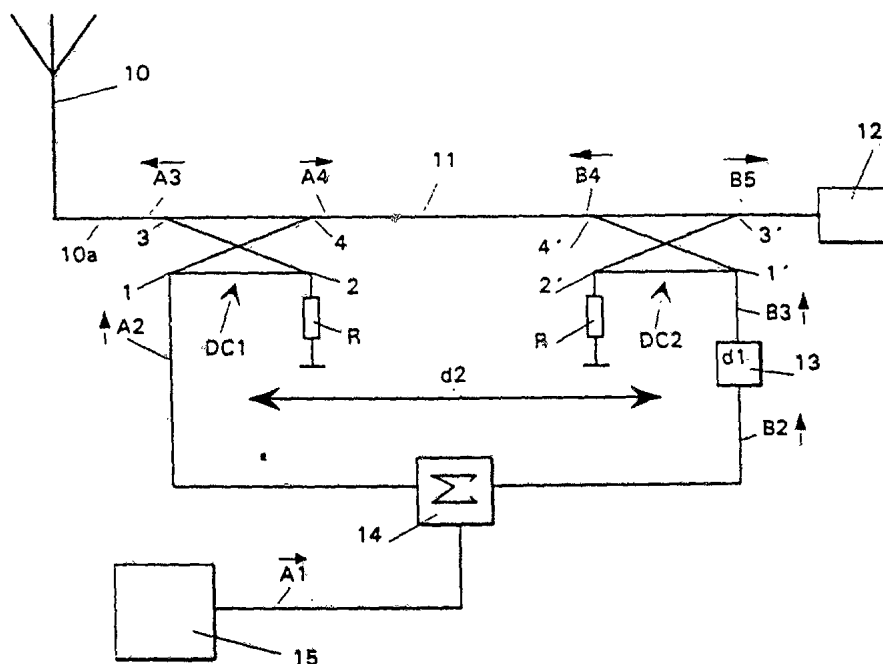
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(54) Title: METHOD AND DEVICE FOR EXTENDING THE DYNAMIC RANGE IN MEASUREMENTS CARRIED OUT WITH A DIRECTIONAL COUPLER

(57) Abstract

The invention relates to a method for extending the dynamic range in measurements carried out with a directional coupler, such as antenna measurements, and to a device for carrying out the method. In the method a signal is supplied to the object under analysis, such as an antenna (10), through a first port (3) of the measuring directional coupler, part of the signal leaking as a leak signal (A4) through a second port (4) of the measuring directional coupler directly towards measuring means (12), and the signal returning from the object (10) under analysis is measured by the measuring means (12). To enable the measuring of signal levels lower than before, spurious signals, such as said leak signal (A4), summing to the signal to be measured are eliminated by supplying a phased compensation signal (B5) through a second directional coupler (DC2) to the measuring line (11).



Method and device for extending the dynamic range in measurements carried out with a directional coupler

The invention relates to a method for extending
5 the dynamic range in measurements carried out with a directional coupler, such as antenna measurements. In the method a signal is supplied to the object under analysis, such as an antenna, through a first port of the measuring directional coupler, part of the signal
10 leaking as a leak signal through a second port of the measuring directional coupler directly towards measuring means, and the signal returning from the object under analysis is measured by the measuring means. The invention also relates to a device for carrying out the
15 method. The device comprises (i) transmitter means for generating an electric measurement signal, (ii) a measuring directional coupler, to which the transmitter means are coupled for coupling the measurement signal to the object to be measured, and (iii) measuring means
20 for measuring the signal returning from the object under analysis. In particular, the invention can be applied to measuring the standing-wave ratio (SWR) of an antenna in order to observe the condition of the antenna.

In measurements such as mentioned above the
25 situation is the following: the signal reflected back from the object to be measured, such as an antenna, is, when summing to the signal leaking from the directional coupler straight in the direction of the measuring means, at a random phase, e.g. depending on variations
30 in the electric length of the antenna cable. The magnitude of the error caused by summation is thus dependent on the phase difference between the returning signal and the leaking signal, which varies e.g. as a function of the electric length of the antenna cable.
35 Known measuring solutions aim at the best possible

directivity of the directional coupler supplying the measurement signal to the antenna, in order to render as small as possible the spurious signal leaking from the directional coupler straight in the direction of the measuring means and summing to the actual signal to be measured. The effect of other spurious signals such as those reflected from the coupling points has been diminished by calibration and by means of modification tables and correction factors. The obtained directivity of the directional coupler is however rarely more than 30 dB; in general the directivity is in the range of 20...30 dB, as the directional coupler is to be realised on the printed circuit board as a micro strip structure, which is production-technically advantageous thanks to easy reproducibility. Owing to the limited directivity, the measuring of low signal levels, such as the signal reflected back from an antenna demonstrating a minor reflection loss, becomes difficult when the (useful) signal to be measured sums to a spurious signal leaking from the directional coupler. On the other hand, the useful signal to be measured sums also to other spurious signals passing to the measuring point, such as said signals reflected from the coupling points. In some cases these other spurious signals may be greater in magnitude than the above-mentioned leaking signal, thus preventing the measuring of low signal levels.

The object of the present invention is therefore to obviate the drawbacks described above and to improve the dynamic range of measurements carried out with a directional coupler so that the measuring of low-level signals will be effected more successfully. This is achieved with the method according to the invention, which is characterised by the fact that spurious signals, such as said leak signal, summing to the signal to be measured are eliminated by supplying a phased

compensation signal through a second directional coupler to the measuring line. The device for carrying out the method is, for its part, characterised by what is described in the characterising portion of attached
5 claim 4.

The basic concept of the invention is to eliminate the dominating spurious signals by supplying a compensation wave to the measuring line by means of the second directional coupler.

10 The solution according to the invention extends the dynamic range of the measuring by 10...25 dB compared with conventional methods of measuring. Another advantage of the solution provided by the invention is that it enables even the use of a directional coupler
15 with a poor directivity, since the spurious wave leaking from the directional coupler is eliminated in any case. The circuit is also inexpensive to realise, and the actual measuring is quick to carry out, as the error correction is effected in real time. The possible tuning
20 of the compensation signal needs to be effected only in the production phase,

In the following the invention will be described in more detail with reference to the example depicted in the attached figure which discloses a
25 measuring arrangement according to the invention in measuring the condition of an antenna.

The figure discloses the measurement arrangement according to the invention when the condition of a receiving antenna 10 of the base station
30 of a cellular network is to be checked. The condition is checked by defining the standing-wave ratio describing the electric matching of the antenna to the rest of the transmitter- and receiver system by measuring the power of the signal reflected back from
35 the antenna with the measuring means 12 at the end of

a measuring line 11 and by comparing this with the power transmitted to the antenna. Only that part of the measuring arrangement which pertains to the invention will be set out. In whole this kind of measuring arrangement is disclosed in Finnish Patent 80,817. At the front end of the measuring line 11 there is disposed a measuring directional coupler DC1 whose input port 1 is coupled to a divider 14, a travelling wave port 3 is coupled through an antenna line 10a to the antenna 10, a port 2 is terminated by resistance R and a gate 4 is coupled to the measuring line 11. Between the measuring means 12 and measuring directional coupler DC1 there is disposed a second directional coupler DC2 whose input port 1' is coupled through a delay unit 13 to the divider 14, a travelling wave port 3' is coupled to the measuring line in the direction of the measuring means 12, a port 2' is terminated by resistance R and a port 4' is coupled to the measuring line 11 in the direction of the antenna 10. Transmitter means 15 are coupled to the divider 14, supplying an electric measurement signal A1 through the divider 14 to the directional couplers. The measurement signal A1 is formed as described in the above-cited Finnish Patent 80,817 from the transmitter signal by mixing it with a transfer oscillator to the desired measuring frequency.

In addition to the measurement signal A1, in the figure signals from and to the directional coupler DC1 are marked with reference signs A_n ($n=2...4$) and signals from and to the directional coupler DC2 with reference signs B_n ($n=2...5$). Next to the reference signs tiny arrows are drawn indicating the travelling direction of the signal in question.

The measurement signal A2 which is supplied to the antenna 10 through the divider 14 and the measuring directional coupler DC1 leaks in the measuring

directional coupler DC1 straight in the direction of the measuring means 12. This leak signal A4 sums to the signal returning from the antenna at a random phase causing an error whose magnitude is dependent on the reciprocal phase of the leak signal and the signal returning from the antenna. In addition to the leak signal, error is caused e.g. by the summing of reflections caused by cables and connectors in the antenna line to the signal returning from the antenna.

The correction of the error (improving the dynamics) can be divided into two situations: (1) a situation in which the leak signal A4 of the measuring directional coupler DC1 is stronger than the other spurious waves and (2) a situation in which the other spurious waves are stronger than the leak signal A4.

In situation (1), which is more general, the leak wave A4 is eliminated by supplying with a second directional coupler D2 in the direction of the measuring means 12 a compensation signal B5 which has an amplitude which is equal to that of the leak signal A4, but in relation thereto delayed in its phase by half a wave length ($\lambda / 2$) or its odd multiplicity. The compensation signal is formed of the measurement signal A1 by branching the measurement signal by means of the divider 14 through a delay unit 13 to the second directional coupler DC2. In order for the amplitude of the compensation signal to be equal to that of the leak wave, the coupling of the second directional coupler DC2 is equal in magnitude to the sum of the coupling and the directivity of the measuring directional coupler DC1 (no losses in the measuring line). If thus for instance the directivity of the measuring directional coupler DC1 ($D_1 = 10 \log A_3/A_4$) is 20 dB and the coupling ($C_1 = 10 \log A_2/A_3$) 20 dB as well, the coupling of the second directional coupler DC2 ($C_2 = 10 \log B_3/B_5$) will be 40 dB. In

order for the phase of the compensation signal to be transferred by half a wave length (or its odd multiplicity) with regard to the leak wave, a delay d1 of the delay unit 13 would be of such magnitude that a delay d2 of the signal between the directional couplers DC1 and DC2 deducted from the delay d1 has a magnitude of half a wave length or its odd multiplicity ($d1 - d2 = n \lambda / 2$, $n=1, 3, 5 \dots$). As the compensation signal B5 eliminates the leak wave A4, the signal to be measured is no longer dependent on the electric length of the antenna line (antenna cable); in other words, the summing of the signal returning from the antenna at a random phase to the leak signal no longer causes measurement error. Measurement error is, however, still caused to some extent by other factors such as cables and connectors. The dynamic range of the measurement can nevertheless be extended by 10...25 dB compared with conventional methods.

In situation (2) the compensation signal must be tuned separately to equal in amplitude the spurious signal in the measuring line and to be in its phase opposite to this spurious signal. The tuning may be accomplished e.g. by terminating the antenna line with a matched resistance (test load) and carrying out in time domain in a manner known per se a measurement (time domain analysis) which gives the amplitude and phase of the reflected spurious signal, in other words, the location of the point causing reflection and the magnitude of the reflection. Before the measurement, already at the planning stage, all points (reflection points) having an effect on the standing-wave ratio in the antenna line should be taken into account by adjusting said points at the measuring frequency in question at intervals of half a wave length or its multiplicity. This enables elimination of all factors causing spurious

signals by means of one additional directional coupler DC2.

Even if the invention was described above with reference to the example depicted in the attached drawing, it is clear that the invention is not restricted thereto but can be modified in many ways within the scope of the inventive concept set forth above and in the attached claims. In principle in place of the directional couplers there could be other directional means, e.g. a capacitively coupled hybrid. For this reason the used term 'directional coupler' should be understood in a larger sense. Neither is measuring limited to sole antenna measurements but the principle according to the invention can also be used in other measurements carried out with directional couplers. It is also possible to change the mutual order of the directional couplers.

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Claims

1. A method for extending the dynamic range in measurements carried out with a directional coupler (DC1),
5 such as antenna measurements, in which method

- a signal is supplied in a first direction towards the object (10) under analysis, such as an antenna, through a first port (3) of the measuring directional coupler, part of the signal leaking as a leak signal (A4) through a
10 second port (4) of the measuring directional coupler in a second direction to a measuring line (11) towards measuring means (12), and

- the signal returning from the object (10) under analysis in said second direction is measured by the
15 measuring means (12), characterised in that

- a spurious signal, such as said leak signal (A4), summing to the signal returning from the object is eliminated by supplying through a second directional coupler (DC2) to said measuring line (11) a phased
20 compensation signal (B5) propagating in said second direction towards said measuring means with substantially the same amplitude as, but substantially opposite phase to, said spurious signal.

2. A method according to claim 1, characterised
25 terised in that the compensation signal (B5) is delayed so that the phase difference between it and the signal (A4) leaking from the measuring directional coupler (DC1) has a magnitude of half a wave length or its odd multiplicity ($n \lambda/2$, $n=1, 3, 5...$), and that the amplitude
30 of the compensation signal (B5) is adjusted to be equal to the amplitude of the leak signal by adjusting the coupling of the second directional coupler (DC2) to be equal in



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magnitude to the sum of the coupling and directivity of the measuring directional coupler (DC1).

3. A method according to claim 1, c h a r a c -
t e r i s e d in that the spurious signal occurring in the
5 measuring line (11) is determined by a separate measurement
and the compensation signal (B5) is tuned on the basis of
said spurious signal measurement so that the amplitude of
the compensation signal is equal to the amplitude of the
spurious signal and the phase of the compensation signal is
10 opposite to the phase of the spurious signal.

4. A device for carrying out the method according to
claim 1, which device comprises

- transmitter means (15) for generating an electric
measurement signal,
15 - a measuring directional coupler (DC1) to which
said transmitter means (15) are coupled for supplying the
measurement signal towards the object (10) to be measured,
and

- measuring means (12) coupled to a measuring line
20 (11) for measuring the signal returning from the object
(10) to be measured,

the port (3) for a travelling wave in the measuring
directional coupler (DC1) being coupled to the direction of
the object (10) to be measured for supplying the
25 measurement signal to the object, and the second port (4)
in the measuring directional coupler being coupled to the
measuring line (11) to the direction of the measuring means
(12), part of the measurement signal leaking as a leak
signal (A4) through the second port (4) of the measuring
30 directional coupler to the measuring line (11) and
propagating towards the measuring means (12), c h a r -
a c t e r i s e d in that a second directional coupler
(DC2) is coupled to the measuring line (11), the port (3')



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for a travelling wave in the second directional coupler (DC2) being coupled to the measuring line (11) to the direction of the measuring means (12) for supplying a phased compensation signal (B5) towards said measuring
5 means, said compensation signal being of substantially the same amplitude as, but of substantially opposite phase to, a spurious signal, such as said leak signal (A4), summing to the signal returning from the object (10), and

said transmitter means (15) being coupled to the
10 input port of said second directional coupler (DC2) through a delay unit (13) for adjusting the phase of the compensation signal (B5).

5. A device according to claim 4, c h a r a c -
t e r i s e d in that the coupling of the second
15 directional coupler (DC2) is equal in magnitude to the sum of the directivity and coupling of the measuring directional coupler (DC1).

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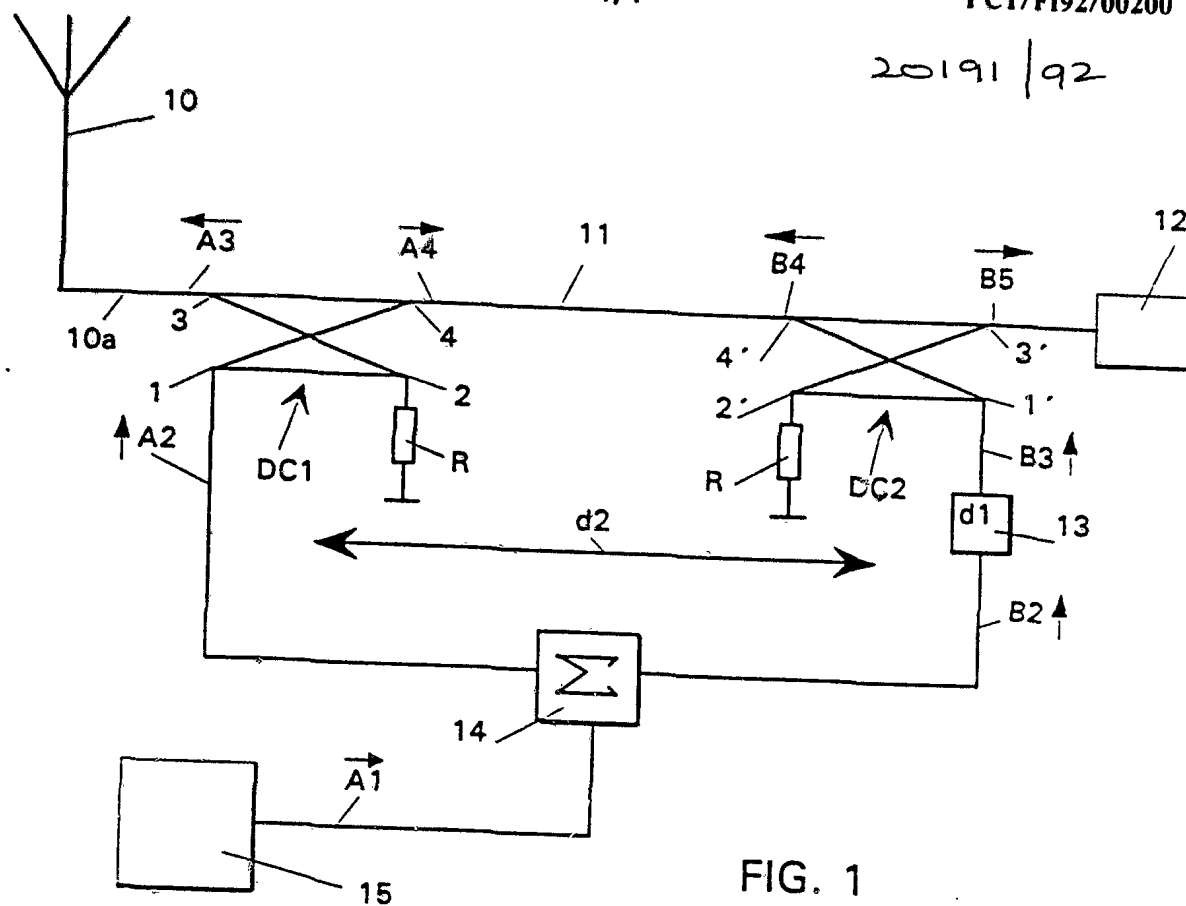
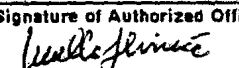


FIG. 1

INTERNATIONAL SEARCH REPORT

International Application No PCT/FI 92/00200

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC5: G01R 27/28, 27/06		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
IPC5	G01R	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched ⁸		
SE,DK,FI,NO classes as above		
III. DOCUMENTS CONSIDERED TO BE RELEVANT⁹		
Category *	Citation of Document, ¹¹ with Indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
X	EP, A1, 0261828 (FLANN MICROWAVE INSTRUMENTS LTD) 30 March 1988, see column 5, line 16 - column 6, line 7; figure 1 --	1,4
A	US, A, 4149122 (V.J. PARATO) 10 April 1979, see figure 4 --	1,4
A	US, A, 4962359 (J.P. DUNSMORE) 9 October 1990, see figures 1,1A --	1,4
A	DE, A1, 3317358 (LICENTIA PATENT-VERWALTUNGS-GMBH) 24 November 1983, see figure 1 -- -----	1,4
* Special categories of cited documents:¹⁰ "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
2nd October 1992	07 -10- 1992	
International Searching Authority	Signature of Authorized Officer	
SWEDISH PATENT OFFICE	 Sven-Olof Wirleé	

**ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.PCT/FI 92/00200**

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the Swedish Patent Office EDP file on 28/08/92
The Swedish Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A1- 0261828	88-03-30	GB-A- 2195454	88-04-07
US-A- 4149122	79-04-10	NONE	
US-A- 4962359	90-10-09	DE-A- 4017412	91-01-10
		GB-A- 2233464	91-01-09
		JP-A- 3039663	91-02-20
DE-A1- 3317358	83-11-24	NONE	