4 Measurements results for GSM-TDMA structure

The immunity measurements have been taken for 12 seperate telephone sets, 8 ordinary desk telephones and 4 one piece, handheld, telephone sets. They are all type approved for use in the fixed telephone network in Norway.

When measuring interference noise at the receive side of the telephone, we used 1000 Hz, with -10 dBm from the fixed side as reference. The noise was then weighted with A-filter and the S/N ratio was calculated. The noise measurement at the transmit side was absolute value, weighted with psophometric filter. The results are shown in annex 5 for receive and 6 for transmit. As can be seen there is a quadratic function from RF-power to noise power. When increasing the RF-power by 3 dB, the noise increases by 6 dB. The high transmit noise level for telephone no 4 with low interference power is due to high internal noise. Below 8 watts GSM power the internal noise is dominant in this telephone.

If we use 0.8 W RF-power on 3 m distance, the S/N for the receiver for the most immune telephone set is about 60 dB and down to 7.7 dB for the most sensitive one. This extreme difference is hard to explain, but this is the consequence of the lack of requirements for field immunity. On the transmit side the same function can be seen, but there are differences in interference noise from receive to transmit side. If we refer to the same RF-power the most immune telephone has a noise level of -71 dBmp and the most sensitive one a noise level of -21.8 dBmp.

From the measured noise values for the receive side in annex 5 we can calculate the graph where the S/N ratio is given as a function of distance from the interferer. Annex 14 and 15 give the signal/noise with 0.8 W handheld and 10 W car-mounted GSM-telephone. Now we can divide the telephone sets into three groups. Set no 1, 2, 8 and 12 are the most sensitive, 5 and 7 are in the middle group, while the most immune are sets no 3, 4, 6, 9, 10 and 11.

If we accept 40 dB S/N as a minimum quality level and the interferer is a 10 W GSM telephone 10 m away from the fixed telephone, 6 of the 12 telephone sets must be rejected. They all have too high interference noise and for telephone set no 2 the car must be more than 70 m away to satisfy the fixed telephone user. However, we cannot draw the conclusion that every user of telephone no 2 is disturbed by the GSM telephone 70 m away, this is a worst case situation, but this exercise gives us an idea of the problem and indicates that sooner or later this problem will arise.

In these measurements we have always used RF-power as reference, but when talking immunity, field strength is the most commonly used criteria. If we look at the instrument set-up in annex 3 where we have a halfwave dipole 0.95 - 2.2 m above perfect reflecting ground and an RF-power of 0.8 W 900 MHz, we come up with 3.9 V/m for horizontal polarized field and 3.7 V/m for vertical field. This calculation is based on far field equation and with maximizing the height of the transmitter antenna.

If we have a quality standard of 40 dB S/N on the receive side, from the graph of annex 5 we can calculate the immunity for each of the 12 telephone sets. The best telephone has an immunity of 12.3 V/m and the most sensitive can only withstand 0.6 V/m. This 26 dB variation in immunity brings dramatic consequences in quality performances.

As mentioned earlier, the TDMA frequency spectrum has most of its energy in the audio frequency band. In annex 7 to 10 there are examples of frequency plot on the receive side for telephone no 2, 3, 5 and 8. For reference the 1000 Hz / -10 dBm tone is also plotted on

the same diagram. By comparing this measured spectrum with that of the calculated one in chapter 2, a great conformity is found. In the lowest frequency band you have lower interference values due to the electric/acoustic frequency response of the telephone and the A-filter.

4.1 Consequences for PSTN user in three different interference environments

The interference from mobile transmitters using TDMA is influenced by a great number of factors. We have the RF-power, the distance from the interferer to the victims, antenna position, additional attenuation in walls and the possibility of shadowing effects of the human body or other obstacles. The user environment is therefore divided into three different interference cases; office, village and base-station surroundings.

4.1.1 Office

In a typical office environment there is a fixed telephone in each room and when the mobile user is walking in the corridor outside, the interference distance is in the range of three meters. The RF-power from the GSM mobile may be as high as 2.0 W and down to 10 mW. The plot 5 and 6 can therefore be used without any changes. The antenna efficiency for the handheld station is in the range of 0 to -3 dB referred to dipole, so that when referring to power delivered to dipole you must take this loss into consideration.

4.1.2 Village

A village or small town is, especially in Norway, characterised by single-family houses made by wood situated near the road. In this situation the interference environment for the fixed telephone user is quite different from the office situation. The RF-power from the car mounted mobile telephone can, according to GSM specification, be up to 20 W, but when talking to mobile operators 10 W is more realistic. The interference distance from the road to the fixed telephone may be in the range of 5 - 10 m. The dry wooden walls give no additional attenuation.

If we look at a situation where a 10 W mobile is running 6 m away from the fixed telephone set, the S/N ratio can be as high as -2.3 dB when using telephone no 2. A speech quality of 40 dB S/N is obtained when the car is 73 m away. In the Norwegian requirement for fixed telephone, the internal noise to the fixed lines should be below -65 dBmp. In order to meet this requirement, the interference distance is more than 80 m.

This exercise is of course extreme in the sense that you have the worst case of interference and the fixed telephone user has the most sensitive telephone, but if you look at the great number of fixed telephones and the number of GSM mobiles which is expected in the future, the worst case will also arise.

As mentioned earlier, there is a great difference in the capability to withstand this TDMA interference. The mean value for all 12 telephone sets is 36.8 dB S/N and standard deviation 19.9 dB when the interference distance is 3 m and the RF power 0.8 W. For the transmitter the mean psophometric noise is -46.2 dBmp with standard deviation of 15.0 dB.

Using this figure for calculating the necessary interference distance we come up with 12.8 m for 40 dB S/N on the receive side and 31.4 m for -65 dBmp on the transmit side.

The conclusion for fixed telephone users in village areas is that there is a strong possibility for unacceptable TDMA interference from car mounted GSM telephones.

4.1.3 Base station surroundings

The TDMA structure of the RF signal is a function of the traffic load in the base station, but you can have the same RF burst in this direction as from the mobile. The RF power is up to 40 W for each carrier and the antenna gain may be 10 dB. If this is the case when calculating the necessary interference distance you come up with 198 m in order to meet the noise requirements on the transmit side using the mean value for the 12 telephone sets. In this situation using the highest power and high gain antenna the number of nearby fixed telephones will probably be low. A more realistic situation will be using 10 W RF power and 6 dB gain antenna. The interference distance is now 62 m for -65 dBmp on the transmit side and 25 m for 40 dB S/N on the receive side.

The base station is on the air all the time and the fixed telephone user will be exposed to this TDMA interference whenever the subscriber is calling.

For the operator there is also the possibility that the fixed telephone at the base station service center will be disturbed.

The operator of TDMA structure mobile systems must be aware of the relatively strong possibility of unwanted disturbances for the fixed subscriber in the base stations neighbourhood.

5 Measurements results for DECT-TDMA structure

The TDMA structure for DECT is somewhat different than shown in chapter 2. The pulse repetition frequency is 100 Hz giving the frequency spectrum in annex 2.

The RF power is defined to be maximum 250 mW EIRP and the interference level for telephone no 2, 5 and 8 is shown in annex 11 to 13. Comparing this interference to a GSM telephone with 0.8 W the noise is 30-40 dB lower for DECT telephone than for GSM.

This lower interference is caused by a lot of factors. The reduction of RF-power lower the noise by 10 dB, the doubling of the frequency gives 6 dB lower interference voltage causing 12 dB lower noise, and with this higher frequency the distributed capacitance on the PCB acts as a low pass filter reducing the induced interference voltage.

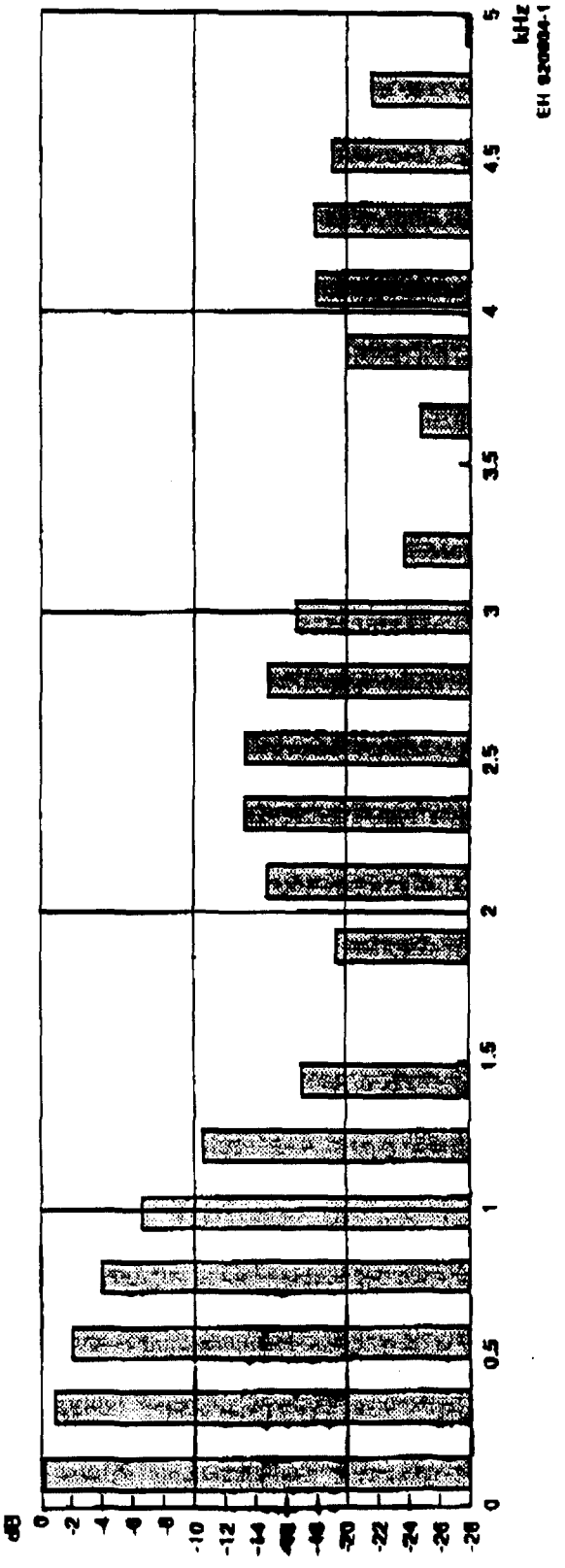
The potential TDMA interference from DECT into fixed telephone sets is then seen to be much lower than for GSM due to the higher frequency and the lower radiated power. This is not to say that TDMA in 2 GHz band is of no problem from an interference point of view.

6 Conclusion

As the measurements have shown there is a high interference potential from a TDMA structure mobile communication system, particulary with the high power transmitters as in the GSM system. The lack of immunity requirements in the VHF/UHF band for amplitude modulated field is a serious matter which has to be dealt with within the relevant standardizing institutions, like ETSI and CENELEC. Some considerations has been given to this subject in for instance ETSI. In a meeting in Paris 10-14 November 1990 in TC-RES a paper was presented by UK DTI - Radiocommunication Agency "THE EMC CONUNDRUM - TDMA TECHNOLOGY". A lot of measurements results from hearing aids exposed by TDMA interference are presented and the conclusions are "that the proposed generic immunity standard of 3 V/m does not offer adequate protection from radio transmitters".

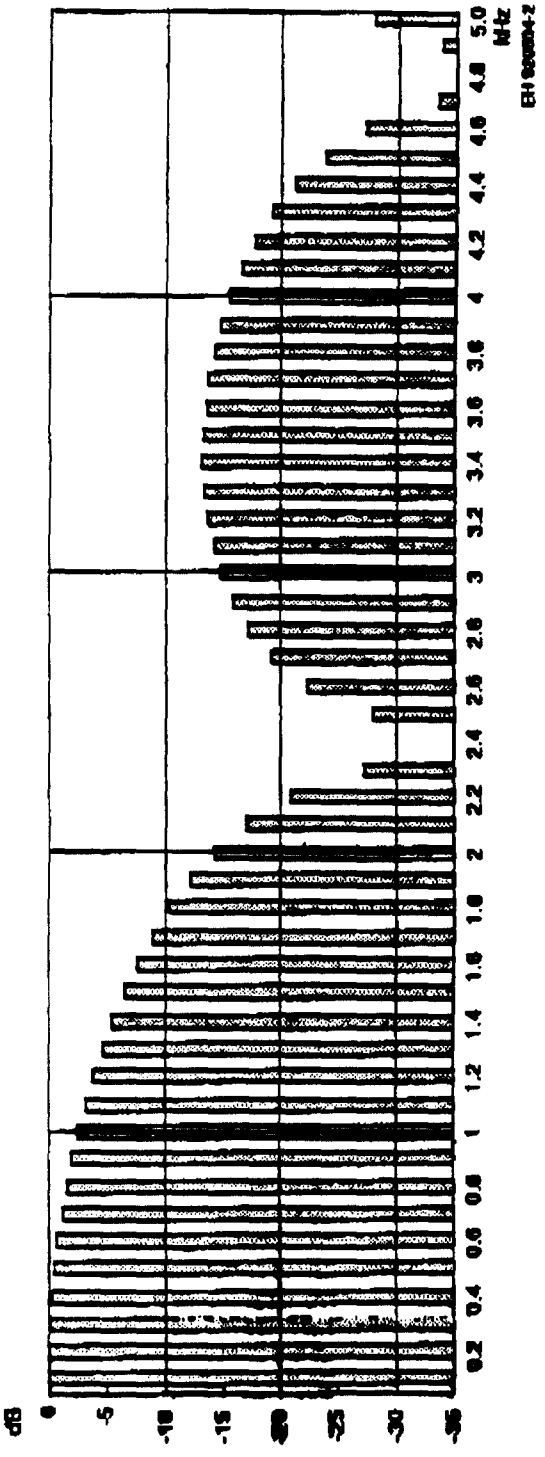
But for the fixed telephones already in use there is little help in better standards for the future. The mobile system operators must be responsible and take proper action to assure the fixed subscriber a conversation free from TDMA interference also in the future. This is not an easy match, but the cost must be on the interferer and not the victim.

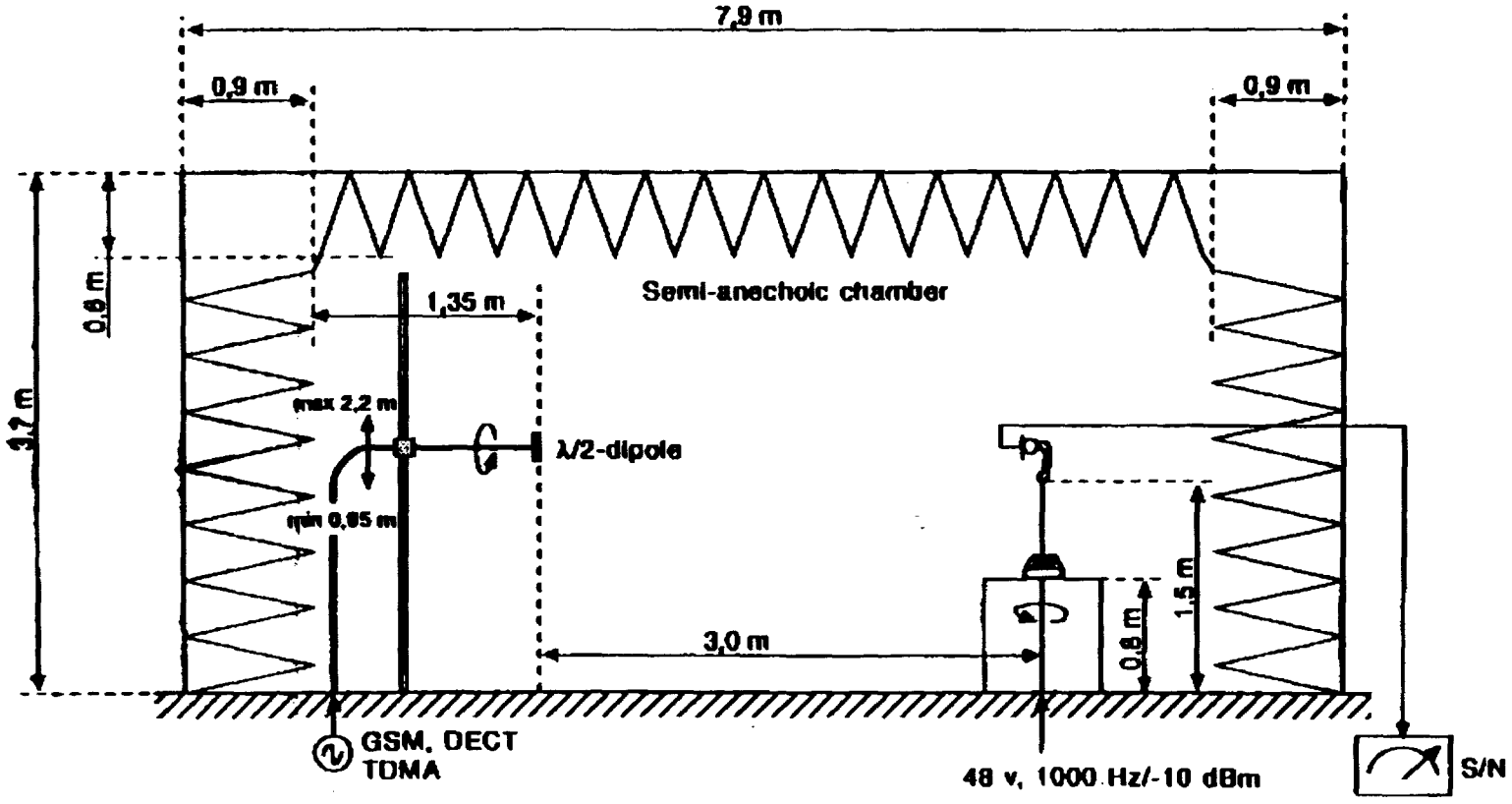
GSM - TDMA frequency specter



Annex 2

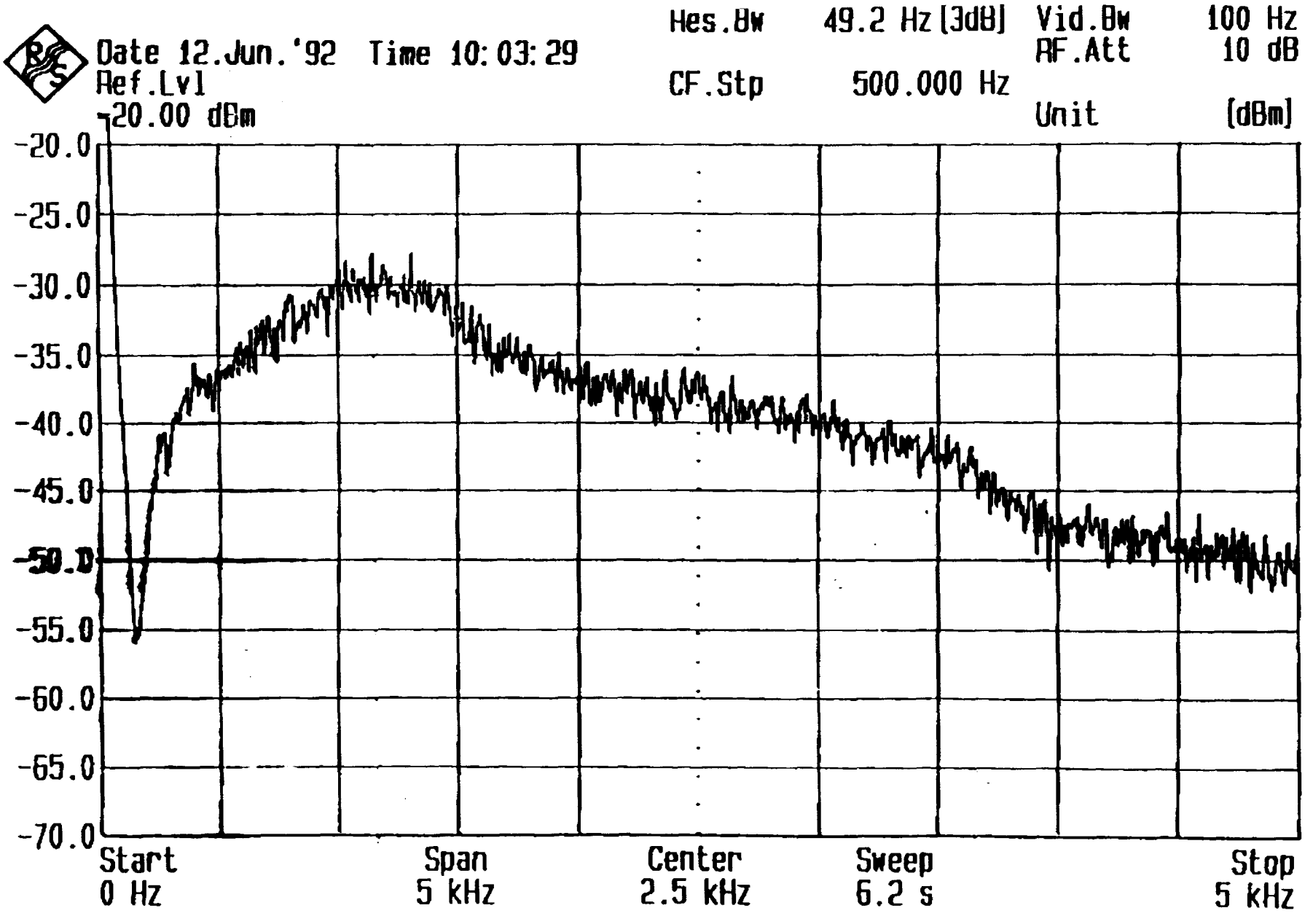
DECT - TDMA specter





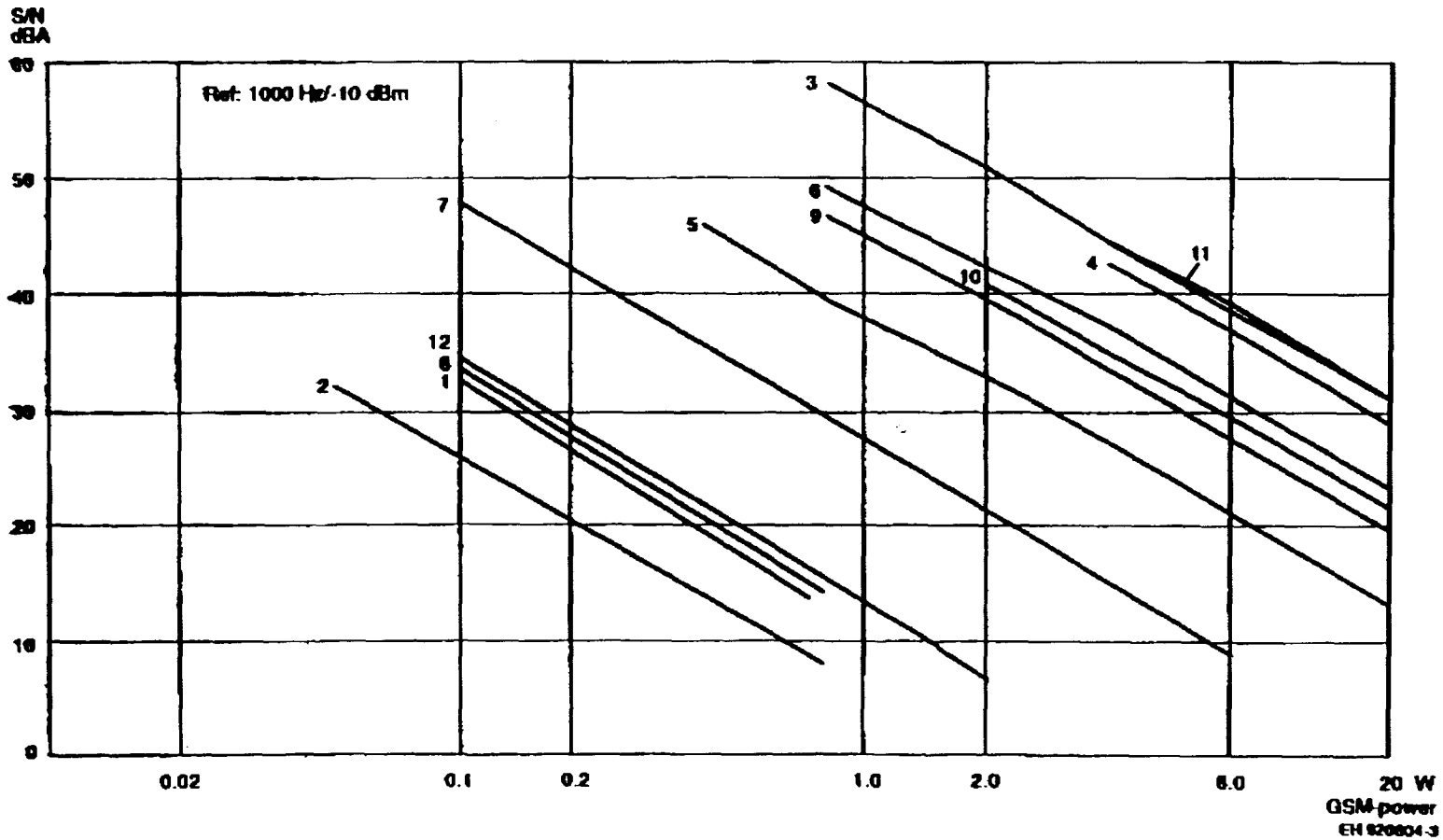
TDMA interference measuring set-up

EH 920723

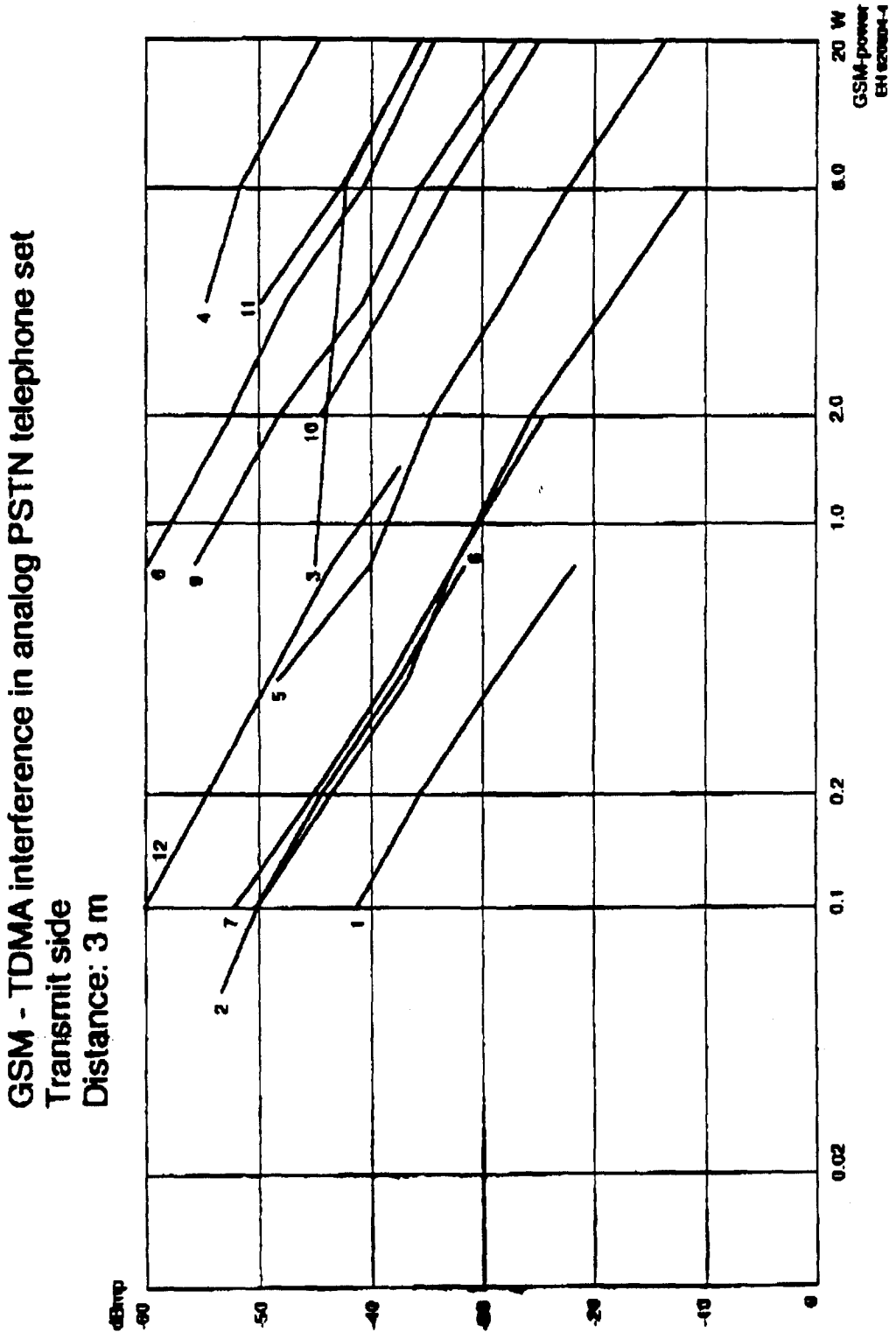


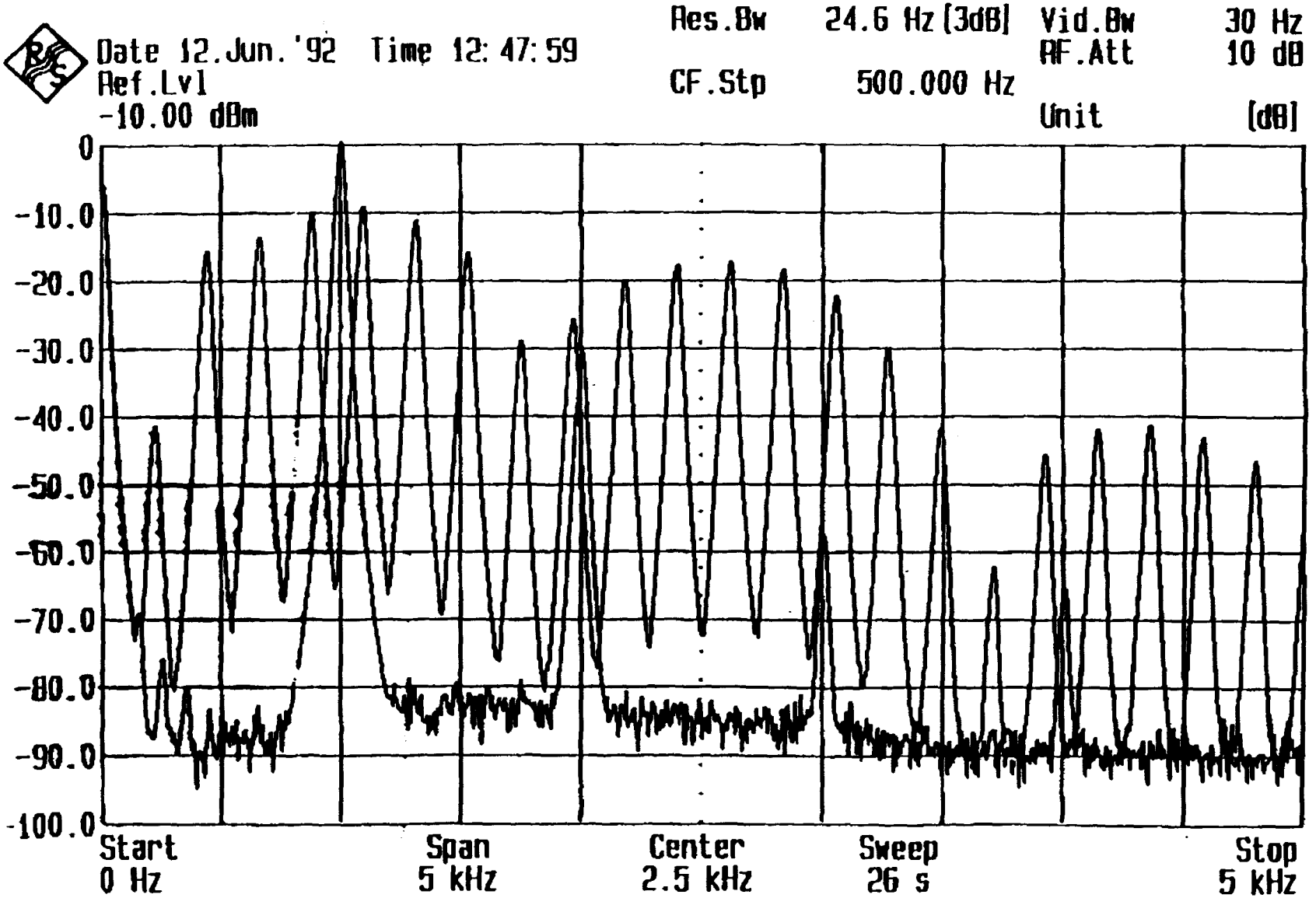
Frequency [illegible] use telephone set nr

GSM - TDMA interference in analog PSTN telephone set
Receive side
Distance: 3 m

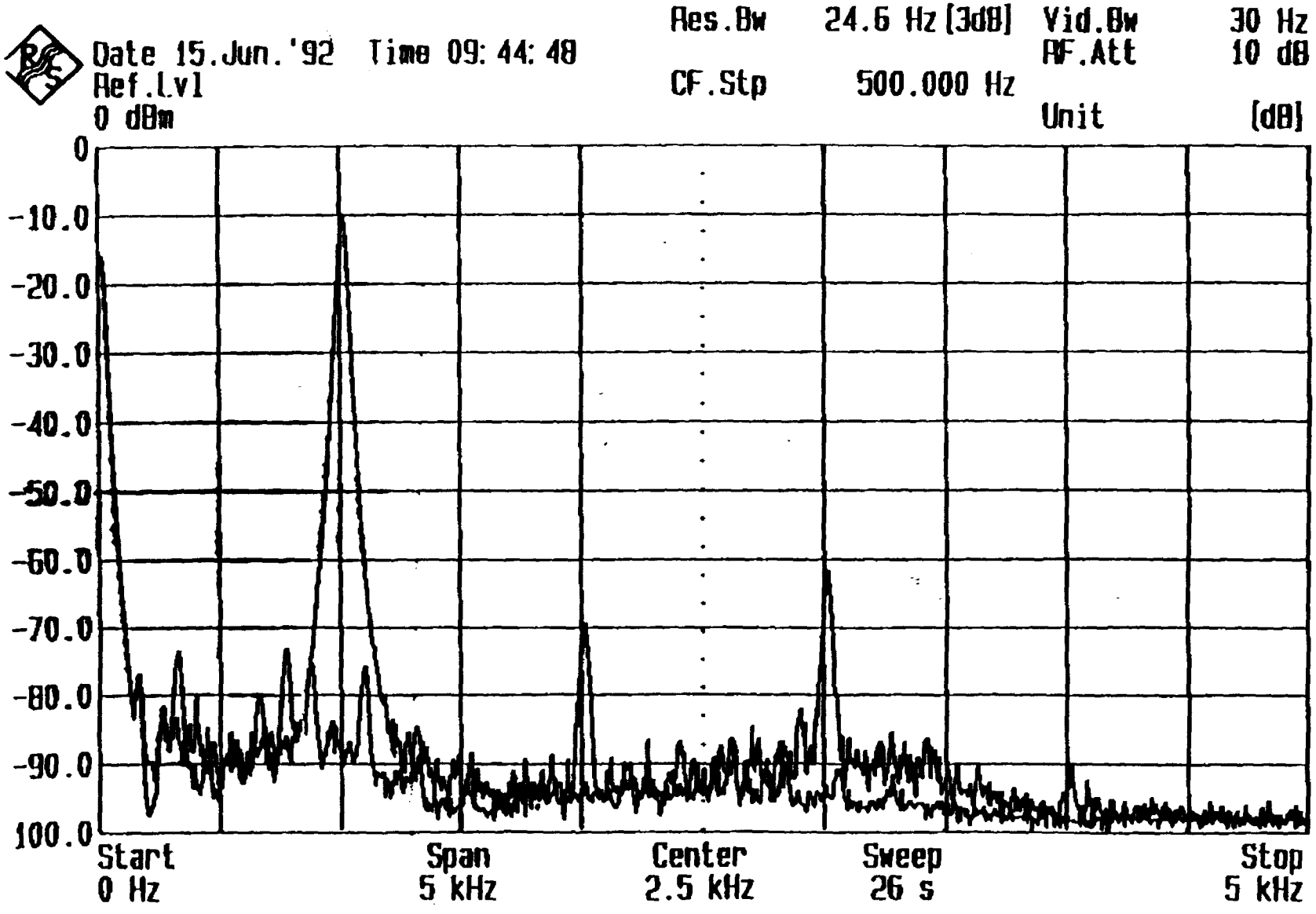


Annex 6

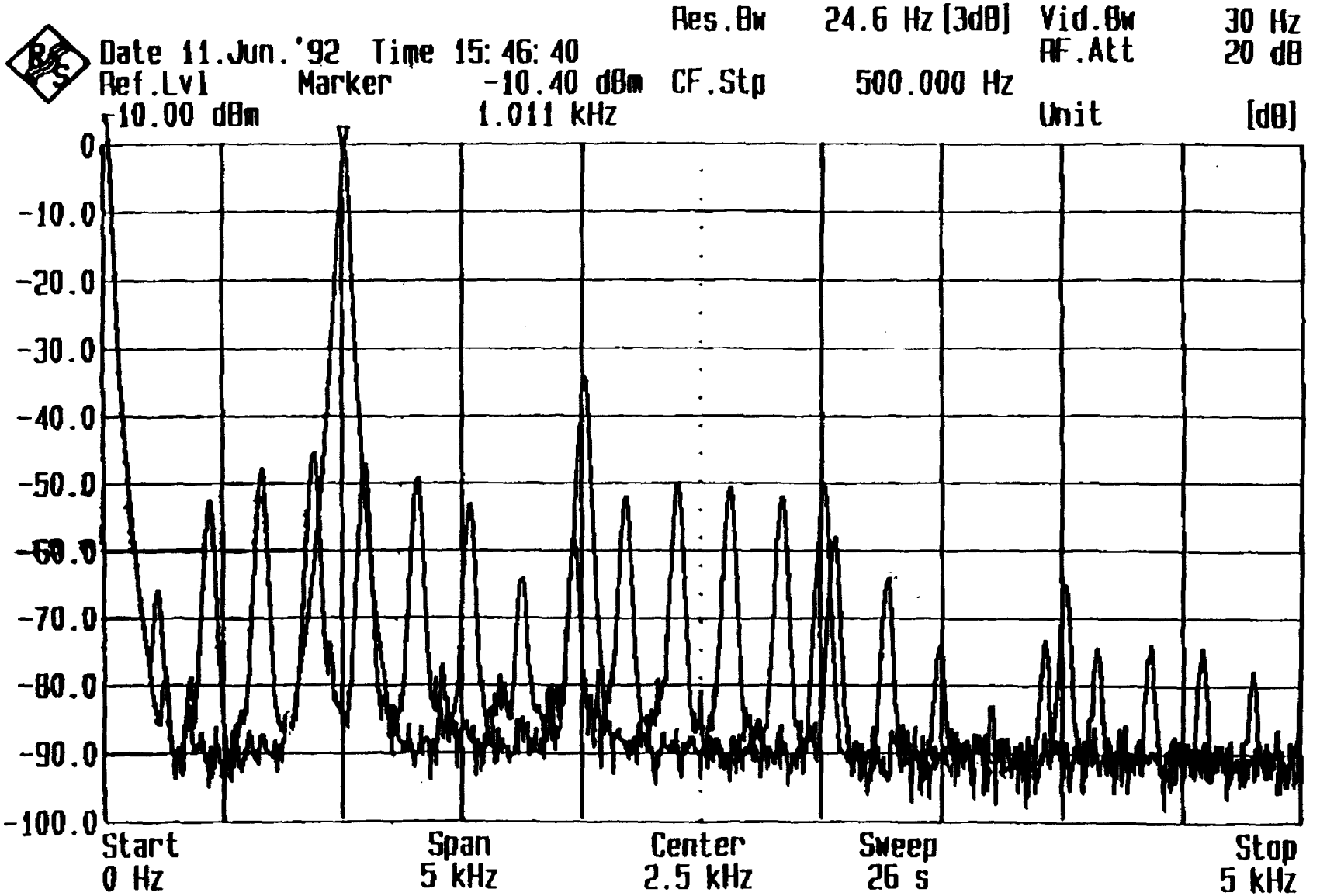

GSM - TDMA interference in analog PSTN telephone set
Transmit side
Distance: 3 m
dBmp
-60
-50
-40
-30
-20
-10
0
0.02
0.1
0.2
1.0
2.0
5.0
20 W
GSM-power
1
2
3
4
5
6
7
8
9
10
11
12



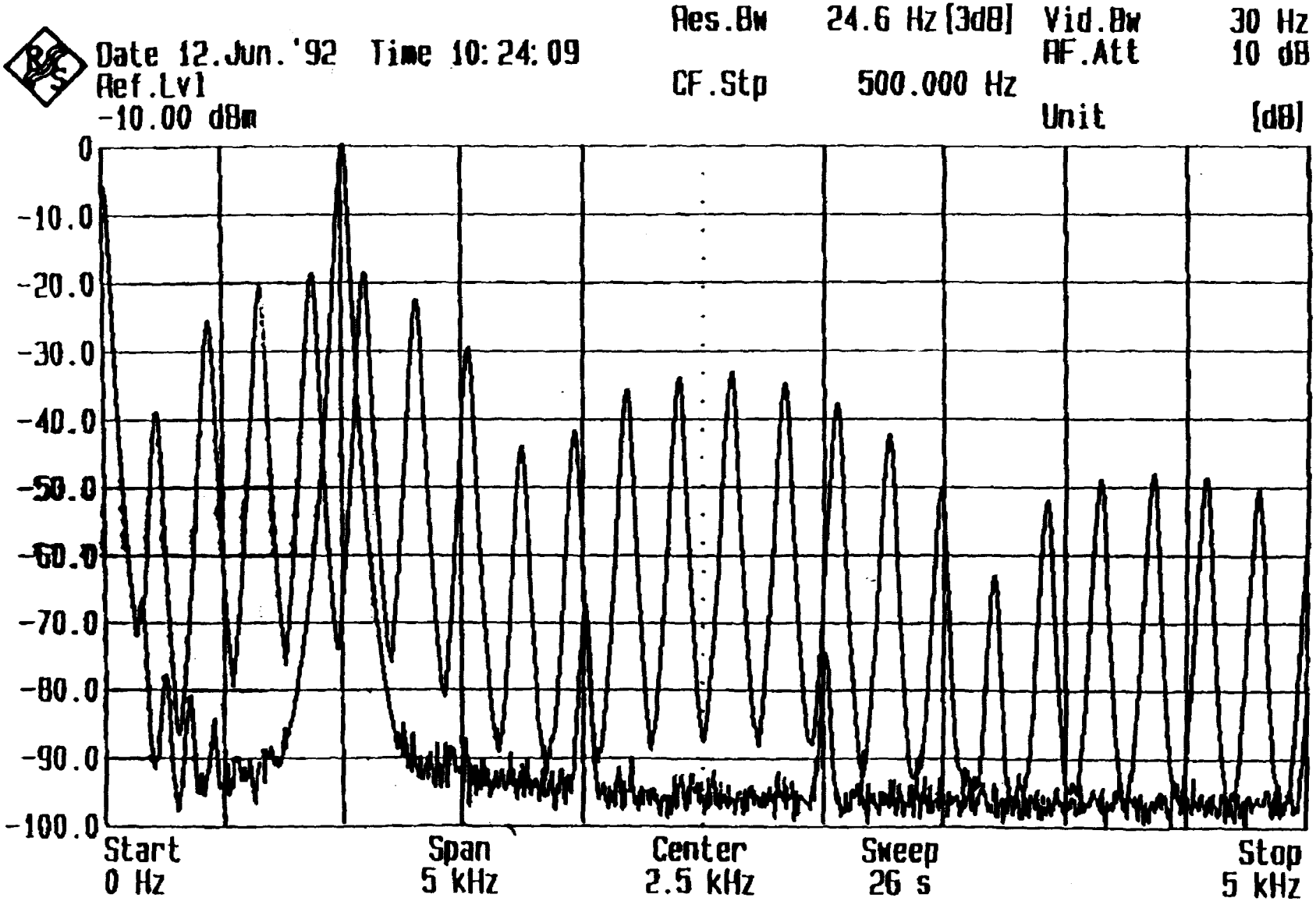
Telephone set nr 2



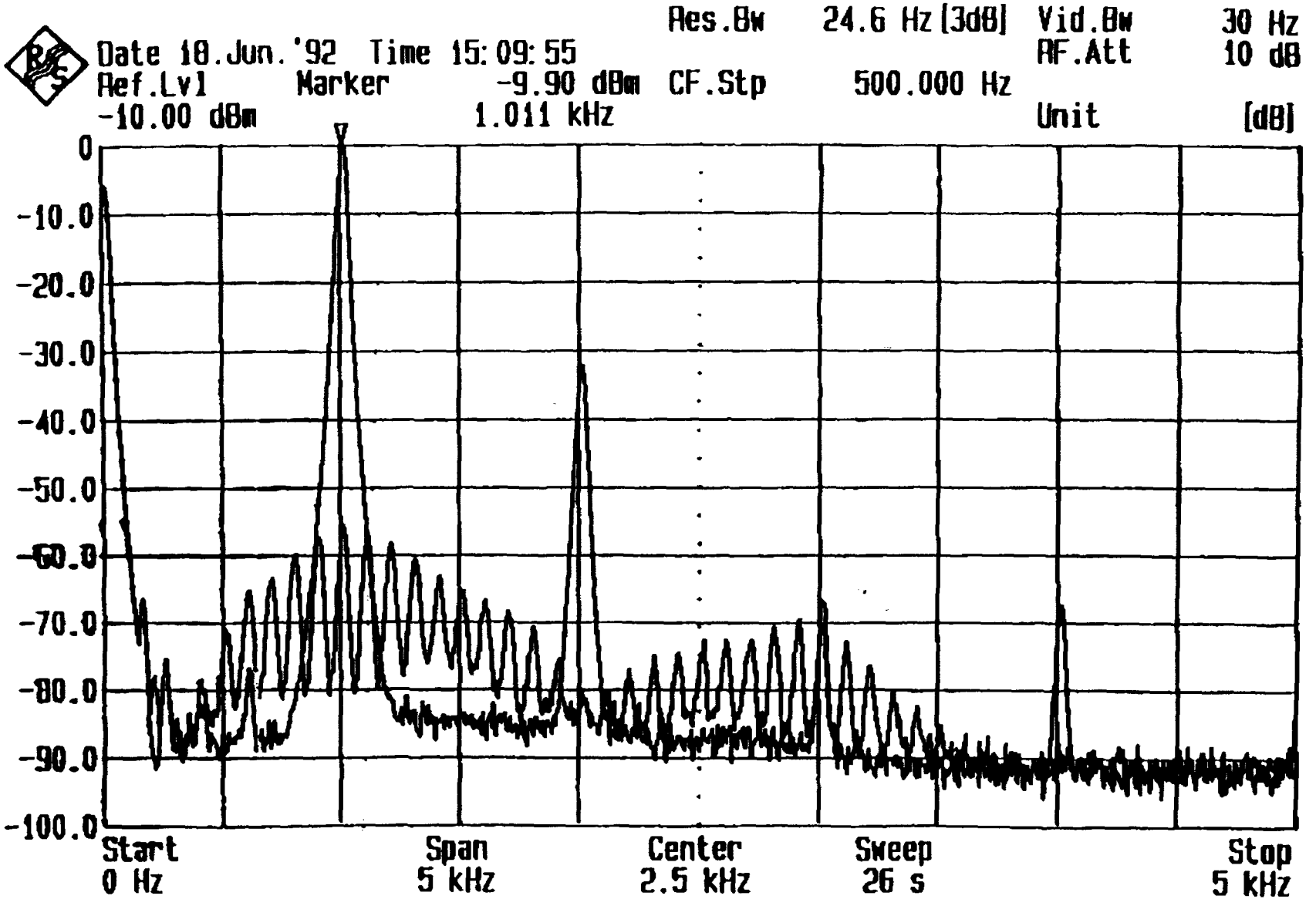
Telephone set nr 3



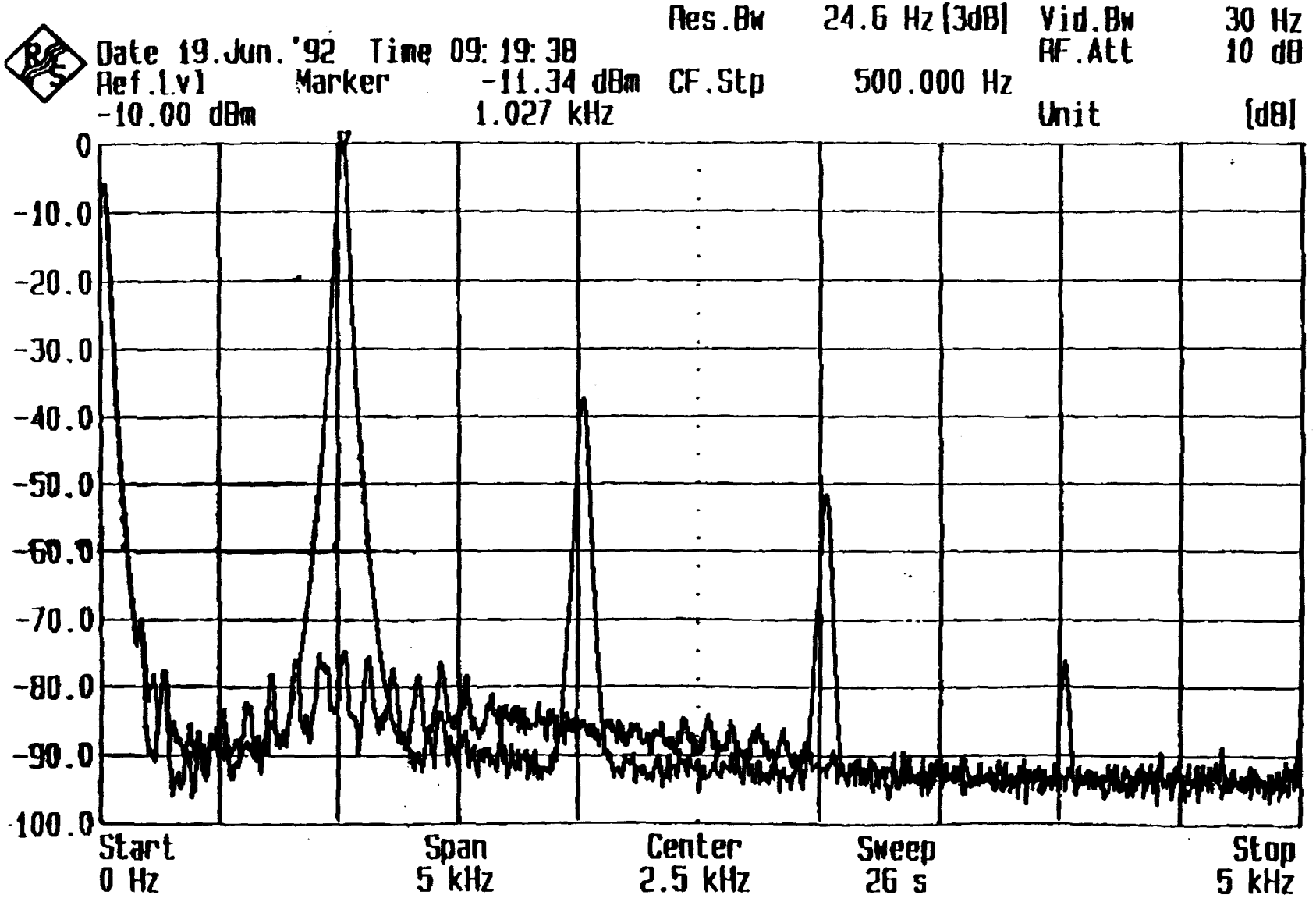
Telephone set nr 5



Telephone set nr 8

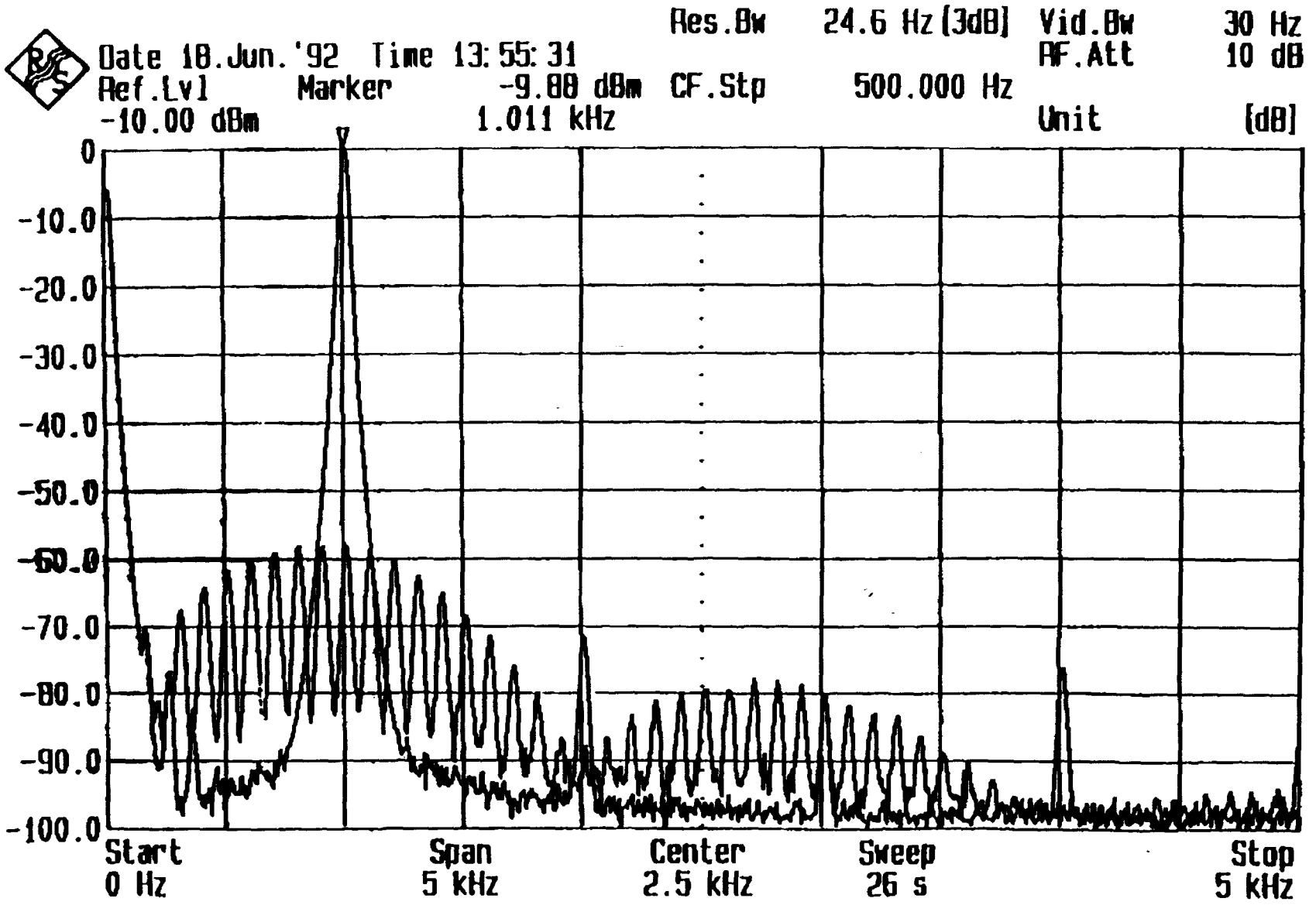


Telephone set nr 2



Telephone set nr 5

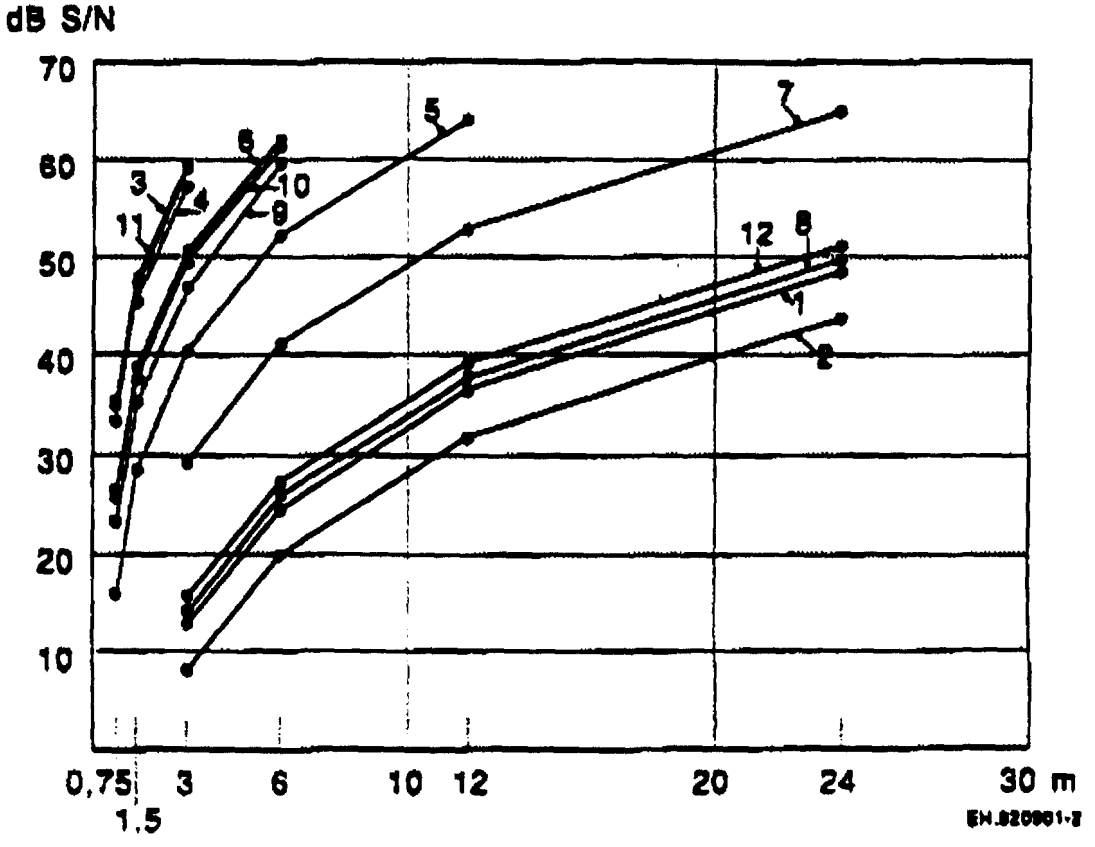
Annex 13



Telephone set nr 8

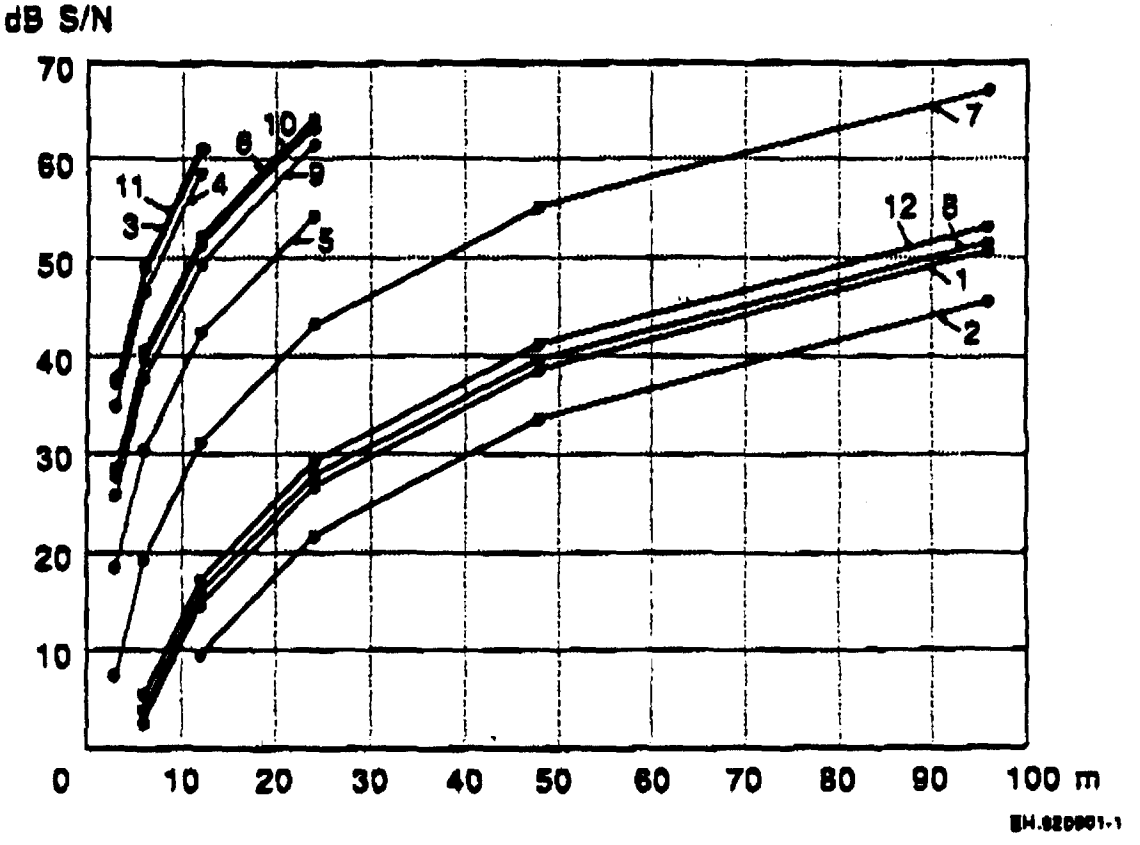
Annex 14

GSM-power 0,8 w (Handheld)



Annex 15

GSM-power 10 w (Car-mounted)



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