European Radiocommunications Committee (ERC)
within the European Conference of Postal and Telecommunications Administrations (CEPT)

RADIOCOMMUNICATIONS REPORTS

COMPATIBILITY BETWEEN CERTAIN MOBILE RADIOCOMMUNICATIONS SYSTEMS OPERATING IN ADJACENT BANDS

Oslo, December 1991

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COMPATIBILITY BETWEEN CERTAIN MOBILE RADIOCOMMUNICATIONS SYSTEMS OPERATING IN ADJACENT BANDS

The present ERC Report contains theoretical studies in Annex A and laboratory testing in Annex B.

SUMMARY

The ERC Report highlights the possible problems which could occur between the Digital Short Range Radio (DSRR) system and GSM cellular systems operating in the same band.
The levels of isolations for the main types of interference are calculated for installed system configurations. This leads to significant increases in the magnitude of the problems which can occur, especially if spurious emissions are such that they fall in-band of another system. Serious interference problems are identified which result in required isolations of up to 90 dB between DSRR and GSM systems and thus attempts need to be made to increase specification values accordingly.

Annex A

1. INTRODUCTION

The possible interference problems between GSM and Digital Short Range Radio (DSRR) were first highlighted within the GSM working groups. The main problem foreseen was that the frequency allocation for DSRR, which is 933-935 and 888-890 MHz, is between the GSM and GSM extension bands. The effects of interference between such systems have so far only been considered in terms of specification values the effects of system implementation largely being ignored. These effects, such as antenna gains, are considered within this document.

The possible interference sources are from receiver blocking or desensitisation, intermodulation product generation, spurious response rejection of the receivers and spurious in-band transmission by transmitters. All these sources of interference are studied here and isolation requirements between each system derived. These isolations may be translated into distances by applying an appropriate propagation law. Actual distances are not considered in this Report due to the wide variations in propagation conditions which may be used depending on the expected environment of operation.

2. SYSTEM SPECIFICATIONS

The specifications of each system control the susceptibility of that system to interference from other systems, and the levels of interference it may generate to other systems. Within this work the effects of systems being in adjacent bands, and thus possibly operating within adjacent channel specifications, have not been considered assuming that cellular systems allow intra-cell handoff to avoid these higher levels of interference. Wide band specifications have therefore been considered here. Table 1 lists all the relevant specifications for the systems.

System	GSM		DSRR	
Specification	Base	Mobile Class 2	Base	Mobile
Tx power e.i.r.p. dBm	50	42	36	36
Feeder Loss and Antenna Gain (dir./omni) dBi	16/5	3	0	0
Sensitivity dBm	−104	−104	−101	−101
Protection Ratio dB	9	9	18	18
Blocking Level dBm	−13	−23	−14	−14
Tx Spur Emms dBm	−36	−36	−36	−36
Tx Spur Emms (in Rx band) dBm	−73	−75		
Rx Spur Rej. dBm	−43	−43	−38	−38
Intermod Rej. dBm	−43	−43	−46	−46

Table 1. System Specifications.

The transmitter power listed in Table 1 is the Effective Isotropic Radiated Power (e.i.r.p.) not the level of power present at the transmitter antenna connector. The antenna gain includes a −3 dB contribution due to feeder losses between the equipment and the antenna. The sensitivity figure is the level of received signal in a static test condition required to achieve acceptable quality. The protection ratios listed are those required to maintain a communication state in the presence of co-channel interference. The levels of the blocking and spurious specifications are normally calculated based on sensitivity specification limits. These are expressed here in dBm whereas in the specifications some are expressed and absolute levels and some are expressed relative to the sensitivity limit. The antenna configurations for DSRR are unclear so the assumption of an isotropic antenna of 0 dBi gain has been used for this work, additional gain will result in higher isolations.

3. BLOCKING INTERFERENCE LEVELS

The isolation required between two system units to prevent this can be calculated from the equation below:

$$I = P_{Tx} + Ag_{Rx} - B_{Rx}$$

Where P_{Tx} is the transmitter power (e.i.r.p.) in dBm
Ag_{Rx} is the antenna gain of the receiver in dBi
B_{Rx} is the blocking limit of the receiver in dBm

From this, the isolations to prevent blocking of the receiver by more than 3 dB are given in Table 2.

The results of Table 2 are for a single carrier operating at full power. However, if a fully loaded cellular system is considered with, say, 28 traffic channels per base site the results where cellular base sites are the interfering transmitter are optimistic. For GSM, 28 traffic channels can be supported on GSM by 4 carriers. The additional power received will therefore increase by 6 dB.

Transmitter	Receiver	Isolation (dB)	
		Single	Full load
GSM Directional Base	DSRR	64	70
GSM Omni Base	DSRR	64	70
GSM Class 2 Mobile	DSRR	56	
DSRR	GSM Directional Base	65	
DSRR	GSM Omni Base	54	
DSRR	GSM Class 2 Mobile	62	

Table 2. Blocking Isolation Requirements.

From the results in Table 2 it is apparent that the high antenna gain of a directional cellular base adds significantly to the isolation requirements between the systems. However, if the near frequency blocking figure of −23 dBm is taken then the isolation increases further to 80 dB.

4. SPURIOUS TRANSMISSION INTERFERENCE LEVELS

Spurious transmission interference is caused by a unit emitting either a modulated or unmodulated signal on a frequency other than its specified transmitter frequency. One example of this would be a DSRR unit transmitting on 933 MHz, using an I.F. of 10.7 MHz. If an intermodulation of the transmitter and the local oscillator occurred, an emission on a frequency of 943.7 may result, which is in the middle of the GSM mobile receiver band. The isolations required to ensure these emissions do not affect another system operating at its sensitivity limit and can be calculated from:

$$I = SP_{Tx} + Ag_{Tx} + Ag_{Rx} + PR - SVTY_{Rx}$$

Where SP_{Tx} is the spurious emission power in dBm
Ag_{Tx} is the antenna gain of the transmitter in dBi
Ag_{Rx} is the antenna gain of the receiver in dBi
PR is the receivers required protection ratio in dB
$SVTY_{Rx}$ is the sensitivity limit of the receiver in dBm

This is a very serious source of interference and therefore it would be desirable to tighten the spurious emission limit within the band of other mobile services by 20 to 30 dB.

This type of interference is normally considered to be narrow band modulated signals. Therefore handoff will allow the interference to be neutralised, but it may still mean that several carriers of the system are unusable. However, it is unclear whether broad band noise can also be generated at this level which would not be nullified by handoff.

Transmitter	Receiver	Isolation (dB)
GSM Directional Base	DSRR	99
GSM Omni Base	DSRR	88
GSM Class 2 Mobile	DSRR	86
DSRR	GSM Directional Base	93
DSRR	GSM Omni Base	82
DSRR	GSM Class 2 Mobile	80

Table 3. Spurious Emissions Isolation Requirements.

Receiver spurious emissions are less than the transmitter spurious emissions by about 20 dB, thus the effect of these will be significantly less, but these could still generate significant isolation requirements of up to 79 dB.

5. SPURIOUS RECEPTION INTERFERENCE LEVELS

Spurious reception interference is the opposite of spurious transmission interference. In this case the receiver suffers the unwanted mixing allowing the transmission from the other system to form effectively co-channel interference to the wanted signal. An example of this may be if a GSM receiver has a 21 MHz I.F. and was tuned to 892 MHz then the image frequency would be 934 MHz, the middle of the DSRR band.

Transmitter	Receiver	Isolation (dB)
GSM Directional Base	DSRR	88
GSM Omni Base	DSRR	88
GSM Class 2 Mobile	DSRR	80
DSRR	GSM Directional Base	95
DSRR	GSM Omni Base	84
DSRR	GSM Class 2 Mobile	82

Table 4. Spurious Reception Isolation Requirements.

The level of isolation to overcome such interference can be calculated from:

$$I = P_{Tx} + Ag_{Rx} - SPREJ_{Rx}$$

Where P_{Tx} is the transmitter power (e.i.r.p.) in dBm
Ag_{Rx} is the antenna gain of the receiver in dBi
$SPREJ_{RX}$ is the receiver spurious response rejection limit in dBm

The effect of this interference and associated isolations shown in Table 4 is effectively the same as that of spurious transmission given in Table 3 above. Again it would be desirable to tighten the spurious response rejection within the band of other mobile services by 20 to 30 dB.

6. INTERMODULATION PRODUCT GENERATION LEVELS

Intermodulation products result when two or more strong signals are present at the input to a receiver. The basic formula to calculate the frequencies of the intermodulation products is:

$$F = f1 \pm 2f2$$

Where f1 and f2 take the values of either input frequency.

The range of frequencies over which intermodulation products can be produced is three times the band allocated to the system. The range of frequencies where GSM intermodulation products may be generated in a receiver are 910 to 985 MHz. Interference of this type will be most common within mobile receivers which are suffering interference from a cellular base site with many full power carriers.

Two equations are necessary to calculate the isolations depending on whether the transmitter bandwidth is wider than one third of the receiver bandwidth. If the bandwidth of the intermodulation product is wider than the receiver bandwidth then only that part of the power within the receiver bandwidth needs to be considered. The isolation required to ensure intermodulation products is not produced when the transmitter bandwidth is wider than one third of the receiver bandwidth can be calculated from:

$$I = P_{Tx} + Ag_{Rx} - IMREJ_{RX} - 3BW_{TX} + BW_{RX}$$

Whereas, if the transmitter bandwidth is less than one third of the receiver bandwidth, then all the intermodulation product power needs to be considered, so the isolation will be:

$$I = P_{Tx} + Ag_{Rx} - IMREJ_{RX}$$

Where P_{Tx} is the transmitter power (e.i.r.p.) in dBm
Ag_{Rx} is the antenna gain of the receiver in dBi
$IMREJ_{RX}$ is the receiver intermodulation product rejection limit in dBm
$3BW_{TX}$ is three times the bandwidth in dB of the transmitted signal
BW_{RX} is the bandwidth in dB of the receiver

The results of the isolation requirements to overcome possible intermodulation product generation are listed in Table 5.

Transmitter	Receiver	Isolation (dB)
GSM Directional Base	DSRR	82
GSM Omni Base	DSRR	82
GSM Class 2 Mobile	DSRR	84
DSRR	GSM Directional Base	95
DSRR	GSM Omni Base	84
DSRR	GSM Class 2 Mobile	82

Table 5. Intermodulation Product Isolation Requirements.

The only results of interest here are those for a GSM base transmitter as this is the most likely source of several high power carriers which will be received at the same level and with high occupancy, indicating a 82 dB isolation requirement. The effect of two or more mobiles being close enough to a DSRR unit to generate intermodulation products is considered negligible. It is possible that a GSM intermodulation product will spread over a bandwidth of 600 kHz, thus blocking 24 DSRR channels.

A significant improvement in the case of DSRR mobile to mobile communication could be provided by swapping the DSRR base and mobile transmit bands, as the intermodulation products generated by the GSM bases can only spread from 910 to 985 MHz. This improvement would be because it is much more unlikely that two high powered mobile transmissions would be received by a DSRR mobile continuously, thus causing intermodulation products to be generated. This would, however, result in intermodulation products within DSRR base units caused by GSM base units, for which more care would be used to place antennas to reduce interference. It would also be possible to specify better filter characteristics and higher intermodulation immunity for base receivers, where higher voltage levels are available which result in better intermodulation performance. In hand held units battery size is paramount, so low voltage receivers are common with low intermodulation immunity. It may be sufficient to allow market demand to drive the production of a high quality DSRR base unit capable of working close to a GSM base for those users who require such a device.

7. CONCLUSIONS

This report shows that when antenna gains are considered there are several combinations of interference sources which require very high isolations in order to ensure that no interference is produced to adjacent systems. Considering the expected usage of all these systems will be in common areas, it will be very difficult to achieve the required exclusion zones. Therefore other methods of overcoming the interference must be considered.

The ideal solutions to these problems would be to increase the blocking specifications of all systems by about 10 dB, and increase all the spurious transmission and spurious receiver response limits by 30 dB in the band 860 to 960 MHz, to levels similar to those specified by GSM for emissions within a unit's associated receive band. The problem of DSRR mobiles suffering high intermodulation product generation could be resolved if the DSRR base and mobile bands are swapped; however, the effect on other interference sources has not been considered.

Annex B

1. INTRODUCTION

This paper concerns the potential interference to DSRR from GSM/EGSM systems, and details the tests conducted on a DSRR prototype by the Radiocommunications Agency's Radio Technology Laboratory.

2. THE DSRR EQUIPMENTS UNDER TEST (EUT's)

Two prototypes DSRR simplex EUT's were supplied by Philips Radio Communication Systems Ltd. The sensitivity of these very large non-production EUT's drifted with temperature/time making absolute measurements difficult. Tests showed, however, that if the EUT's were not operated at their maximum sensitivity, their protection requirements remained constant, i.e. the relative difference between the wanted and unwanted signals for a given impairment was stable.

3. TESTS

3.1. Subjective Tests

The two EUT's were connected via variable attenuators to provide appropriate signal levels (it was necessary to place one of the EUT's in a screened enclosure to prevent stray coupling from affecting the results).

A simplex (single frequency operation) call was established between the two EUT's and the subjective quality of the transmission assessed.

A Frequency Agile Signal Simulator was used to simulate a GSM/EGSM transmission at various frequency offsets from the DSRR transmission. The GSM/EGSM signal was injected into the DSRR transmission path and the level adjusted until CCIR Grade 4 impairment occurred, and the difference between the amplitude of the wanted (DSRR) and unwanted (GSM/EGSM) signal levels (the Grade 4 protection ratios) was noted. This was then repeated to determine the CCIR Grade 1 protection ratios.

The above tests were conducted with two types of GSM/EGSM simulation. One simulated a busy base station, i.e. all eight time slots in each frame were occupied, the other simulated a mobile station, i.e. only one time slot in each frame was occupied. Tests were also conducted with a CW signal to facilitate comparison with the DSRR adjacent channel and blocking specification.

A block diagram of the test configuration is given in Annex 1.

3.2. Bit Error Rate Tests

It was not possible to conduct BER tests in the time available as there were no facilities on the EUT's for the connection of this type of test equipment. It should be possible to identify suitable connection points, and construct appropriate interfaces, given further information on the EUT's.

4. RESULTS

The protection ratios measured are tabulated in Annex 2, together with the calculated interfering GSM/EGSM signal level that would have been present at the DSRR receiver input (had it been operating at its maximum usable sensitivity). The isolation required to avoid interference from a 100 W (50 dBm) medium power GSM/EGSM base station is also calculated and given in Annex 2.

All of these results are presented graphically in Annex 3.

4.1. Calculation of Interference Range

CCIR 900 MHz propagation data is only available for distances in excess of 1 km as it is impossible to make generalisations about terrain and building clutter, etc. over shorter distances. However, for very short distances (< 10 m), calculations based on free space path loss are probably reasonably realistic, and at 100 m a calculation based on free space path loss plus 10 dB building attenuation does not seem unreasonable.

The above assumptions were used to produce the isolation vs. distance graph given in Annex 4, and evaluate the distance at which the prototype DSRR EUT would suffer interference, given the interference scenarios detailed in Annex 5.

4.2. Calculation of Interference Probability

4.2.1. The probability of the frequency differences detailed in Annex 5 occurring is estimated to be:

	Worse Case	Typical
GSM Base Stations	≈ 0.05	≈ 0.5
GSM Mobile Stations	≈ 0.05	≈ 0.5
EGSM Base Stations	≈ 0.05	≈ 0.5
EGSM Mobile Stations	≈ 0.05	≈ 0.5

4.2.2. The probability of a DSRR unit being within the predicted interference range of a base station, or one or more mobile stations (based on 50 mobiles per cell, and the ratio of the area of the predicted interference range and the area of a 20 km (diameter) GSM/EGSM cell) is estimated to be

	Worse Case	Typical
GSM Base Stations	≈ 0.078	≈0.0001
GSM Mobile Stations	≈ 1.125*	≈0.0018
EGSM Base Stations	≈ 1.0	≈0.0001
EGSM Mobile Stations	≈24.5*	≈0.0018

*These probabilities indicate that the DSRR unit will be within the interference range of more than one mobile station.

4.2.3. The probability of a GSM/EGSM mobile or base station being active at the same time as a DSRR unit is estimated to be:

	Worse Case	Typical
GSM Base Stations	≈0.9	≈0.9
GSM Mobile Stations	≈0.005	≈0.005
EGSM Base Stations	≈0.9	≈0.9
EGSM Mobile Stations	≈0.005	≈0.005

4.2.4. Multiplying the probabilities given in 4.2.1./2./3. yields the following overall estimate for the probability of a DSRR unit suffering interference from GSM/EGSM transmissions:

	Worse Case	Typical
GSM Base Stations	≈0.0035	≈0.000045
GSM Mobile Stations	≈0.000281	≈0.0000045
EGSM Base Stations	≈0.045	≈0.000045
EGSM Mobile Stations	≈0.006125	≈0.0000045

This indicates that ≈0.4% (1 in 250) of all DSRR calls will suffer interference from GSM, and this will increase to ≈5.1% (1 in 20) when EGSM (sharing the same spectrum) is introduced

5. OBSERVATIONS

The DSRR prototype tested may have slightly different immunity characteristics from those of the final production models.

5.1. Interference to an Established DSRR Call

The onset of interfrence was very sudden.

The protection requirements, and the difference between the Grade 1 and 4 protection ratios, depended on the frequency separation between the DSRR and GSM/EGSM transmission and the number of time slots that were occupied in each GSM/EGSM frame.

Generally the interference was worse when all eight time slots were occupied, but for large frequency separations interference was worse when just one time slot was occupied.

The difference between the Grade 1 and 4 protection ratios was as little as 2 to 3 dB for CW and GSM/EGSM signals with all eight time slots occupied, but was over 20 dB for close in (≈ ± 100 kHz) GSM/EGSM signals when only one time slot was occupied.

GSM/EGSM signals cause more interference than CW signals. This difference was typically 8 dB for co-channel, 26 dB at 250 kHz offset, and 22 dB at 10 MHz offset. It should be noted that the DSRR specification only details the minimum adjacent channel and blocking performance with respect to CW signals.

5.2. Interference Preventing a DSRR Call Being Established

The level at which a GSM/EGSM transmission prevented a DSRR call from being established was slightly lower than that required to cause interference to an established call.

It has not been possible to determine precise figures for this in the time available. Further investigation may be required.

6. CONCLUSIONS

These conclusions are based on the results of tests conducted on a DSRR prototype which may have slightly different immunity characteristics from those of the final production models.

GSM/EGSM signals cause more interference than CW signals. The interference range, and hence the probability of interference, will therefore be considerably greater than that predicted by calculations based on the minimum (CW) adjacent channel and blocking performance detailed in the DSRR specification.

The level at which a DSM/EGSM transmission prevents a DSRR call from being established is slightly lower than that at which it causes interference to an established call. No allowance has been made for this in calculating the interference range.

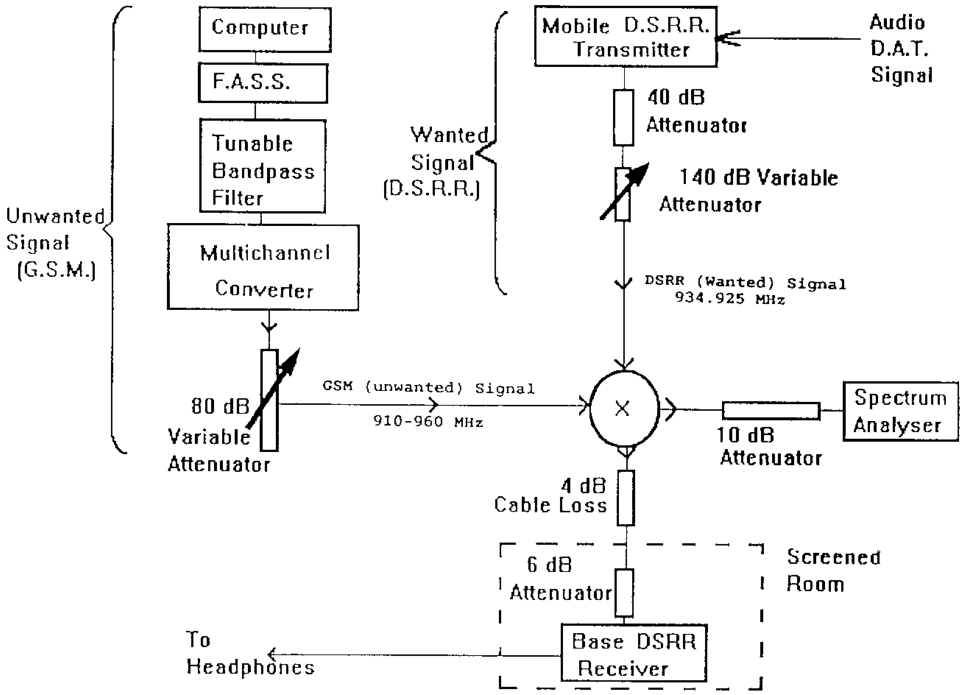
The propagation model and interference scenarios detailed in section 4 and Annex 5 of this paper predict the following interference ranges:

	Worse Case	Typical
GSM Base Stations	2,800 m	110 m
GSM Mobile Stations	1,500 m	60 m
EGSM Base Stations	30,000 m	110 m
EGSM Mobile Stations	7,000 m	60 m

The probability calculations detailed in section 4 of this paper indicate that approximately 0.4% (1 in 250) of all DSRR calls will suffer interference from GSM, and this will increase to approximately 5.1% (1 in 20) when EGSM (sharing the same spectrum) is introduced.

Annex 1

TEST CONFIGURATION



Annex 2(a)

PROJECT No. 60
SUBJECTIVE LISTENING TEST RESULTS
TO EVALUATE THE INTERFERENCE POTENTIAL OF GSM TRANSMISSION ON DSRR SYSTEM

Maximum Usable Sensitivity (DSRR)	=	-103.30 dBm
GSM Base Station Output Power	=	50.00 dBm
DSRR (Wanted Signal) Frequency	=	934.925 MHz
Unwanted Signal	=	GSM With Eight Burst

GSM Frequency (MHz)	GSM Offset from DSRR (MHz)	Protection Ratios (dB) *1	Protection Ratios (dB) **2	DSRR Receiver Input Level (dBm) *1	DSRR Receiver Input Level (dBm) **2	Isolation Required between GSM/DSRR (dB) *1	Isolation Required between GSM/DSRR (dB) **2	Difference in dB for *1 & **2 (dB)
844.925***	90.000	−57.00	−58.80	−46.30	−44.50	96.30	94.50	1.8
909.925	−25.000	−66.80	−69.00	−36.50	−34.50	86.50	84.30	2.2
924.925	−10.000	−64.00	−66.20	−39.30	−37.10	89.30	87.10	2.2
929.925	−5.000	−63.40	−64.60	−39.90	−39.70	89.90	88.70	1.2
933.925	−1.000	−48.80	−50.00	−54.50	−53.30	104.50	103.30	1.2
934.425	−0.500	−38.00	−39.40	−65.30	−63.90	115.30	113.90	1.4
934.650	−0.275	−25.80	−27.90	−77.50	−75.40	127.50	125.40	2.1
934.675	−0.250	−20.40	−21.60	−82.90	−81.70	132.90	131.70	1.2
934.700	−0.225	−16.90	−18.00	−96.40	−85.30	136.40	135.30	1.1
934.725	−0.200	−16.60	−19.20	−86.70	−84.10	136.70	134.10	2.6
934.750	−0.175	−8.90	−11.70	−94.40	−91.60	144.40	141.60	2.8
934.775	−0.150	−1.70	−3.60	−101.60	−99.70	151.60	149.70	1.9
934.800	−0.125	1.70	0.20	−105.00	−103.50	155.00	153.50	1.5
934.825	−0.100	5.20	3.90	−109.50	−107.20	158.50	157.20	1.3
934.850	−0.075	8.90	7.90	−112.20	−111.20	162.20	161.20	1.0
934.875	−0.050	10.00	9.20	−113.30	−112.50	163.30	162.50	0.8
934.900	−0.025	14.20	13.30	−117.50	−116.60	167.50	166.60	0.9
934.925****	0.000	11.90	10.90	−115.20	−114.20	165.20	164.20	1.0
934.950	0.025	14.10	13.10	−117.40	−116.40	167.40	166.40	1.0
934.975	0.050	10.00	8.00	−113.30	−111.30	163.30	161.30	2.0
935.000	0.075	10.90	9.80	−114.20	−113.10	164.20	163.10	1.1
935.025	0.100	9.40	8.20	−112.70	−111.50	162.70	161.50	1.2
935.050	0.125	7.70	5.40	−111.00	−108.70	161.00	158.70	2.3
935.075	0.150	−2.20	−4.00	−101.10	−99.30	151.10	149.30	1.8
935.100	0.175	−14.20	−15.70	−89.10	−87.60	139.10	137.60	1.5
935.125	0.200	−17.40	−19.30	−85.90	−84.00	135.90	134.00	1.9
935.150	0.225	−18.10	−19.70	−85.20	−83.60	135.20	133.60	1.6
935.175	0.250	−19.50	−20.90	−83.80	−82.40	133.80	132.40	1.4
935.200	0.275	−23.90	−25.70	−79.40	−77.60	129.40	127.60	1.8
935.425	0.500	−25.70	−27.20	−77.60	−76.10	127.60	126.10	1.5
935.925	1.000	−44.30	−46.50	−59.00	−56.80	109.00	106.80	2.2
939.925	5.000	−57.50	−62.00	-45.80	−41.30	95.80	91.30	4.5
944.925	10.000	−60.50	−62.80	-42.80	−40.50	92.80	90.50	2.3
959.925	25.000	−63.50	−65.30	−39.80	−38.00	89.80	88.00	1.8
1024.925***	90.000	−63.20	−67.30	−40.10	−36.00	90.10	86.00	4.1

* Just Perceptible (CCIR Grade 4 Impairment)
** Very Annoying (CCIR Grade 1 Impairment)
*** Image Response Frequency
**** Co-channel Frequency

Note: The isolation required in dB between GSM & DSRR path is calculated using GSM base output power of +50 dBm (100 Watts).

Annex 2(b)

PROJECT No. 60
SUBJECTIVE LISTENING TEST RESULTS
TO EVALUATE THE INTERFERENCE POTENTIAL OF GSM TRANSMISSION ON DSRR SYSTEM

Maximum Usable Sensitivity (DSRR)	=	−102.40 dBm
GSM Base Station Output Power	=	50.00 dBm
DSRR (Wanted Signal) Freauencv	=	934.925 MHz
Unwanted Signal	=	GSM With Single Burst

GSM Frequency (MHz)	GSM Offset from DSRR (MHz)	Protection Ratios		DSRR Receiver Input Level		Isolation Required between GSM/DSRR		Difference in dB for *1 & **2 (dB)
		(dB) *1	(dB) **2	(dBm) *1	(dBm) **2	(dB) *1	(dB) **2	
844.925***	−90.000	−51.60	−55.30	−50.80	−47.10	100.80	97.10	3.7
909.925	−25.000	−50.40	−51.60	−52.00	−50.80	102.00	100.80	1.2
924.925	−10.000	−51.40	−53.20	−51.00	−49.20	101.00	99.20	1.8
929.925	−5.000	−51.40	−53.70	−51.00	−48.70	101.00	98.70	2.3
933.925	−1.000	−41.40	−44.50	−61.00	−57.90	111.00	107.90	3.1
934.425	−0.500	−34.40	−36.90	−68.00	−65.50	118.00	115.50	2.5
934.650	−0.275	−36.40	−39.40	−66.00	−63.00	116.00	113.00	3.0
934.675	−0.250	−30.80	−37.70	−71.60	−64.70	121.60	114.70	6.9
934.700	−0.225	−28.00	−35.20	−74.40	−67.20	124.40	117.20	7.2
934.725	−0.200	−29.00	−36.20	−73.40	−66.20	123.40	116.20	7.2
934.750	−0.175	−22.40	−31.40	−80.00	−71.00	130.00	121.00	9.0
934.775	−0.150	−12.40	−21.00	−90.00	−81.40	140.00	131.40	8.6
934.800	−0.125	−12.30	−20.30	−90.10	−82.10	140.10	132.10	8.0
934.825	−0.100	−0.50	−18.50	−101.90	−83.90	151.90	133.90	18.0
934.850	−0.075	1.30	−9.00	−103.70	−93.40	153.70	143.40	10.3
934.875	−0.050	4.70	−9.30	−107.10	−93.10	157.10	143.10	14.0
934.900	−0.025	7.50	−19.60	−109.90	−82.80	159.90	132.80	27.1
934.925****	0.000	7.00	−13.20	−109.40	−89.20	159.40	139.20	20.2
934.950	0.025	7.00	−13.20	−109.40	−89.20	159.40	139.20	20.2
934.975	0.050	8.10	−9.70	−110.50	−92.70	160.50	142.70	17.8
935.000	0.075	1.10	−23.80	−103.50	−78.60	153.50	128.60	24.9
935.025	0.100	3.70	−6.40	−106.10	−96.00	156.10	146.00	10.1
935.050	0.125	−9.60	−20.40	−92.80	−82.00	142.80	132.00	10.8
935.075	0.150	−14.40	−21.60	−88.00	−80.80	138.00	130.80	7.2
935.100	0.175	−24.80	−38.40	−77.60	−64.00	127.60	114.00	13.6
935.125	0.200	−30.90	−45.50	−71.50	−56.90	121.50	106.90	14.6
935.150	0.225	−30.60	−46.30	−71.80	−56.10	121.80	106.10	15.7
935.175	0.250	−29.80	−38.10	−72.60	−64.30	122.60	114.30	8.3
935.200	0.275	−37.70	−48.50	−64.70	−53.90	114.70	103.90	10.8
935.225	0.300	−35.50	−40.00	−66.90	−62.40	116.90	112.40	4.5
935.925	1.000	−40.10	−45.70	−62.30	−56.70	112.30	106.70	5.6
939.925	5.000	−47.70	−53.10	54.70	−49.30	104.70	99.30	5.4
944.925	10.000	−50.00	−54.60	−52.40	−47.80	102.40	97.80	4.6
959.925	25.000	−52.40	−55.70	−50.00	−46.70	100.00	96.70	3.3
1024.925***	90.000	−47.70	−50.30	54.70	−52.10	104.70	102.10	2.6

* Just Perceptible (CCIR Grade 4 Impairment)
** Very Annoying (CCIR Grade 1 Impairment)
*** Image Response Frequency
**** Co-channel Frequency

Note: The isolation required in dB between GSM & DSRR path is calculated using GSM base output power of +50 dBm (100 Watts).

Annex 2(c)

PROJECT No. 60
SUBJECTIVE LISTENING TEST RESULTS
TO EVALUATE THE INTERFERENCE POTENTIAL OF GSM TRANSMISSION ON DSRR SYSTEM

Maximum Usable Sensitivity (DSRR)	=	−103.30 dBm
GSM Base Station Output Power	=	50.00 dBm
DSRR (Wanted Signal) Frequency	=	934.925 MHz
Unwanted Signal	=	CW

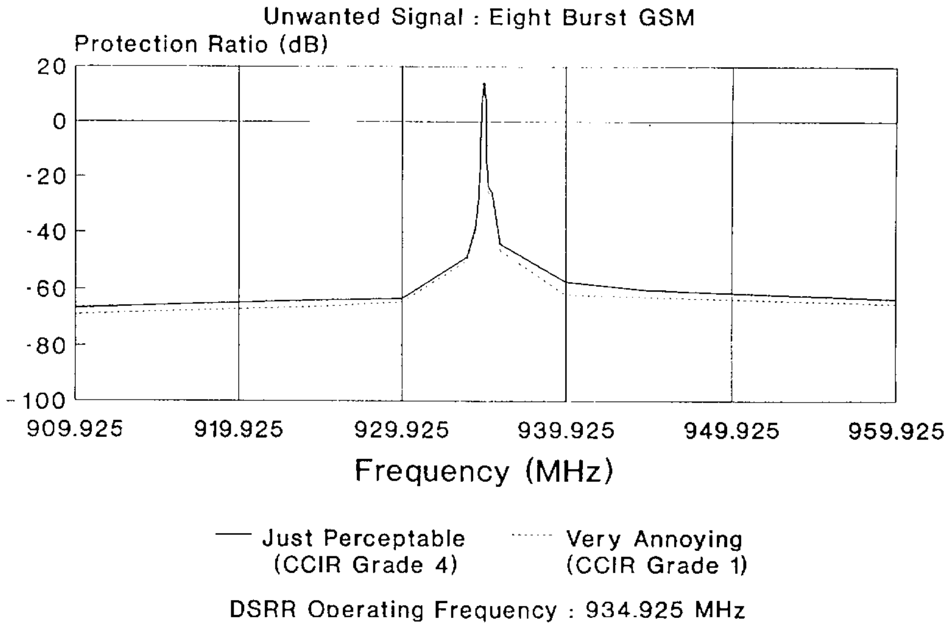
GSM Frequency (MHz)	GSM Offset from DSRR (MHz)	Protection Ratios (dB) *1	Protection Ratios (dB) **2	DSRR Receiver Input Level (dBm) *1	DSRR Receiver Input Level (dBm) **2	Isolation Required between GSM/DSRR (dB) *1	Isolation Required between GSM/DSRR (dB) **2	Difference in dB for *1 & **2 (dB)
844.925***	−90.000	−64.90	−67.90	−38.40	−35.40	88.40	85.40	3.0
909.925	−25.000	−78.00	−81.40	−25.30	−21.90	75.30	71.90	3.4
924.925	−10.000	−79.60	−81.40	−23.70	−21.90	73.70	71.90	1.8
929.925	−5.000	−76.40	−80.20	−26.90	−25.10	76.90	73.10	3.8
933.925	−1.000	−62.10	−64.20	−41.20	−39.10	91.20	89.10	2.1
934.425	−0.500	−53.40	−55.40	−49.90	−47.90	99.90	97.90	2.0
934.650	−0.275	−53.20	−55.20	−50.10	−48.10	100.10	98.10	2.0
934.675	−0.250	−53.40	−55.40	−49.90	−47.90	99.90	97.90	2.0
934.700	−0.225	−53.40	−55.40	−49.90	−47.90	99.90	97.90	2.0
934.725	−0.200	−53.40	−55.50	−49.90	−47.80	99.90	97.80	2.1
934.750	−0.175	−53.40	−55.50	−49.90	−47.80	99.90	97.80	2.1
934.775	−0.150	−53.40	−56.40	−49.90	−46.90	99.90	96.90	3.0
934.800	−0.125	−53.40	−55.50	−49.90	−47.80	99.90	97.80	2.1
934.825	−0.100	−53.40	−54.40	−49.90	−48.90	99.90	98.90	1.0
934.850	−0.075	−52.40	−56.40	−50.90	−46.90	100.90	96.90	4.0
934.875	−0.050	−52.40	−56.40	−50.90	−46.90	100.90	96.90	4.0
934.900	−0.025	−49.50	−52.40	−53.80	−50.90	103.80	100.90	2.9
934.925****	0.000	1.50	−7.70	−104.80	−95.60	154.80	145.60	9.2
934.950	0.025	−43.50	−45.90	−59.80	−57.40	109.80	107.40	2.4
934.975	0.050	−51.60	−55.60	−51.70	−47.70	101.70	97.70	4.0
935.000	0.075	−53.50	−56.60	−49.80	−46.70	99.80	96.70	3.1
935.025	0.100	−53.50	−56.60	−49.80	−46.70	99.80	96.70	3.1
935.050	0.125	−53.50	−56.60	−49.80	−46.70	99.80	96.70	3.1
935.075	0.150	−52.50	−54.60	−50.80	−48.70	100.80	98.70	2.1
935.100	0.175	−52.50	−57.10	−50.80	−46.20	100.80	96.20	4.6
935.125	0.200	−52.50	−57.00	−50.80	−46.30	100.80	96.30	4.5
935.150	0.225	−52.50	−57.00	−50.80	−46.30	100.80	96.30	4.5
935.175	0.250	−52.50	−57.00	−50.80	−46.30	100.80	96.30	4.5
935.200	0.275	−56.30	−59.30	−47.00	−44.00	97.00	94.00	3.0
935.225	0.300	−57.30	−60.20	−46.00	−43.10	96.00	93.10	2.9
935.925	1.000	−60.50	−64.40	−42.80	−38.90	92.80	88.90	3.9
939.925	5.000	−74.90	−80.00	−28.40	−23.30	78.40	73.30	5.1
944.925	10.000	−76.70	−81.00	−26.60	−22.30	76.60	72.30	4.3
959.925	25.000	−76.80	−79.70	−26.50	−23.60	76.50	73.60	2.9
1024.925***	90.000	−63.30	−66.30	−40.00	−37.00	90.00	87.00	3.0

* Just Perceptible (CCIR Grade 4 Impairment)
** Very Annoying (CCIR Grade 1 Impairment)
*** Image Response Frequency
**** Co-channel Frequency

Note: The isolation required in dB between GSM & DSRR path is calculated using GSM base output power of +50 dBm (100 Watts).

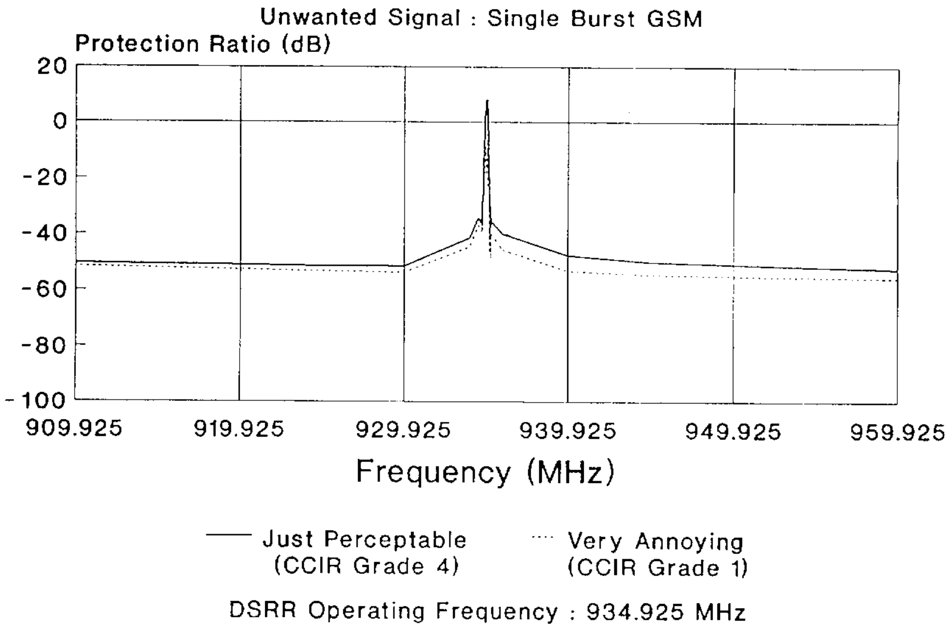
Annex 3(a)

SUBJECTIVE LISTENING TEST RESULTS
PROTECTION RATIOS



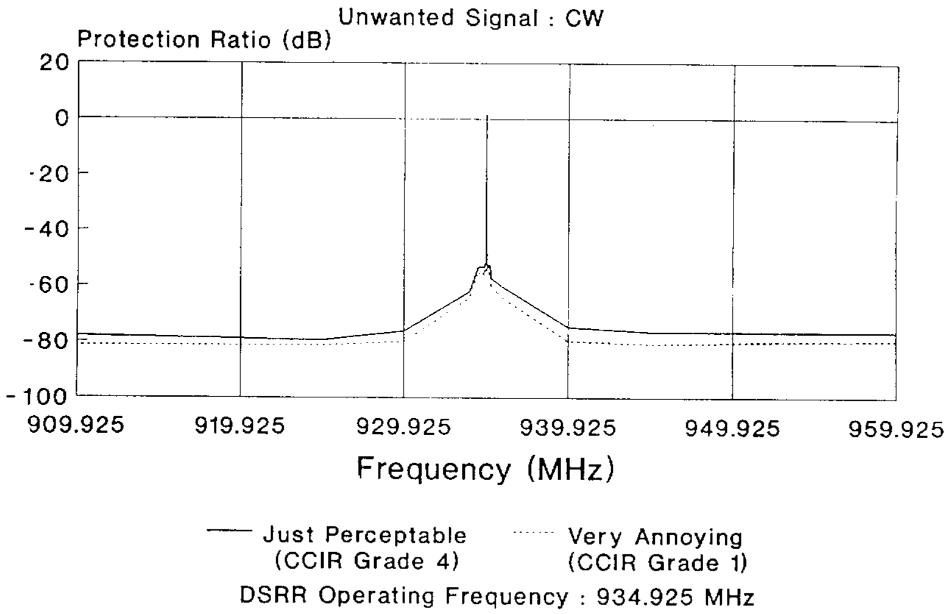
Annex 3(b)

SUBJECTIVE LISTENING TEST RESULTS
PROTECTION RATIOS



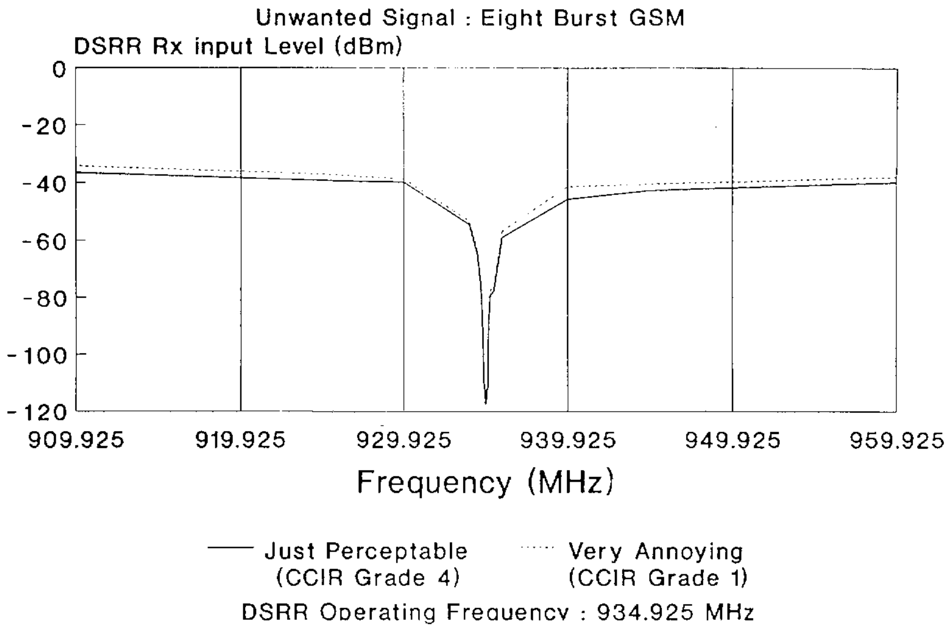
Annex 3(c)

SUBJECTIVE LISTENING TEST RESULTS
PROTECTION RATIOS



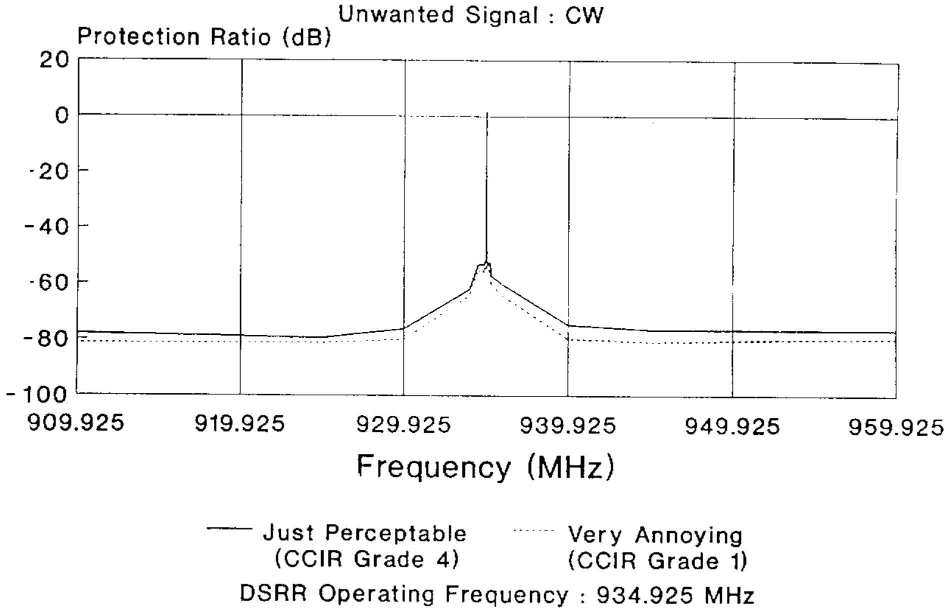
Annex 3(d)

SUBJECTIVE LISTENING TEST RESULTS
INTERFERING SIGNAL LEVEL AT DSRR Rx I/P



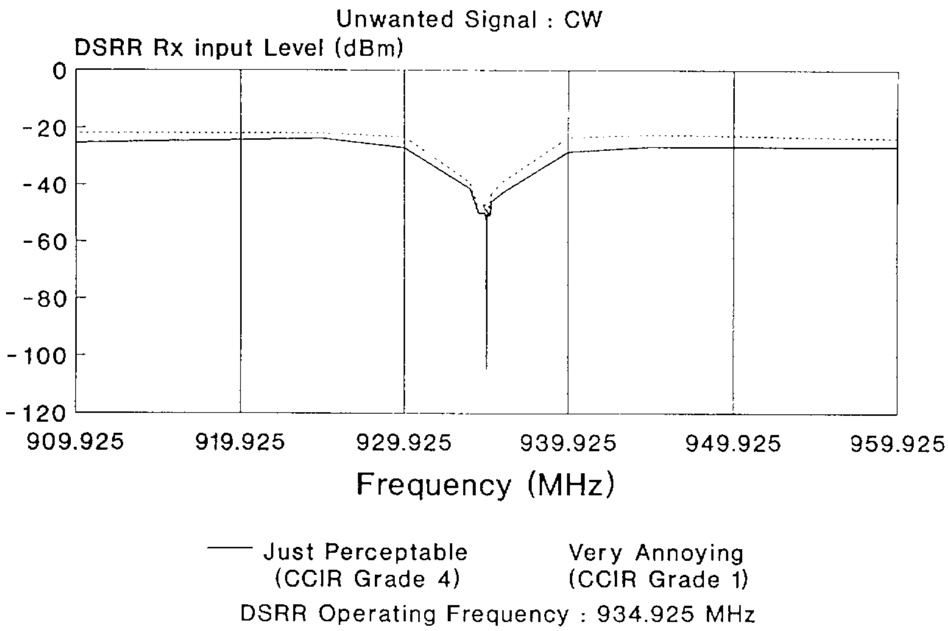
Annex 3(c)

SUBJECTIVE LISTENING TEST RESULTS
PROTECTION RATIOS



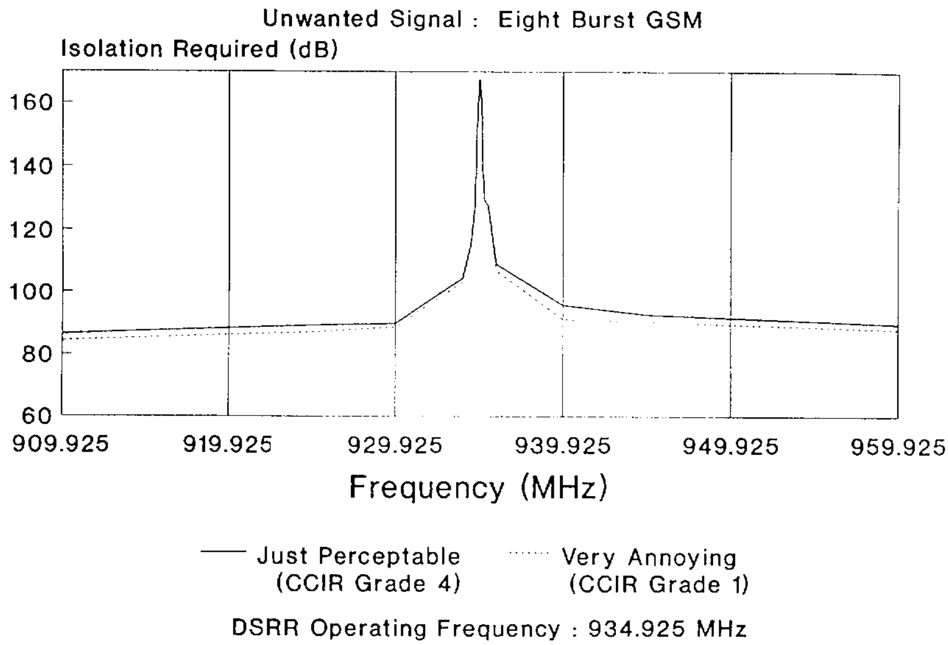
Annex 3(f)

SUBJECTIVE LISTENING TEST RESULTS
INTERFERING SIGNAL LEVEL AT DSRR Rx I/P



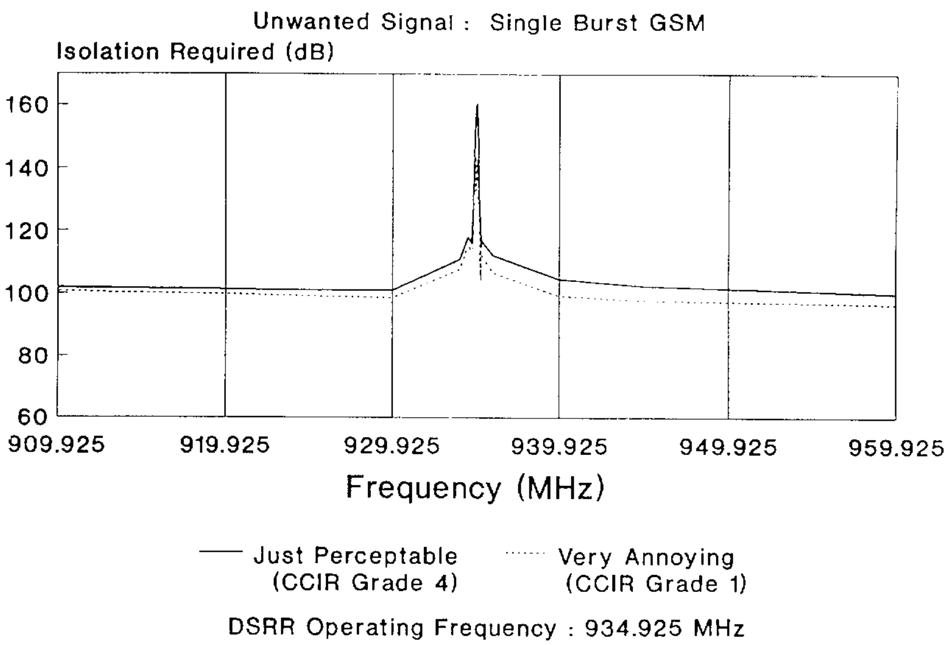
Annex 3(g)

SUBJECTIVE LISTENING TEST RESULTS
ISOLATION REQUIRED FROM 100 Watts GSM Tx



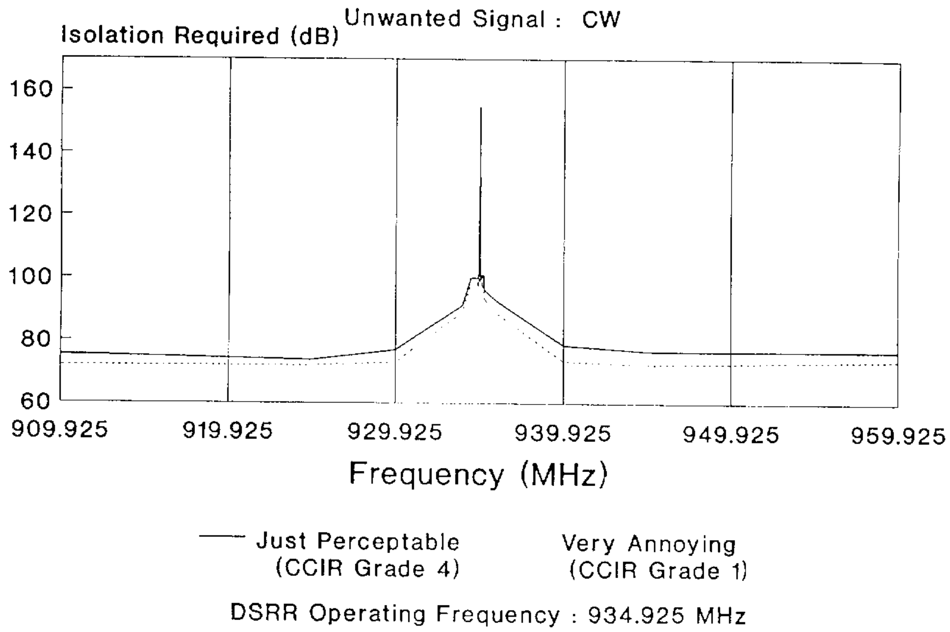
Annex 3(h)

SUBJECTIVE LISTENING TEST RESULTS
ISOLATION REQUIRED FROM 100 Watts GSM Tx



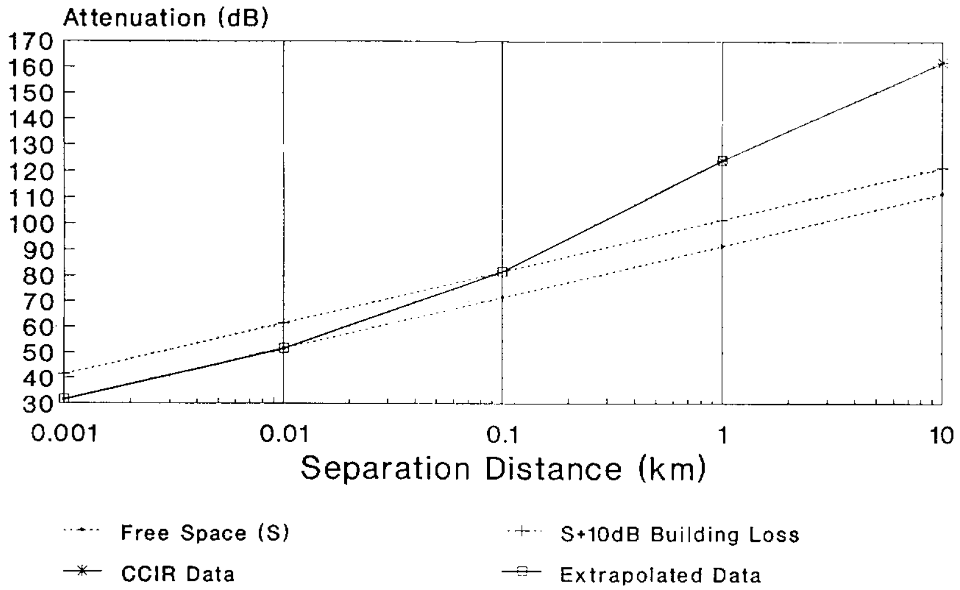
Annex 3(i)

SUBJECTIVE LISTENING TEST RESULTS
ISOLATION REQUIRED FROM 100 Watts GSM Tx



Annex 4

PATH LOSS (Iso.-Iso.) EXTRAPOLATED FROM FREE SPACE AND CCIR DATA (Rep. 567-4)



CCIR data: 900 MHz, urban area, 50% time, 50% locations
h1 = 30 metres, h2 = 1.5 metres

Annex 5(a)

DSRR Interference Scenarios Considered

Interference from GSM Base Stations	**Worse Case**	**Typical**
GSM/DSRR frequency difference	= 250 kHz	= 10 MHz
Number of time slots occupied per frame	= 8	= ?
DSRR protection required for above conditions	= − 20 dB	= − 55 dB
DSRR received signal level	= − 107 dBm	= − 90 dBm
Maximum GSM signal at DSRR	= − 87 dBm	= − 35 dBm
GSM Base e.r.p.	= + 55 dBm	= + 50 dBm
Isolation required	+ 142 dBm	+ 85 dB
This equates to an interference range of	2,800 m	110 m

Interference from GSM Mobile Stations	**Worse Case**	**Typical**
GSM/DSRR frequency difference	= 250 kHz	= 10 MHz
Number of time slots occupied per frame	= 1	= 1
DSRR protection required for above conditions	= − 20 dB	= − 51 dB
DSRR received signal level	= − 107 dBm	= − 90 dBm
Maximum GSM signal at DSRR	= − 87 dBm	= − 39 dBm
GSM Mobile e.r.p.	= + 43 dBm	= + 37 dBm
Isolation required	+ 130 dBm	+ 76 dB
This equates to an interference range of	1,500 m	60 m

GSM Base Stations affect DSRR Mobile Station (unit) and single frequency Base Station (master unit) receivers.
GSM Mobile Stations affect DSRR Base Station (master unit) and Repeater receivers.

Annex 5(b)

DSRR Interference Scenarios Considered

Interference from EGSM Base Stations	Worse Case	Typical
EGSM/DSRR frequency difference	= 0 kHz	= 10 MHz
Number of time slots occupied per frame	= 8	= ?
DSRR protection required for above conditions	= + 12 dB	= − 55 dB
DSRR received signal level	= − 107 dBm	= − 90 dBm
Maximum EGSM signal at DSRR	= − 119 dBm	= − 35 dBm
EGSM Base e.r.p.	= + 55 dBm	= + 50 dBm
Isolation required	+ 174 dBm	+ 85 dB
This equates to an interference range of	30,000 m	110 m

Interference from EGSM Mobile Stations	Worse Case	Typical
EGSM/DSRR frequency difference	= 0 kHz	= 10 MHz
Number of time slots occupied per frame	= 1	= 1
DSRR protection required for above conditions	= + 7 dB	= − 51 dB
DSRR received signal level	= − 107 dBm	= − 90 dBm
Maximum EGSM signal at DSRR	= − 114 dBm	= − 39 dBm
EGSM Mobile e.r.p.	= + 43 dBm	= + 37 dBm
Isolation Required	+ 157 dBm	+ 76 dB
This equates to an interference range of	7,000 m	60 m

GSM Base Stations affect DSRR Mobile Station (unit) and single frequency Base Station (master unit) receivers.
GSM Mobile Stations affect DSRR Base Station (master unit) and Repeater receivers.