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Telecom Regulatory Authority of India

Consultation Paper

on

"Issues related to prescribing Minimum Channel Spacing, within a License Service Area, in FM Radio Sector in India"

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Preface

Government has issued consolidated policy guidelines on the expansion of FM radio broadcasting through private agencies for phase III on 25th July 2011, which provides for 839 new private FM stations in 294 cities across the country. In the meanwhile, the industry has been demanding that more number of channels be put up for bidding, especially in A+ and A category cities, in order to provide better choice to the consumers, realistic bidding process, better business opportunities for the operators of the private FM channels and higher revenue to the Government through efficient use of the FM radio spectrum by reducing the minimum channel spacing.

Keeping in view the demand of the FM radio operators, the technological developments and viability of the FM operations in a city category, Ministry of Information and Broadcasting (MIB) has requested TRAI to reconsider the issue of reduction in minimum channel spacing and release of additional frequencies in A+ & A category cities.

In line with established practice, this consultation paper has attempted to bring out various issues and its implications to various stakeholders associated with reduction of minimum channel spacing within a license service area of FM radio broadcasting in India. All stakeholders are requested to benefit the Authority with their valuable comments by 26th December, 2011. Counter comments, if any, on the comments received may be sent by 2nd January, 2012. The full text of the consultation paper is available on TRAI website – www.trai.gov.in.

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Introduction

i. Radio broadcasting has been the main medium for entertainment, information and education amongst the masses in India largely owing to its wide coverage, terminal portability, low setup costs and affordability. Presently, radio coverage is available in Short Wave (SW), Medium Wave (MW) and Frequency Modulation (FM) in analogue mode. The All India Radio (AIR), the public broadcaster, has a the network comprising of 237 stations & 380 transmitters (149 MW, 54 SW & 177 FM), which provide radio coverage to 99.14 % of the population and reaches 91.79 % area of the country. However, the FM coverage of AIR transmitters is only 37% of the territory of India. In the digital radio transmission AIR is running a test transmission based on DRM (Digital Radio Mondiale)[1] technology since 2009, and during the 12th Five year plan AIR plans to commission DRM stations in 76 MW and 10 SW frequencies.

ii. The policy objective of the Government for Radio in the 9th Five year plan was to improve the variety of content and technical quality of Radio. On the technology front the focus shifted from amplitude modulated (AM Radio) transmissions to frequency modulated (FM) transmissions (FM Radio)[2] as the latter has much better noise handling capability. Keeping in line with the policy of liberalization and reforms followed by the Government since 1991, the Government during the 9th Five year plan allowed Indian companies to setup private FM Radio stations and in May 2000, the Government auctioned 108 frequencies in the FM spectrum across 40 cities as part of the First phase of FM Radio expansion through private participation in India.

[1] DRM : Digital Radio Mondiale (DRM) is the universal, open standard digital broadcasting system for all broadcasting frequencies up to 174MHz, including LW, MW, SW, band I and II (FM band).

[2] Modulation is a process through which the original information (known as modulating signal which may carry Audio, video or data information) is translated on to another signal, called carrier signal, which is better equipped to handle channel aberrations and easy for reception through a suitably sized antenna. In case of Amplitude Modulation (AM) the amplitude of the carrier signal varies according to the modulating signal whereas in Frequency Modulation(FM) the frequency of the carrier signal varies and carries the intelligence of the modulating signal. At the receiver, the demodulation process retrieves back the original information from the carrier signal.

iii. The results of the first phase of private FM radio expansion were not very encouraging as only about 25% of the expected licenses could become operational. Government received bids for 101 frequencies in Phase-I, out of which bidder paid money for only 37 frequencies, i.e. bidders in respect of 64 frequencies defaulted. Out of these 37 permissions, only 22 channels became operational, of which one channel closed down subsequently.

iv. The subsequent second phase of private FM Radio expansion has been well received by all the stakeholders. The scheme to rope in private broadcasters for FM radio has significantly contributed to the enhancement of the FM radio coverage and provision of good quality of reception to radio listeners. It has also encouraged local talent and generated employment opportunities in various cities. Employment opportunities in this sector are thus no longer confined to Metros and handful of Class 'A' cities, but are also becoming available in other smaller cities. Private FM Radio services have made rapid strides in the recent past, particularly since the launching of Phase-II. The cities with a population of three lakh and above besides the state capitals were taken up in the first two phases. The policy has been well received and presently, a total of 245 channels are operational, including 21 channels of Phase-I, in 86 cities.

v. With a view to further expand the spread of FM services to other cities particularly in J&K, North Eastern States and island territories and to address certain other issues, Government , on 25th July 2011, issued consolidated policy guidelines on phase III of expansion of FM radio broadcasting through private agencies. The Phase-III is intended to extend FM radio's reach to 294 cities with additional 839 FM radio stations. It will also help boost the regional growth of radio stations. It is expected that post Phase III, the FM radio will cover around 85% of the country.

vi. The Ministry of Information and Broadcasting, vide DO No. 102/2/2008-FM(Vol. IV) dated 8th Aug. 2011, has made a reference to TRAI for its recommendation concerning the issue of minimum channel spacing in the category A+ and A cities. The reference encloses inputs from some of the existing FM operators, proposing a reduction in the minimum channel spacing from existing 800 KHz to 400 KHz in the category A+ and A cities so as to enable more number of channels in such cities.

vii. Issues related with keeping a minimum channel spacing within a license service area were analyzed in TRAI's earlier recommendations on FM Radio. The main reasons for keeping 800 KHz as the channel spacing were design limitation of existing combiners, limitation of the capability to separate out closely spaced channels of large number of consumer receivers, and the unlikely requirement of large number of frequencies in the C and D category cities (majority of cities in phase III), where FM coverage was just taking roots.

viii. While seeking reduction in the minimum channel spacing, the FM operators have proposed two alternatives to tackle the port to port isolation issue of the combiners deployed at the transmitters: a) Existing combiners should be replaced with other combiners that can handle more FM channels while maintaining the required isolation. b) New common transmission infrastructure (CTI) could be developed with existing type of combiners with cost shared by the new broadcasters. On the issue of the capability of consumers' radio receivers to faithfully separate out closely spaced FM radio stations, these operators, in support of their demand for more channels in A and A+ cities, have argued that large majority of receivers with the consumers in such cities are mobile receiver/car receiver sets which are capable to operate satisfactorily even with channel spacing of 200KHz.

ix. In the consultation paper, an effort has been made to discuss all the relevant issues concerning the minimum channel spacing within a license service area for the FM radio sector in India. The first chapter of this paper details the position of channel spacing and related issues in the international market of FM sector. The second chapter discusses the techno-commercial factors that have a bearing on deciding the value of minimum channel spacing within a license service area and puts forth the consultation issues for comments of the stakeholders. The third chapter lists the issues posed for consultation.

Chapter I : International Scenario

1.1 This chapter discusses the issue of channel spacing & the related issue in some of the major international markets.

1.2 With regard to the minimum usable field strength, the ITU specifications (ITU-R BS.412-9) prescribe that in the presence of interference from industrial and domestic equipment a satisfactory service requires a median field strength (measured at 10 m above ground level) not lower than those given in Table 1.1:

Areas	Services	
	Monophonic dB(μV/m)	Stereophonic dB(μV/m)
Rural	48	54
Urban	60	66
Large cities	70	74

TABLE 1.1

In the absence of interference from industrial and domestic equipment, the field strength values (measured at 10 m above ground level) given in Table 1.2 can be considered to give an acceptable monophonic or stereophonic service, respectively. These field strength values apply when an outdoor antenna is used for monophonic reception, or a directional antenna with appreciable gain for stereophonic reception (pilot-tone system, as defined in Recommendation ITU-R BS.450).

Services	
Monophonic dB(μV/m)	Stereophonic dB(μV/m)
34	48

TABLE 1.2

NOTE 1 – The figures of Table 1.2 are not median values and, consequently, they are not directly comparable with those given in Table 1.1

In a practical plan, because of interferences from other sound broadcasting transmissions, the field strength values that can be protected will generally be higher than those of Table 1.1. Moreover, in the case of the boundary area between any two countries, the exact values to be used should be agreed between the administrations concerned.

1.3 With regard to the channel spacing, the ITU specifications (ITU-R BS.412-9) prescribe that in frequency planning, channels are to be assigned in such a way that: a) the carrier frequencies which define the nominal placement of the RF channels within the band are integral multiples of 100KHz; b) a uniform channel spacing of 100 KHz applies for both monophonic and stereophonic transmissions. In those cases where a 100 KHz channel spacing would be difficult to implement, the use of a spacing which is an integral multiple of 100 KHz would be acceptable, provided that the carrier frequencies are chosen in accordance with 'a' above. In many countries, including India, England, South Africa, Turkey, Sweden, Germany, France, Italy , Japan etc., the channel spacing used is 100 KHz whereas in many other countries it is kept as 200 KHz, which includes USA, Australia, Korea, Columbia etc. while Singapore has kept it as 300 KHz.

1.4 The channel spacing referred above in para 1.3, relates to the frequency assignment to the FM radio channels in the overall frequency planning of the FM band (generally 88-108 MHz) and not specific to any particular area of operation. However, the issue under consideration is minimum channel spacing between the FM Radio Stations, operational in a particular geographical area i.e. within a license area. In India, currently the channel spacing deployed is 100 KHz for the overall network planning whereas the minimum channel spacing specified for a particular license area is 700/800 kHz.

United States of America (USA)

1.5 In USA, the FM band of 88-108 MHz is divided into 100 Channels with a channel spacing of 200 KHz. Originally, the FCC devised a band-plan in which FM radio stations were assigned with channel spacing of four channels (800 kHz separation) for any one geographic area. Thus, in one area, stations might be at 88.1, 88.9, 89.7, etc., while in an adjacent area, stations might be at 88.3, 89.1, 89.9, 90.7 etc. In the late 1980s, the FCC switched to a band-plan based on a distance separation table using currently operating stations. As of late 2004, a station can be "squeezed in" anywhere as long as the location and class conform to the rules in the FCC separation table. Depending upon the transmitter powers and antenna heights, eight different classes of FM stations, viz. A, B1, B, C3, C2, C1, C0 and C, have been made. The minimum effective radiated power (ERP)[3] varies from 6 KW to 100 KW. The permissible height varies between 100 to 600 meters. Rule 73.211 of FCC Code of Federal Regulation mentions about minimum and maximum ERP for each class of FM station (Table 1.3). For example class C1 can have ERP in range of 50-100 KW with HAAT[4] in the range of 150 to 299 meters. The FM channel can be assigned a frequency out of the 100 channels and depending upon the transmitter power, height of antenna etc. these channel frequencies could be re-used at different geographical locations.

FM Station Class	Reference(Maximum) facilities for station class ERP(in KW) / HAAT (in meters)	FM Protected or Primary Service Contour		Distance to Protected or Primary Service Contour (km)
		dBu	mV/ m	
CLASS A	6.0 KW/ 100 meters	60 dBµ	1 mV/ m	28.3 km
CLASS B1	25.0 KW/ 100 meters	57 dBµ	0.71 mV/ m	44.7 km
CLASS B	50.0 KW/ 150 meters	54 dBµ	0.50 mV/ m	65.1 km
CLASS C3	25.0 KW/ 100 meters	60 dBµ	1 mV/ m	39.1 km
CLASS C2	50.0 KW/ 150 meters	60 dBµ	1 mV/ m	52.2 km
CLASS C1	100.0 KW/ 299 meters	60 dBµ	1 mV/ m	72.3 km
CLASS C0	100.0 KW/ 450 meters	60 dBµ	1 mV/ m	83.4 km
CLASS C	100.0 KW/ 600 meters	60 dBµ	1 mV/ m	91.8 km

Table 1.3: Minimum and maximum ERP for each class of FM station (Rule 73.211 of FCC Code of Federal Regulation)

[3] ERP : The ERP is the product of the transmitter output power, the transmission line (and combiner) efficiency and the power gain of the antenna relative to a half-wave dipole.

[4] The HAAT/EHAAT : The effective height of the antenna above average terrain (EHAAT) is the average of the antenna heights above the average terrain (HAATs) for eight radials spaced every 45 degrees of azimuth starting with true north. The height of the antenna above average terrain (HAAT) is the height of the centre of radiation of the antenna above the average elevation of the terrain between 3 to 16 km from the antenna for each radial.

1.6 The FCC uses certain criteria to determine an FM radio station's service areas and interference potential by using field strength measurements at certain distances. Field Strength can be measured in either micro-volts per meter (μV/m) or in decibels unterminated (dBu). The higher the decibel number, the stronger the signal. If the sum of the sizes of the service contour[5] and interference contour[6] exceed the distance between the two stations, then the coverage area of the two transmitters overlap and there is a potential for interference. The Table 'A' (reproduced below as Table 1.4) as prescribed by FCC under section 73.207 of the FCC code, depicts the relation between channel spacing and the minimum distance between any two FM transmitters.

Relation	Co-Channel (Same Frequency)	200 KHz (First-Adjacent Channel)	400 or 600 KHz (Second- or Third-Adjacent Channel)	10.6 or 10.8 MHz (I.F. Channel)
A to A	115	72	31	10
A to B1	143	96	48	12
A to B	178	113	69	15
A to C3	142	89	42	12
A to C2	166	106	55	15
A to C1	200	133	75	22
A to C0	215	152	86	25
A to C	226	165	95	29
B1 to B1	175	114	50	14
B1 to B	211	145	71	17
B1 to C3	175	114	50	14
B1 to C2	200	134	56	17
B1 to C1	233	161	77	24

[5] **Service contour**-Also sometimes referred to as a protected contour indicates the primary service area of the station. This is the primary area that the FCC protects for FM stations. Most stations including low power FM (LPFM) are protected to a 60 dBu (1 μV/M) contour.

[6] **Interference contour-**This is a contour that a station has the potential to radiate to but is less likely but there is still a potential for interference. There are different interference contours for minimum channel (same channel), first adjacent, second adjacent and third adjacent channels with the minimum channel being the largest of the interference contours

B1 to C0	248	180	87	27
B1 to C	259	193	105	31
B to B	241	169	74	20
B to C3	211	145	71	17
B to C2	241	169	74	20
B to C1	270	195	79	27
B to C0	272	214	89	31
B to C	274	217	105	35
C3 to C3	153	99	43	14
C3 to C2	177	117	56	17
C3 to C1	211	144	76	24
C3 to C0	226	163	87	27
C3 to C	237	176	96	31
C2 to C2	190	130	58	20
C2 to C1	224	158	79	27
C2 to C0	239	176	89	31
C2 to C	249	188	105	35
C1 to C1	245	177	82	34
C1 to C0	259	196	94	37
C1 to C	270	209	105	41
C0 to C0	270	207	96	41
C0 to C	281	220	105	45
C to C	290	241	105	48

Table 1.4 : Minimum Distance Separation Requirements in Kilometers (FCC Regulation , Section 73.207)

1.7 It can be seen from the table above that as the channel spacing is reduced the separation between two transmitters needs to be kept more and vice-versa. For example, if a transmitter of category A is to be installed in the vicinity of another transmitter of category say C1, then the transmitter A cannot be placed closer than 75 Kms if the channel separation is 400 to 600 KHz. As the channel separation is reduced to 200 KHz than it cannot be placed closer than 133 Kms and if the transmitter A is operating at the same frequency as that of C1 then transmitter A can only be placed beyond 200 Kms from the location of transmitter C1. Further, for a particular channel spacing, with the increase in the power ratings of the transmitters, the requirement of minimum distance between the transmitters also increases. A list of FM radio stations operating in the city of New York is placed at Annexure III.

New Zealand

1.8 VHF-FM broadcasting usage in New Zealand is based on a minimum frequency separation of 800 KHz between licensees at the co-located transmitting sites. This has been kept so recognizing the typical quality of receivers in use, and the efficient practice of multiplexing transmitters to a common antenna.

Australia

1.9 As per the "technical planning parameters and methods for terrestrial broadcasting" specified by Australian Broadcasting Authority, the following overlap rules vis-a-vis the specified frequency differences apply:

800 KHz -	may be used to serve the same service area;
600 KHz -	may have partially overlapping service areas;
400 KHz -	may not have overlapping service areas, except if they carry identical programs when a small overlap may be permissible;
200 KHz, 0 KHz -	will not be assigned to the same or adjacent service areas

1.10 The channels are spaced every 200 KHz between 88-108 MHz starting at 88.1, 88.3……….107.7, 107.9 MHz. Where necessary, to optimize channel allotments, a frequency offset may be used. The Stations are not assigned frequencies separated by less than 400 KHz unless the necessary protection ratios are met.

1.11 There is no specific maximum value of ERP designated for FM transmitters. The required value will depend upon the size of the service area, the effective height of the transmitting antenna and the field strength required to provide adequate reception throughout the service area, but interference to other services may limit the permissible ERP and the maximum height of the antenna. Multiple transmitters may be necessary if the service area cannot be covered from a single transmitter.

Japan

1.12 The minimum channel separation in Japan is 800 KHz for co-sited FM transmitters.

Singapore

1.13 In Singapore, all FM broadcasts are carried out on a nationwide basis. The channel spacing's typical range is 400 KHz to 800 KHz.

Canada

1.14 In North-America, the channel spacing in the FM sound broadcasting band (88-108 MHz) is 200 kHz and stations are assigned on "odd" frequencies such as 88.1 MHz, 88.3 MHz, 88.5 MHz, etc. The initial planning of the FM band was based on the assignment of the every 4th, 5th or 6th adjacent channels in the same market (i.e. channels assigned frequencies with channel separation of 200x4, 200x5 and 200x6 KHz) depending on other FM assignment frequencies in adjacent geographical areas. Depending upon the ERP and associated EHAAT values, different FM classes[7] have been defined. Factored upon the channel separation, the table below depicts the minimum distance between the FM transmitters of varying transmitting powers.

Class A1	**Co-channel**	78					
	200 kHz	45					
	400 kHz	22					
Class A	**Co-channel**	131	151				
	200 kHz	78	97				

[7] FM Classes:
Class A1: a maximum ERP or 250 W with an EHAAT of 100 metres.
Class A: a maximum ERP or 6 KW with an EHAAT of 100 metres.
Class B1: a maximum ERP or 25 KW with an EHAAT of 100 metres.
Class B: a maximum ERP or 50 KW with an EHAAT of 150 metres.
Class C1: a maximum ERP or 100 KW with an EHAAT of 300 metres.
Class C: a maximum ERP or 100 KW with an EHAAT of 600 metres.

	400 kHz	42	47				
Class B1	**Co-channel**	164	184	197			
	200 kHz	98	118	131			
	400 kHz	55	60	63			
Class B	**Co-channel**	189	209	222	236		
	200 kHz	117	137	150	164		
	400 kHz	68	73	77	84		
Class C1	**Co-channel**	223	243	256	270	291	
	200 kHz	148	168	181	195	216	
	400 kHz	90	95	99	106	119	
Class C	**Co-channel**	238	258	271	285	306	317
	200 kHz	166	186	199	213	234	245
	400 kHz	101	106	110	117	131	139
	Relationship	**Class A1**	**Class A**	**Class B1**	**Class B**	**Class C1**	**Class C**

Table 1.5 : Table of Minimum Domestic Separation Distances (km)

1.15 Due to extreme congestion, recently (w.e.f. June 2010), in certain markets, Industry Canada[8] started to assign stations on the 3rd adjacent channels i.e. having channel spacing of 600 KHz for the co-located transmitters (with similar powers) with no adverse effect on the receivers. Industry Canada also introduced some flexibility regarding the use of 600 and 800 KHz channel spacing in non-co-located situations. As per the Canadian technical regulations on FM broadcasting (Part 3 of Application Procedures and Rules for FM Broadcasting Undertakings (BPR-3)), FM stations separated by 600 or 800 kHz and operating in the same area may interfere with each other if not co-sited and therefore co-siting[9] is strongly recommended if possible. For co-sited proposals, there are no interference remedying responsibilities; however, the ERP shall not exceed the ERP of the incumbent station by more than 20 dB in any direction. Further, for the new station not co-sited with the incumbent station, the regulations also provide the criteria for interference complaints and the remedying responsibilities (such as receiver replacement, receiver filter, change of site, co-siting with the incumbent etc.) of the new FM station.

[8] Department of Industry who sets the technical standards and specifications for FM services in Canada.

[9] co-siting is defined by the regulations, in this context, as new transmitter being located within 100 m of an incumbent station

United Kingdom[10]

1.16 In the United Kingdom, there are quite a few instances where FM channels are functioning at a spacing of 400 KHz. The Ofcom generally permits co-located transmitters with 400 KHz carrier spacing under the condition that Ofcom technical criteria requirements are met for the protection ratios[11]. The protection ratio as defined by the Ofcom for 400 KHz carrier spacing is -20 dB. In planning the services, Ofcom may or may not take in account the extra protection margin achieved by other factors such as antenna directivity[12] and cross-polarization discrimination[13] and these are dealt on a case by case basis. List of FM radio stations operating in London are placed at Annexure IV.

[10] New Zealand Ministry of Economic Development- report on Radio Spectrum Management 400 KHz channelling Plan for FM Radio, 2007

[11] The Radio-Frequency (RF) protection ratio is the minimum value of wanted-to-unwanted signal ratio, usually expressed in decibels at the receiver input, determined under specified conditions such that a specific reception quality is achieved at the receiver output.

[12] An antenna's directivity is a component of gain of an antenna; (the other component is its efficiency). It measures the power density the antenna radiates in the direction of its strongest emission, versus the power density radiated by an ideal isotropic radiator (which emits uniformly in all directions) radiating the same total power. It is an important measure because most emissions are intended to go in a particular direction or at least in a particular plane (horizontal or vertical); emissions in other directions or planes are wasteful.

[13] Cross-Polarization Discrimination (XPD) is the ratio between the energy received in the wanted (transmitted) polarization to that received in the unwanted (orthogonal) polarization. The XPD of an antenna for a given direction is the difference in dB between the peak co-polarized gain of the antenna and the cross-polarized gain of the antenna in the given direction.

Chapter II: Minimum Channel spacing-Issues and Implications

2.1 Government has, on 25th July 2011, issued consolidated policy guidelines on expansion of FM radio broadcasting through private agencies for phase III. The policy for the phase III provides for 9 to 11 channels in A+ cities and 6 channels in class A cities, except for Bangalore and Hyderabad where 8 channels are provided. For B and C category cities, 4 channels are provided and for category D cities (and cities with population less than one lakh) 3 channels are provided. Apart from the minimum channel separation (i.e. the channel spacing between adjacent channels within a city) the other factor that has been considered for determining the number of channel in a city is the viability of FM radio channels in a particular city depending upon its revenue potential for that city category.

2.2 In their representations to the Ministry of Information & Broadcasting, the FM operators have demanded reduction in the minimum channel spacing within a license area and release of more frequencies, specially, for A+ and A category cities. The operators have mentioned that since 2008, when TRAI made its recommendations to the Government to keep 800 KHz as the minimum channel spacing, significant technological developments have taken place making possible the release of additional frequencies for FM radio operations and thereby have the potential of generating additional revenue for the Government by efficient utilization of the earmarked spectrum for FM Radio operations. It has also been said that increased availability of frequencies would lead to rational bidding and would also help in providing a greater variety of music and other programmes to listeners thereby leading to enhanced growth of the radio sector.

2.3 Citing the example of New York, London etc. where 50-75 FM channels are operational, the operators are demanding that in India the channel spacing should be reduced and more frequencies should be allocated in a license area so that consumers have more choice of channels and the service providers have better business opportunities.

2.4 In their reference dated 8th Aug 2011 (Annexure I), the Ministry of Information & Broadcasting have stated that in India, except for the A+ category cities, it may be possible to release some additional frequencies even without reducing the minimum separation between the channel frequencies, but in A+ cities release of additional frequencies may not be possible unless the minimum separation between the channel frequencies in not reduced from the present level of 800 KHz.

2.5 FM Radio is an important medium of communications that is capable of becoming a change agent in the Indian Society in general and more particularly in the semi-urban and rural areas. Employment opportunities are said to have been created specifically in the areas of local content provision to feed the fast growing FM Radio Services. As far as the demand/viability is concerned, the operators, in their representation, have stated that even in the C and D category towns, there should be atleast 6 channels available-this would lead to 2-3 contemporary music channels, 1-2 retro music channels and 1-2 regional music channels. They have further stated that at a later point in time, the Government may want to reassess the demand situation and launch more frequencies at that time whereas in the larger towns, there is a big demand for radio spectrum and the proposal to reduce the channel separation should be considered seriously for these towns initially.

2.6 The issue of a suitable minimum frequency separation between channels, as contained in the reference of the Ministry of Information & Broadcasting in this regard to TRAI, has been analyzed and the issues that arise have been discussed in the subsequent paragraphs.

2.7 The FM radio transmission service is analogue in nature. Thus each FM radio channel, operating at a specified frequency, requires a separate transmitter. However, if these transmitters are co-located then the output of these transmitters can be clubbed through a combiner and fed to a single transmitting antenna system. Irrespective of whether the individual transmitters are co-located or not, the channels so radiated from these transmitters can be received, within the coverage area, by the FM radio receiver sets of the listeners. A listener's FM receiver set separates out the individual channels through frequency tuning to the specified channel frequency.

2.8 The channel spacing i.e. the frequency separation between the adjacent channels' carrier frequencies is an important parameter which determines its faithful reception through the listener's FM receiver set. In a given area, if the channel spacing between the channels being operated is too low, it causes interference and affects adversely the reception of channels. If it is too large, it limits the number of channels that can be operated in the given area. Thus, these two aspects are required to be balanced out in favour of optimum utilization of the radio spectrum without affecting the faithful reception of the channels.

2.9 There is a limit beyond which channel spacing cannot be reduced. There are several factors that limit the minimum channel spacing for effective transmission/reception. The major factors are described below:

i. At the transmitter end:

The ability of the combiner to combine two (or more) channels without causing interference to any of the individual channels. The relevant combiner characteristics are frequency response[14], insertion loss[15], group delay[16], port-to-port isolation[17] etc.

ii. At the receiver end:

The ability of the consumer's receiver set to separate out an individual channel from received signal(s) consisting of several channels from one or more transmitters.

iii. Location of the Transmitters (i.e. whether co-located or located at a distance apart) :

In case of co-located transmitters i.e. the transmitters of all the broadcasters of a particular city are located at the same site sharing the same tower and antenna, then the propagation path for all the channels is same and they attenuate similarly making it possible to maintain nearly constant wanted to unwanted signal ratio in the service area thus avoiding creation of interference zone around individual towers which may so happen in case the transmitting sites are at different location. Thus, co-location of transmitters allows lesser minimum channel spacing as compared to the case when the transmitters are placed at different locations.

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[14] Frequency response:A graph with signal amplitude or gain plotted against frequency

[15] Insertion Loss- The change in load power due to the insertion of a particular device into a transmission system. A well-designed power splitter will offer high isolation, low insertion loss and good VSWR.

[16] Group delay is a measure of phase distortion. Group delay is the actual transit time of a signal through a device under test as a function of frequency. When specifying group delay, it is important to specify the aperture used for the measurement.

[17] Isolation-A unit of measure (in dB) that states the separation of signal levels on adjacent ports of a device. The greater the isolation value, lesser the interference from a signal on one port is present at the other port.

2.10 The Radio-Frequency (RF) protection ratio which is defined as the minimum value of wanted to unwanted signal ratio, usually expressed in dB at the receiver input, determined under specified conditions, so that a specific reception quality of the wanted signal is received. The RF Protection ratio is an important parameter to determine likelihood of interference in any particular area. Higher the carrier frequency spacing is, lower the RF protection ratio in an area is required for FM Broadcast. ITU has defined RF protection ratio in its specification BS.412.9 which is reproduced in table 1below:

Carrier frequency spacing (kHz)	Radio-frequency protection ratio (dB) using a maximum frequency deviation of ± 75 kHz			
	Monophonic		Stereophonic	
	Steady interference	Tropospheric interference	Steady interference	Tropospheric interference
0	36.0	28.0	45.0	37.0
25	31.0	27.0	51.0	43.0
50	24.0	22.0	51.0	43.0
75	16.0	16.0	45.0	37.0
100	12.0	12.0	33.0	25.0
125	9.5	9.5	24.5	18.0
150	8.0	8.0	18.0	14.0
175	7.0	7.0	11.0	10.0
200	6.0	6.0	7.0	7.0
225	4.5	4.5	4.5	4.5
250	2.0	2.0	2.0	2.0
275	–2.0	–2.0	–2.0	–2.0
300	–7.0	–7.0	–7.0	–7.0
325	–11.5	–11.5	–11.5	–11.5
350	–15.0	–15.0	–15.0	–15.0
375	–17.5	–17.5	–17.5	–17.5
400	–20.0	–20.0	–20.0	–20.0

Table 2.1: RF Protection Ratio as defined by ITU-R

2.11 The RF protection ratio values are given for steady and tropospheric interference[18] respectively. The protection ratio for steady interference provide approximately 50 dB

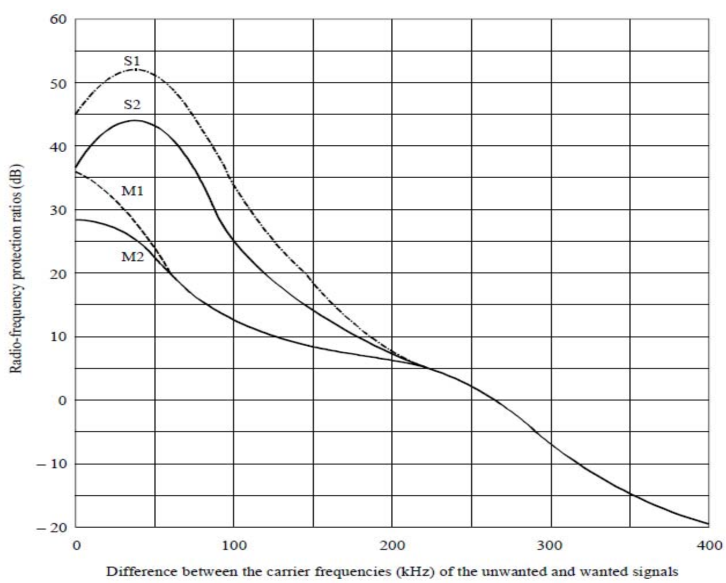
[18] Whether interference is steady or tropospheric is defined by ITU, through the concept of the 'nuisance field' wherein nuisance field is defined as the field strength of the interfering transmitter enlarged by the relevant protection ratio. The field strength of the nuisance field exceeding the normalized ERP (normalized to 1 KW) of the interfering transmitter by a margin of protection ratio, defined for steady interference, for more than 50% of times, is termed as the **nuisance field strength for the steady interference**. If the field strength of the nuisance field exceeds the normalized ERP (normalized to 1 KW) of the interfering transmitter by a margin of protection ratio, defined for tropospheric interference, only within 1 – 10% of times, it is termed as **nuisance field for the tropospheric interference**. However at the VHF/FM conference, Geneva 1984, times exceeding 1% was chosen for considering it as tropospheric interference. When the nuisance field for steady interference is higher than the nuisance field for the tropospheric interference, curves corresponding to the steady interference is used for deciding the engineering parameters for the transmitting setup, otherwise, curves corresponding to the troposheric interference is used for deciding the engineering parameters for the transmitting setup

signal-to-nose ratio. The protection ratio for tropospheric interference corresponds closely to a slightly annoying impairment condition and it is considered acceptable only if the interference occurs for a small percentage of the time, not precisely defined but generally considered to be between 1% and 10%. It may also be seen from the Table 2.1 that the protection ratio required for monophonic signals are much lower than that required for stereophonic signals when the frequency separation between the wanted and interfering signal is small.

2.12 The RF protection ratio curves (Figure 1) were originally determined by subjective evaluation of interference effects. As subjective tests are rather time consuming, an objective measurement method was developed and found to yield results which are in fair agreement with those to the subjective tests.

FIGURE 1

Radio-frequency protection ratio required by broadcasting services in band 8 (VHF) at frequencies between 87.5 MHz and 108 MHz using a maximum frequency deviation of ± 75 kHz



Curves M1: monophonic broadcasting; steady interference
M2: monophonic broadcasting; tropospheric interference
S1: stereophonic broadcasting; steady interference
S2: stereophonic broadcasting; tropospheric interference

0412-01

In case all the transmitters in one city/ district (coverage area) are not co-located, the attenuation patterns of the signals from different transmitters will vary from place to place within the coverage area. Therefore it may be possible that at several points in coverage area, desired power protection is not achieved. Keeping in view the above and other facts like early roll-out, efficient use of infrastructure and demographical requirements etc, the Authority, in its recommendation dated 11th August 2004 for the phase II expansion of private FM radio, had recommended mandatory co-location of transmitters. While recommending, it was also observed that--"In metro and large cities (category A cities of phase I) demand of large number of channels can be met by reducing the carrier separation (say from 800 KHz to 400 KHz)." However, no specific channel spacing was recommended by the Authority. The channel frequencies allocated to various broadcasters had a minimum channel spacing of 700/800 KHZ.

2.13 In the policy for FM radio Phase II, it was made mandatory for all the Phase II permission holders to co-locate their transmission facilities on the existing identified towers in all the cities except where new towers were to be got constructed by Ministry of Information & Broadcasting. Pending creation of co-location facility, the successful bidders in these cities were permitted to operationalise their channels on the individual basis for a period of two years or till the co-location facility is commissioned, whichever is later, at the end of which they were to shift their operations to the new facilities.

2.14 Regarding the co-location of Transmitters, TRAI, in its recommendation dated 22nd Feb 2008, on 3rd Phase of Private FM Radio Broadcasting, has recommended to mandate all the successful bidders to co-locate their transmitters. In the consolidated policy guidelines dated 25th July 2011, on expansion of FM radio broadcasting through private agencies for phase III, it is mandatory for all phase operators to co-locate transmission facilities in all the cities, irrespective of the fact as to whether the infrastructure of Prasar Bharati is available or not. Operators of phase III would be required to utilize the infrastructure of Prasar Bharati, if available, or form a consortium and develop a common Land and Transmission Infrastructure (LTI) and if they fail to form a consortium within a stipulated timeframe then they will be required to utilize a LTI developed by BECIL.

2.15 On the issue of limitation posed by the combiners, TRAI, in its recommendations dated 22nd Feb 2008, for the phase III, had stated that with minimum channel spacing lesser than 800 KHz, it would be difficult to achieve required level of port-to-port isolation and this would result in interference between the signals so combined in the combiner. Some of the existing operators, based on their experts advise, are of the view that combiners are now available in the market which can ensure adequate port-to-port isolation with even 400 KHz channel spacing. However, issues related to the cost and certain performance characteristics such as group delay and filtering would be required to be addressed. The proposed alternative approaches (Annexure I) to deal with the limitations posed by combiners along with the implications are discussed in later part of this chapter.

2.16 The selectivity[19] of radio receivers determines the capability of the receiver to faithfully separate out different channels received from one or more transmitters. On the issue of selectivity, it was observed in the TRAI recommendations dated 22nd Feb 2008, for phase III, that the low cost FM radio receivers widely available in the country are popular among the masses, may not have good selectivity performance. Affordability of FM radio receivers is one of the reasons for popularity of FM radio broadcast and high listenership. Thus, while deciding upon the minimum channel spacing the issue of selectivity of the receivers also needs consideration.

2.17 The FM operators are stating that the majority of receivers in the metro cities now consists of mobile phone sets and the car radios, both capable of tuning into FM channels which are separated by as low as 200 KHz, and therefore the receivers available with the majority of listeners no longer pose a challenge for the reduction in the minimum channel spacing. In support of their argument, relevant portion of the survey report - 'Radio Establishment Survey- Universe Update 2011', published by TAM, has been cited by the operators (Annexure IV). The said report is based on a survey/study conducted in June-Aug. 2010 with a sample size of 3000 in each of the Radio Audience Measurement cities (RAM cities) - Delhi, Kolkata, Bangalore and Mumbai.

2.18 One of the findings of the said study is that as compared to year 2007, in the year 2011, percentage of listeners, owning only one device has seen an increase in the cities of Mumbai and Delhi whereas for Bangalore and Kolkata it has decreased in favour of owners having 2 devices. As compared to year 2007, in the year 2011 the mobile phone ownership among the FM owners has significantly increased whereas other radio devices like radio sets, 2-in-1, Hi-Fi music systems etc. have witnessed a fall. From the table below it can be seen that though the majority of radio listening is through Mobile

[19] The selectivity of a receiver is the ability of the receiver to receive the wanted signal and reject unwanted signals in adjacent channels. Selectivity is a measure of the performance of a radio receiver to respond only to the radio signal it is tuned to (such as a radio station) and reject other signals nearby in frequency, such as another broadcast on an adjacent channel.

phone sets (specially in Mumbai and Delhi) however, sizable number of listeners do have radio/transistor sets, especially in Bangalore and Kolkata.

City	FM penetration (%)	No. of FM devices owned (%)		Device used for listening to FM Radio (%)	
		Single device	Two devices	Mobile Phone set	Radio/ Transistor set
Mumbai	70	64	28	94	16
Delhi	88	63	25	88	27
Kolkata	64	60	29	72	52
Bangalore	87	44	38	84	47

Source: Compiled from findings of 'Radio Establishment Survey- Universe Update 2011'

2.19 On the premise that the selectivity of the receivers would no longer pose a challenge for faithful reception of closely spaced channels, two solutions have been suggested by the operators (Appendix 2 to Annexure I) to achieve the objective of more channels in an area:

a) Existing combiners should be replaced by combiners which are capable of effectively combining closely spaced (400 KHz) channels. Apart from the fact that such combiners would cost substantially more, replacement of the existing antenna and feeder system would also be required to match up with the higher power handling capability requirement due to more number of transmitters being combined. As per the operators, this solution would be objected to by the existing operators as they would not be gaining directly by allowing more broadcasters in. The new broadcasters should share the cost for the replacement of combiners, antenna and feeder system. In this regard, if the terms and conditions of the tender are suitably prescribed, the new broadcasters could factor the cost into their business plans and bid accordingly. Alternatively, the Government could decide to pick up the costs since it would also be a big beneficiary of the additional spectrum created.

b) The second solution suggested by the operators requires a separate common transmission infrastructure (CTI) which includes transmitting tower, combiners, feeder cable, transmitting antenna etc. Effectively there would be two CTIs, one existing and another new one. The combiner designed for 800 KHz spacing could be used as the channel separation within a CTI would remain 800 KHz. However, suitably choosing the new channel frequencies (having channel separation of 800 KHz) in between the existing channel frequencies radiated from the existing CTI (also having channel separation of 800 KHz), would effectively result in channels spaced at 400 KHz for the license area for which these two CTIs are meant. For example if the channels radiated from existing CTI are 100, 100.8, 101.6 and 102.4 MHz then from new CTI the channels could be placed at 100.4, 101.2, 102.0 and 102.8 MHz. As per the operators, this solution entails identifying a new and suitable tower location and building a new tower there, which would be a fairly expensive proposition, however, if it is built into the tender terms for new bidders, they could factor the cost into their business plans and bid accordingly.

2.20 However, as indicated in Para 2.17, a sizeable number of listeners do have radio/transistor sets as FM receivers. These consumer receivers as well as the lower end mobile phone sets, may or may not have the tuning capability to separate out channels, spaced closer than the existing minimum separation. In case they do not support separating of the channels spaced closer than the existing separation, these receivers would be required to be upgraded.

2.21 In case, it is not feasible to add more transmitters (channels) at the existing facilities of Prasar Bharati / BECIL, in the A+ and A category cities, new CTI may be required to be installed. In such a scenario extra caution may be required to be exercised in network planning, in order to maintain the desired RF protection ration.

2.22 A propos the above, the issues for consultation are as under:

You are requested to provide detailed justifications for your response.

a) What should be the minimum channel spacing within a license service area for the FM radio channels? Should it be reduced from the current level of 800 KHz, if so, what should be the appropriate minimum channel spacing? Please justify your response with appropriate reasoning. While giving the response, the issues such as the viability and desirability of having more number of channels in the interest of the stakeholders, selectivity of FM receivers available with the consumers (such as mobile handsets, car radios, and other receivers), transmission from a single or multiple transmission setups may please be factored in.

b) What are the implications of reducing/not-reducing the minimum channel spacing within a license service area?

c) In the event of reduction of minimum channel spacing, from the current level of 800 KHz, should the minimum channel spacing be reduced only in A+ and A category cities or should it be reduced across the country?

d) **In case a reduction is proposed in the minimum channel spacing, from the current level, in response to "a)" above, what should be the mode of funding for the modification of transmitting setups?**

e) **Any other relevant issue that you may like to raise or comment upon.**

Chapter III

Issues for Consultation

You are requested to provide detailed justifications for your response.

3.1 What should be the minimum channel spacing within a license service area for the FM radio channels? Should it be reduced from the current level of 800 KHz, if so, what should be the appropriate minimum channel spacing? Please justify your response with appropriate reasoning. While giving the response, the issues such as the viability and desirability of having more number of channels in the interest of the stakeholders, selectivity of FM receivers available with the consumers (such as mobile handsets, car radios, and other receivers), transmission from a single or multiple transmission setups may please be factored in.

3.2 What are the implications of reducing/not-reducing the minimum channel spacing within a license service area?

3.3 In the event of reduction of minimum channel spacing, from the current level of 800 KHz, should the minimum channel spacing be reduced only in A+ and A category cities or should it be reduced across the country?

3.4 **In case a reduction is proposed in the minimum channel spacing, from the current level, in response to "3.1" above, what should be the mode of funding for the modification of transmitting setups?**

3.5 **Any other relevant issue that you may like to raise or comment upon.**

GLOSSARY

S. No.	Abbreviation	Description
1.	BECIL	Broadcast Engineering Consultants India Ltd
2.	CTI	Common Transmission Infrastructure
3.	EHAAT	Effective Height of Antenna above Average Terrain
4.	ERP	Effective Radiated Power
5.	FCC	Federal Communications Commission
6.	ITU-R	International Telecommunication Union-Radio
7.	LPFM	Low Power FM radio
8.	LTI	Land and Transmission Infrastructure
9.	Ofcom	Office of Communications
10.	OTEF	One Time Entry Fee
11.	RF	Radio Frequency
12.	UHF	Ultra High Frequency
13.	VHF	Very High Frequency

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GOVERNMENT OF INDIA
MINISTRY OF INFORMATION & BROADCASTING
NEW DELHI-110115

D.O.No. 102/2/2008-FM(Vol.IV) 8th August, 2011

Dear Dr. Sarma,

As you might be aware, the Cabinet has recently approved policy guidelines for expansion of FM Radio Broadcasting services through private agencies (Phase-III). A copy of these guidelines is being enclosed for reference. FM Phase-III policy extends FM radio services to about 227 new cities in addition to present 86 cities, with a total of 839 new FM radio channels in 294 cities.

2. The FM Phase III Policy is primarily based on the recommendations of TRAI made in 2008. TRAI in its recommendations had examined the issue of co-channel spacing and had recommended that the same may be kept at 800 khz within a district and should not be reduced any further. While making such recommendations, TRAI had *inter alia* taken into account various technical factors including transmitter power, quality and level of port to port isolation at combiners, channels selectivity of FM receivers etc.

3. The FM Radio Policy provides for 9 channels in A+ category cities and 6 channels generally in category A cities except for Bangalore and Hyderabad where total number of channels has been kept at 8. In B & C category cities, the total number of channels proposed is 4, and in D category cities the total number of channels proposed is 3. Apart from the co- channel spacing, one of the factors that was considered in finalizing the total number of channels in a city category has also been the viability of operations of FM radio channels considering revenue potential of that city category.

4. The Ministry is in receipt of a number of representations from the FM Radio industry wherein it has been demanded that co-channel spacing be reduced and additional frequencies released especially in A+ and A category cities. The arguments being given arc that since 2008 significant technological developments have taken place making possible the release of additional frequencies for FM radio operations and thereby have the potential of generating additional revenue for the Government by efficient utilization of the ear-marked spectrum for FM Radio operations. It has also been suggested that increased availability of frequencies will lead to rational bidding and will also help in providing a greater variety of music and other programmes to listeners thereby leading to enhanced growth of radio sector.

.....2/-

5. In this context, it is also pertinent that while in A category cities it may be possible to release some additional frequencies even without reducing the co-channel spacing, but in A+ cities release of additional frequencies will not be possible unless the co-channel spacing is reduced.

6. Keeping in view the demand of the FM radio operators, the technological developments and viability of the FM operations in a city category, TRAI is requested to reconsider the issue of reduction in co-channel spacing and release of additional frequencies in A+ and A category cities. Some of the inputs given by FM radio operators on technological developments are being enclosed for reference. TRAI is requested to give its recommendations as per Section 11(1)(a)(viii) of TRAI Act, 1997.

With kind regards,

Yours sincerely,

(Raghu Menon)

Dr. J.S. Sarma,
Chairman,
The Telecom Regulatory Authority of India,
Mahanagar Doorsanchar Bhawan,
Jawaharlal Nehru Marg,
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New Delhi 110 002.

Encl :a/a

Appendix 1

Why we believe that TRAI's 2008 recommendations are outdated

May we first point out the obvious: That in spite of our tremendous economic success, India is today the most backward nation when it comes to the availability of FM channels in our cities. Almost any global city (New York, London etc) today boasts of as many as 50-75 FM channels each. Even **Colombo has 25 channels on offer.** These are cities with lower population than most Indian metros. How then can the major cities in India not have at least 25 channels?

If the reasons are technical, then there are solutions readily available.

TRAI, in its 2008 recommendations, has raised certain objections with reducing the separation between two FM channels to 400 Khz. Some of these are:

1. Port-to-port isolation of minimum 50 db required in the combiner:

This is a valid observation made by TRAI even though my experts tell me that the isolation required is 35 db and that is what the current combiner at the transmitter location has as its specification. Whether it is 50 db or 35 db is immaterial; the point raised, is that this is the minimum isolation required in the combiner. If more channels were mounted on the existing combiner, it would lead to unwanted mixing of channels and consequently an unpleasant listening experience. This is indeed true.

Solutions:

There are two solutions readily available to overcome this problem:

(i) The first is that the existing combiner should be replaced with another combiner that can handle more FM channels while maintaining the needed isolation. However, a new combiner would entail fresh costs which would have to be incurred by the existing broadcasters. As per an initial estimation, this would be approx Rs 1.5 crore for buying a new combiner, even though a buy back of the present combiner would help in reducing costs substantially. Even if a buy back was done, each existing broadcaster would have to spend fresh monies to make the switch-over.

This would be objected to by them as they gain nothing directly by allowing more broadcasters in. The new broadcasters would be the real beneficiaries of the extra spectrum created and one simple solution would be to **make them (the new broadcasters) pay for the new combiner.** If this were made part of the tender conditions, new bidders could factor the cost into their business plans and bid accordingly. It would be just another component of the project cost for them. **Alternatively, the government could decide to pick up the costs of the new combiner since it would also be a big beneficiary of the additional spectrum created.....the OTEF generated would be very substantial.**

The advantage in changing the combiner is that the current tower infrastructure could continue to be used. It is also the more practical of the two solutions.

(ii) The second solution is to **house the new channels in a *new* tower.** At this new tower facility, a new combiner with the requisite technical features could be ordered. This solution entails identifying a new and suitable tower location and building a new tower there (if there is no existing facility available). If an existing tower can be spared for housing new FM channels, then a new tower need not be created. Building a new tower is a fairly expensive proposition, but again, **if it were built into the tender terms for new bidders, they would bid keeping this cost in mind.**

Both of these solutions are practical – the first one more so – and relatively easy to implement. There are certain monetary costs involved, but in the larger interest of developing the radio industry, these costs need to be incurred.

Not increasing frequencies should not be seen as an option by the government as it would harm the radio industry in more ways than can be imagined right now. In many ways creating more spectrum is akin to the government buying land from the public to build industrial parks –costs need to be incurred in doing so, but is there any alternative to industrial growth? In this case, as long as existing broadcasters do not have to incur any costs, they should be fine with the plan.

I am attaching a note written by our expert in the field of telecommunications.

2. Selectivity of FM receivers:

TRAI was probably right in making this observation in the year 2008. At that time, mobile penetration was not as high as it is today.

However, today, as per an independent survey done by TAM (the research agency which measures TV and radio consumption), as much as 90-99% of the audience in the four major metros of Delhi, Mumbai, Kolkata and Bangalore has access to FM radio channels on their mobile phones. You may yourself have seen people traveling in buses and trains listening to radio on their mobile phones. The relevant pages of this research are attached along with this letter.

It is a well known fact that mobile phones are capable of tuning into FM channels which are separated by as low as 200 Khz. The other devices used to listen to FM channels are the car stereos or the home stereo systems –both of which are usually digital by design and can easily tune into channels separated by even 200 Khz.

The common belief that some of us have that people listen to FM radio on cheap hand-held devices is misplaced. There was a time when this was true, but that is no longer the case. In fact, today there is no manufacturer of FM radio sets left in the country (to the best of my knowledge). No one buys a "radio set" any longer – it is always built into either a mobile phone or a car stereo or a home stereo system.

In smaller markets where mobile penetration is low --say less than 70% or so-- selectivity of FM receivers may be an issue today. But even in these towns, the situation is changing on a daily basis.

By the time, the new Phase-III stations become operational, mobile penetration would have further increased in even these towns. **In any case, we are asking for the channel separation to be reduced only in the major markets right now –maybe only in the A+ and A category towns to start with.**

To sum up, in today's times, selectivity of FM receivers is not an area of worry at all.

3. No demand for more FM spectrum:

The third objection raised by TRAI in reducing the channel separation to 400 Khz is that in the smaller C and D category towns, there really is no need to have more channels. This is a fair point given the fact that the radio market size in these towns is quite small. However, even in these towns, there should be at least six channels available.....this would lead to 2-3 contemporary music channels, 1-2 retro music channels and 1-2 regional music channels emerging. At a later point in time, the government may want to reassess the demand situation and launch more frequencies at that time. In the larger towns however, there is a big demand for radio spectrum and the proposal to reduce channel separation should be considered seriously for these towns initially.

4. Signal interference in adjacent districts:

The fourth objection raised by TRAI is about allocation of frequencies in two adjacent districts and the interference that would happen if channel separation was reduced to 400 Khz. As per experts in the transmission business, frequency planning in an efficient manner is a well known science. The WPC (Wireless Planning Cell) in the DoT is well equipped to carry out this task. Worldwide, planning spectrum allocation in an optimal manner is a routine exercise undertaken by the authorities. We do not see any major problem in planning that we in India cannot overcome. Given the advantages of frequency reduction, the additional effort required is well worth it.

Appendix 2: Expert's opinion

Reducing the separation between FM channels in a centre to 400 KHz instead of the existing 800 KHz

Large metropolitan stations that rarely exceeded 10 combined FM broadcast stations in the 1990s are now routinely being replaced by systems in several countries with room for 20 stations or more. At the same time the changes in the FM spectrum with usage of sub-carriers transmission has made increased filtration a necessity, the FM channel itself became increasingly complicated. In the 1980s, the 67 KHz Subsidiary Communications Authorization (SCA) became more widely used. The 93 KHz SCA quickly followed this, pushing critical information to the ±100 KHz fringe of the FM channel and closer to potentially interfering signals. In India, however, as on date the broadcasters are not authorized to utilize sub-carrier transmissions.

As the FM channel becomes larger and more complex, filters and combiners have had to evolve to provide the necessary isolation between closer-spaced signals at the same time that their own pass bands must be more tightly controlled to pass the desired channel. Today's combiners are even being used to isolate separate signals on the same channel to facilitate the combining of analog and digital signals.

Important characteristics of combiners are frequency response, insertion loss, group delay, impedance, physical size, port-to-port isolation and tuning compromises. Improving one parameter may result in a reduction in another. Excessive group delay within the pass band can result in signal distortion. Combiners are often made up of multiple elements, which as a system provide the desired results. Separating the elements can lead to mismatches or other incompatibilities.

In fact some of the frequencies allocated for Community FM Radio, in our country, is in the same service area of the commercial FM channels and are spaced within 400 KHz spacing.

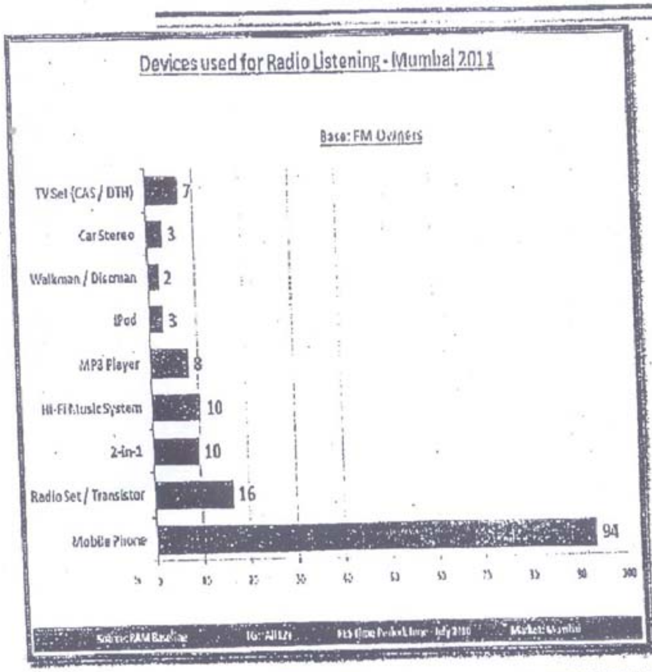
A comparison of possible options for implementing the new FM channels with 400 KHz spacing is indicated below:

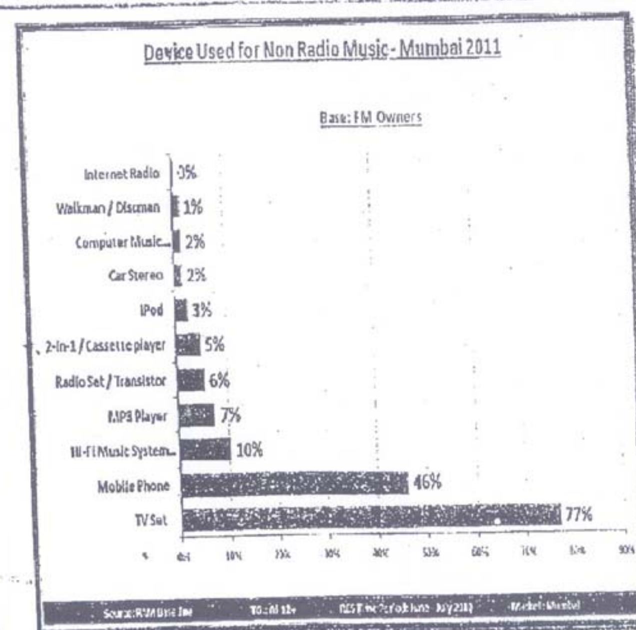
Parameter	Option-1 Implementation in Existing CTIs		Option-2 Implementation in separate & additional CTIs		Remarks
	Merits	Demerits	Merits	Demerits	
Power Combiner	Additional channels are available	A new combiner chain is needed. The cost of this would be quite high (say 200% of 800 KHz combiners) as multi stage filtering	Additional channels are available without affecting the existing operators	New Tower will be needed	The specifications of the new combiner need to be evaluated for the group delay performance, which is likely to deteriorate with 400

		would be needed to provide isolation. The existing operators may be reluctant to share this additional cost.			KHz separation due to multistage filtering. Similarly, the isolation from WB to NB needs to be maintained by increasing the filtering.
Power handling of Antenna & feeder System		The existing antenna & feeder system needs to be replaced leading to discontent among the existing operators	Since the entire set up is designed to cater for all the channels, no problem is envisaged		
Tower	Existing tower could be utilized			A new tower is needed	

Conclusion:
In view of the above, it is concluded that the 400 KHz separation between FM channels could be implemented with the new / additional CTIs to be setup in the same city/town. However, by suitably placing the new FM frequencies, which fall in between the existing frequencies (spaced at 800 KHz), in the new CTI, the combiner designed for 800 KHz spacing could be used in the new CTI to avoid a new design based on 400 KHz spacing and thus avoid group delay & isolation problems.
Since the digital receivers are capable of narrow band tuning, the 400 KHz spacing would not be a problem at the receiving end.

Majority of the radio listening is preferred on Mobile Phones whereas TV sets are used maximum for non radio music.





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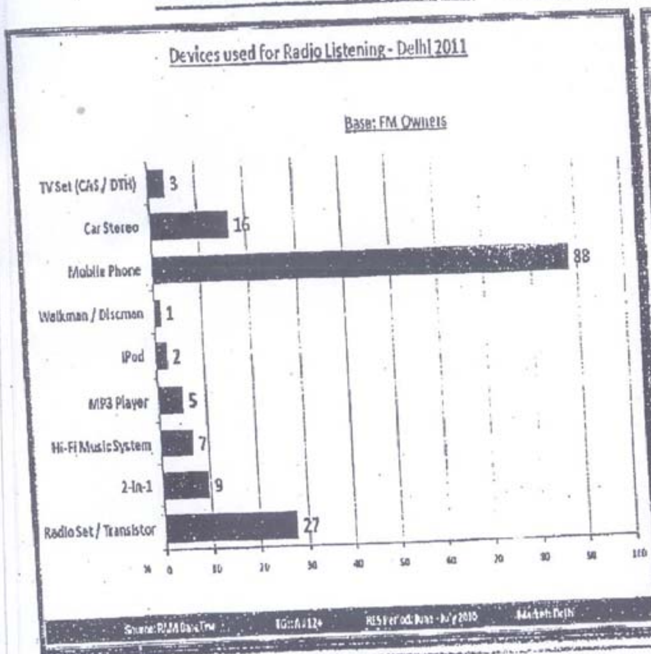
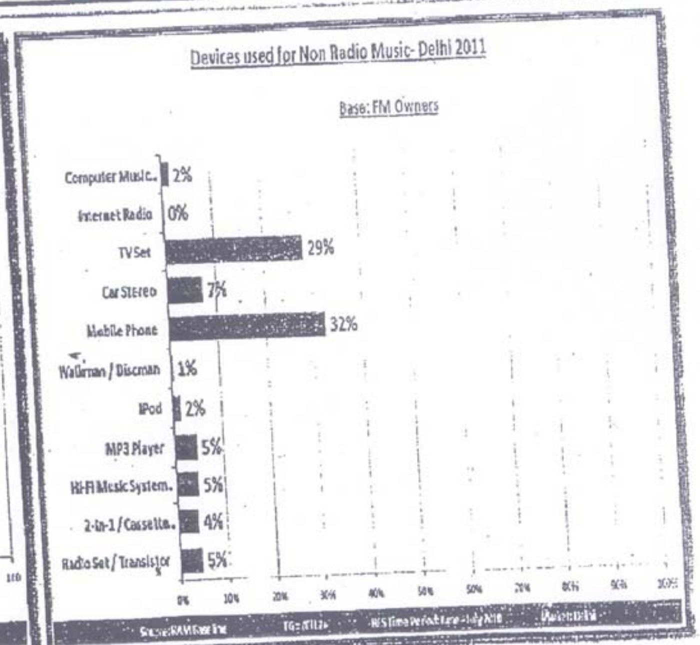
Mobile phones has been used maximum for radio and non radio music listening





RAM

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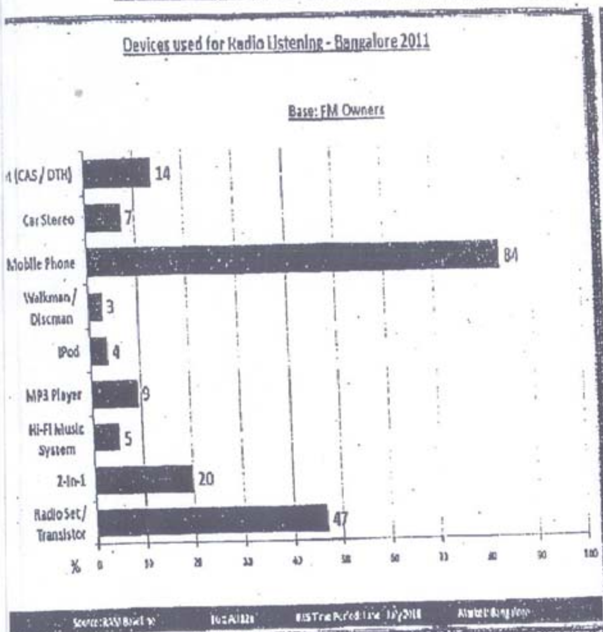
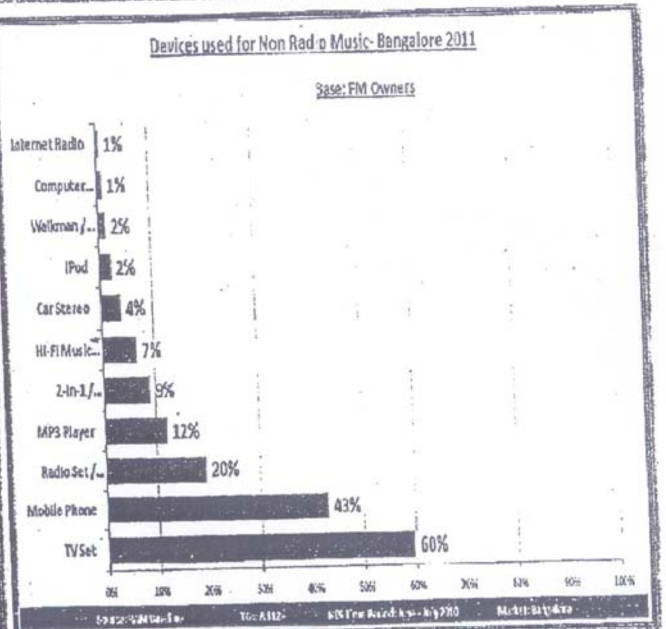
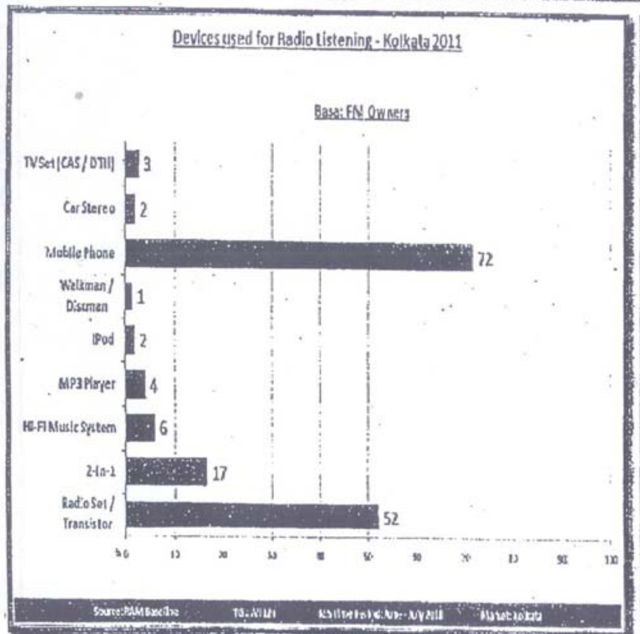
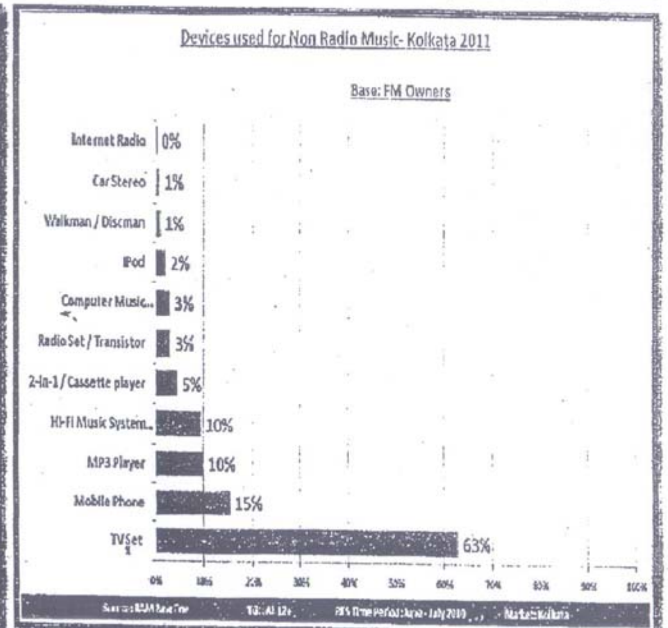




Mobile phones followed by Radio Set/ Transistors has been preferred maximum for Radio Listening whereas TV sets are used maximum for non radio music.





RAM

RECOMMENDATION ITU-R BS.450-3

Transmission standards for FM sound broadcasting at VHF*

(1982-1995-2001)

The ITU Radiocommunication Assembly,

recommends

1 that for FM sound broadcasting in band 8 (VHF) the following transmission standards should be used:

1 Monophonic transmissions

1.1 Radio-frequency (RF) signal

The RF signal consists of a carrier frequency-modulated by the sound signal to be transmitted, after pre-emphasis, with a maximum frequency deviation equal to:

±75 kHz or ±50 kHz.

NOTE 1 – In the West European countries and the United States of America, the maximum deviation is ±75 kHz. In the ex-USSR and in some other European countries, it is ±50 kHz.

1.2 Pre-emphasis of the sound signal

The pre-emphasis characteristic of the sound signal is identical to the admittance-frequency curve of a parallel resistance-capacitance circuit having a time constant of:

50 μs or 75 μs.

NOTE 2 – In Europe, the pre-emphasis is 50 μs. In the United States of America, it is 75 μs.

2 Stereophonic transmissions

2.1 Polar-modulation system

2.1.1 RF signal

The RF signal consists of a carrier frequency-modulated by a baseband signal, known in this case as the "stereophonic multiplex signal", with a maximum frequency deviation equal to:

±75 kHz or ±50 kHz (see Note 1, § 1).

2.1.2 Stereophonic multiplex signal

This signal is produced as follows:

2.1.2.1 A signal *M* is formed equal to one half of the sum of the left-hand signal, *A*, and the right-hand signal, *B*, corresponding to the two stereophonic channels. This signal, *M*, is pre-emphasized in the same way as monophonic signals (see § 1).

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* Administrations are invited to supply further information on the system parameters, particularly concerning new tables on frequency tolerances.

NOTE 1 – M is a "compatible" signal in the sense that the stereophonic transmission may be received by a monophonic receiver equipped for the same maximum frequency deviation and the same pre-emphasis.

2.1.2.2 A signal S is produced equal to one half of the difference between signals A and B mentioned above. This signal, S, is pre-emphasized in the same way as signal M. The pre-emphasized signal, S, is used for the amplitude modulation of a sub-carrier at 31.25 kHz; the spectrum of the amplitude-modulated sub-carrier is formed so that the sub-carrier amplitude is reduced by 14 dB and the spectral components of the given modulating signal appear to be transformed as follows:

$$\overline{K}(f) = \frac{1 + \mathrm{j}\,6.4\,f}{5 + \mathrm{j}\,6.4\,f}$$

where f is equal to each frequency component (kHz).

2.1.2.3 The stereophonic multiplex signal is the sum of:

– the pre-emphasized signal, M;

– the sideband spectral components which are the product of amplitude-modulated unsuppressed carrier by a pre-emphasized signal S additionally transformed from the law $\overline{K}(f)$;

– the sub-carrier with the amplitude reduced by 14 dB.

2.1.2.4 The amplitudes of the various components of the stereophonic multiplex signal, referred to the maximum amplitude of that signal (which corresponds to the maximum frequency deviation) are:

– signal M: maximum value 80% (A and B being equal, and in phase);

– signal S: maximum value 80% (A and B being equal but of opposite phase);

– reduced sub-carrier at 31.25 kHz; maximum residual amplitude 20%.

2.1.2.5 The frequency modulation is arranged in such a way that positive values of the multiplex signal correspond to a positive frequency deviation of the main carrier and negative values to negative frequency deviation.

2.2 Pilot-tone system

2.2.1 RF signal

The RF signal consists of a carrier frequency-modulated by a baseband signal, known in this case as the "stereophonic multiplex signal", with a maximum frequency deviation equal to:

±75 kHz or ±50 kHz (see Note 1, § 1).

2.2.2 Stereophonic multiplex signal

This signal is produced as follows:

2.2.2.1 A signal M is formed equal to one half of the sum of the left-hand signal, A, and the right-hand signal, B, corresponding to the two stereophonic channels. This signal, M, is pre-emphasized in the same way as monophonic signals (see § 1) (see Note 1, § 2).

2.2.2.2 A signal S is produced equal to one half of the difference between signals A and B mentioned above. This signal, S, is pre-emphasized in the same way as signal M. The pre-emphasized signal, S, is used for the suppressed-carrier amplitude modulation of a sub-carrier at 38 kHz ±4 Hz.

NOTE 2 – The same effect is obtained by pre-emphasizing the left-hand signal *A* and the right-hand signal *B* before encoding. For technical reasons this procedure is sometimes preferred.

2.2.2.3 The stereophonic multiplex signal is the sum of:

– the pre-emphasized signal, *M*;

– the sidebands of the suppressed sub-carrier amplitude modulated by the pre-emphasized signal, *S*;

– a "pilot signal" with a frequency of 19 kHz exactly one-half the sub-carrier frequency.

2.2.2.4 The amplitudes of the various components of the stereophonic multiplex signals referred to the maximum amplitude of that signal (which corresponds to the maximum frequency deviation) are:

– signal M: maximum value 90% (*A* and *B* being equal and in phase);

– signal S: maximum value of the sum of the amplitudes of the two sidebands: 90% (which corresponds to *A* and *B* being equal and of opposite phase);

– pilot signal: 8 to 10%;

– sub-carrier at 38 kHz suppressed: maximum residual amplitude 1%.

2.2.2.5 The relative phase of the pilot signal and the sub-carrier is such that, when the transmitter is modulated by a multiplex signal for which A is positive and $B = -A$, this signal crosses the time axis with a positive slope each time the pilot signal has an instantaneous value of zero. The phase tolerance of the pilot signal should not exceed ±3° from the above state. Moreover, a positive value of the multiplex signal corresponds to a positive frequency deviation of the main carrier.

2.2.3 Baseband signal in the case of a supplementary signal transmission

If, in addition to the monophonic or stereophonic programme, a supplementary monophonic programme and/or supplementary information signals are transmitted and the maximum frequency deviation is ±75 kHz, the following additional conditions must be met:

2.2.3.1 The insertion of the supplementary programme or signals in the baseband signal must permit compatibility with existing receivers, i.e. these additional signals must not affect the reception quality of the main monophonic or stereophonic programmes.

2.2.3.2 The baseband signal consists of the monophonic signal or stereophonic multiplex signal described above and having an amplitude of not less than 90% of that of the maximum permitted baseband signal value, and of the supplementary signals having a maximum amplitude of 10% of that value.

2.2.3.3 For a supplementary monophonic programme, the sub-carrier and its frequency deviation must be such that the corresponding instantaneous frequency of the signal remains between 53 and 76 kHz.

2.2.3.4 For supplementary information signals, the frequency of any additional sub-carrier must be between 15 and 23 kHz or between 53 and 76 kHz.

2.2.3.5 Under no circumstances may the maximum deviation of the main carrier by the total base signal exceed ±75 kHz.

3 System parameters

The system parameters used in different countries are given in Annex 1.

ANNEX 1

Current sound broadcasting systems in the bands included in the Radio Regulations (RR) used in different countries/areas in the world

TABLE 1a

Terrestrial FM sound broadcasting (above 30 MHz)

Country/Geographical area	International agreements				Information related to current emission applications: Frequency bands used (MHz)							Modulation characteristics							Polarization			Transmitter frequency tolerances (RR Article 1)	
	Geneva 60	Stockholm 61	Geneva 84	Others	66-68	68-73	73-74	76-87.5	87.5-108	88.0-108	Others	Monophonic	Stereophonic	Polar-modulation system	Pilot-tone system	Channel spacing (¹) (kHz)	Pre-emphasis/ de-emphasis (µs)	Maximum frequency deviation (kHz)	Horizontal	Vertical	Mixed	Current requirement	Long-term design objective
Germany (Federal Republic of)		+	+						+			+	+		+	100	50	±75	+	Except cases			
Aruba										+			+			200	75	±75		+	+		
Australia									+				+		+	200	50	±75	+	+	+		
Bahamas										+			+		+	200	75	±75	+				
Bangladesh (People's Republic of)			+						+			+				200	50	±75	+				
Cyprus (Republic of)			+						+				+		+	100	50	±75			+		
Vatican City State		+	+						+				+		+	100	75	±75			+		
Colombia (Republic of)			+							+			+			200	75	±75			+		
Korea (Republic of)			+							+		+	+		+	200	75	±75			+		
Denmark			+						+				+		+	100	50	±75	+				
Ecuador										+			+		+	200		±75		+			
Spain			+						+				+		+	100	50	±75	+	+	+		
United States of America											87.8 108	+	+		+	200	75	±75	+	+	+		
Finland			+						+				+		+	100	50	±75	+	+	+		
France			+						+			+	+		+	100	50	±75	+	+		20×10^{-6}	
Gambia (Republic of the)			+							+		+	+		+		75	±75		+			
Hungary (Republic of)	+	+	+		+	+			+			+	+		+	30 100	50	±50 ±75	+				
India (Republic of)											100-108	+	+		+	100	50	±75			+		
Iran (Islamic Republic of)			+						+			+	+		+		50	±75	+		+		
Italy			+						+				+		+	100	50	±75			+		
Japan				X							76 90				+	100	50	±75	+	+			

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TABLE 1a (*end*)

Country/Geographical area	International agreements				Information related to current emission applications: Frequency bands used (MHz)							Modulation characteristics							Polarization			Transmitter frequency tolerances (RR Article 1)	
	Geneva 60	Stockholm 61	Geneva 84	Others	66-68	68-73	73-74	76-87.5	87.5-108	88.0-108	Others	Monophonic	Stereophonic	Polar-modulation system	Pilot-tone system	Channel spacing (1) (kHz)	Pre-emphasis/ de-emphasis (µs)	Maximum frequency deviation (kHz)	Horizontal	Vertical	Mixed	Current requirement	Long-term design objective
Kuwait (State of)			+						+				+			100	50	±75			+		
Lithuania (Republic of)		+	+		+	+	+		+			+	+	+	+	30 100	50 75	±50 ±75	+	+			
Mali (Republic of)			+						+				+		+	100	50	±75	+	+			
Morocco (Kingdom of)		+	+						+			+	+		+		75	±75	+		+		
Norway		+	+						+				+		+	100	50	±75	+	few	+		
New Zealand				Rec. ITU-R BS.412							88-100		+		+	50	50	±75		+	+		
Oman (Sultanate of)			+						+				+		+	100	50	±75	+	+			
Papua New Guinea			+						+			+	+		+	100	50	±75	+				
Netherlands (Kingdom of the)			+						+			+	+		+	100	50	±75	+	+			
Qatar (State of)										+			+			200	50	±75			+		
Czech Republic									+			+	+		+	100	50	±75	+	+	+		
United Kingdom of Great Britain and Northern Ireland			+						+				+		+	100	50	±75			+		
Rwandese Republic	+		+						+			+				100	50	±75	+				
Senegal (Republic of)			+						+			+	+		+	100	50	±75	+				
Singapore (Republic of)										+			+		+	300	50	±75			+		
Slovenia (Republic of)		+	+						+				+			100	50	±75	+	+	+		
South Africa (Republic of)			+						+				+		+	100	50	±75		+			
Sweden			+						+				+		+	100	50	±75	+				
Switzerland (Confederation of)			+						+				+		+	100	50	±75	+	few	few		
Turkey			+						+				+		+	100	75	±50	+				
Ukraine		+	+			+	+		+			+	+	+	+	30 100	50 75	±50 ±75	+	+	+		

(1) For definition see Recommendation ITU-R BS.412. It is not meant the frequency spacing in overlapping service areas or tuning steps of the receiver.

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TABLE 1b

Terrestrial FM sound broadcasting (above 30 MHz)

Country/Geographical area	Information related to current receiving applications				Additional information		Remarks
	Recommended or used IF (MHz)	Oscillartor position		Electromagnetic immunity requirements for receivers	Compressor or compander systems	Supplementary information	
		High	Low				
Germany (Federal Republic of)	10.7	+		EN 55 020	Oui	ARI, RDS	Variable pre-emphasis at transmitter site in order to avoid excess of ±75 kHz frequency deviation
Aruba	10.7	+					
Australia	10.7	+				ACS on 57 kHz (RDS) 67 kHz and below 95 kHz	
Bahamas							
Bangladesh (People's Republic of)	10.7	+					
Cyprus (Republic of)							
Vatican City State					Compression +10 dB		
Colombia (Republic of)	10.7				No	SCA (67 kHz)	
Korea (Republic of)	10.7	+			Optimod FM 8200	No	
Denmark	10.7	+		EMC	Yes	RDS	
Ecuador	10.7						
Spain	10.7	+				RDS, SCA (67 kHz)	
United States of America	10.7	Not defined		FCC 47 CFR 15	Optional	RBDS (RDS), SCA	
Finland	10.7	+			ORBAN compressor	RDS	

TABLE 1b (*continued*)

Country/Geographical area	Information related to current receiving applications				Additional information		Remarks
	Recommended or used IF (MHz)	Oscillator position		Electromagnetic immunity requirements for receivers	Compressor or compander systems	Supplementary information	
		High	Low				
France	10.7	+			Yes, mainly for local radio	RDS	Synchronous frequency VHF-FM service for motorists in stereophonic mode along motorways. Frequency tolerance among all synchronous transmitters: 10^{-9}
Gambia (Republic of)	10.8	+					
Hungary (Republic of)	10.7	Not defined		EN 55020, draft Hungarian standard		ARI, RDS, SCA pilot, MBS	
India (Republic of)	10.7		+			RDS, SCA (experimental transmissions)	
Iran (Islamic Republic of)	10.7	+		No	No	RDS	
Italy	10.7	+			Compressor of deviation control		"ISORADIO" – ISO frequency VHF-FM service for motorists in monophonic mode is introduced along the motorways
Japan	10.7	+				DARC	
Kuwaït (State of)	10.7	+					
Lithuania (Republic of)	10.7	+					
Mali (Republic of)	10.7						
Morocco (Kingdom of)							

TABLEAU 1b (*end*)

Country/Geographical area	Information related to current receiving applications				Additional information		Remarks
	Recommended or used IF (MHz)	Oscillator position		Electromagnetic immunity requirements for receivers	Compressor or compander systems	Supplementary information	
		High	Low				
Norway	10.7	+			Yes	RDS	
New Zealand	10.7	+				SCA use being developed	100-108 MHz presently used for domestic services
Oman (Sultanate for)					None	None	
Papua New Guinea					None	None	
Netherlands (Kingdom of the)	10.7	Left to manufacturer		Comply with EEC standards	Yes	RDS, CSI	
Qatar (State of)						No	
Czech Republic	10.7	+			Compression	RDS	
United Kingdom of Great Britain and Northern Ireland	10.7	+		REC, EEC EMC Directive; Radiation EN 55013; Immunity 55020	Yes	RDS	
Rwandese Republic	10.7	+					
Senegal (Republic of)	10.7						
Singapore (Republic of)	10.7	+			Optimod	SCA	
Slovenia (Republic of)	10.7	+			Yes	RDS	
South Africa (Republic of)	10.7	+	+	No	Optimod	RDS, SST	SST still on trial
Sweden	10.7	+		No	Yes, audioprocessing (compression, limiter)	RDS	
Switzerland (Confederation of)	10.7	+				ARI, RDS	
Turkey	10.7		+	No	No	No	
Ukraine	10.7						

List of FM channels in New York City **Annexure-III**

Sr. No	Freq	Channel Name	Description
1	87.75	WNYZ- LP	Russian
2	88.1	WCWP	Jazz(LIU/ C.W.Post Campus)
3	88.3	WBGO (Jazz-88)	Jazz
4	88.7	WRHU	variety Music (Hofstra University)
5	88.9	WSIA	Variety Music(Staten island University)
6	89.1	WFDU	Music Variety(Fairleigh Dickinson University)
7	89.1	WNYU	Variety Music(Newyork University)
8	89.5	WSOU	Rock(Seton Hall University)
9	89.9	WKCR	Variety Music(Columbia University)
10	90.3	WKRB	CHR(Kingsborough Community College)
11	90.3	WHCR	Variety(City college of New York)
12	90.3	WHPC	Music Variety (Nassau Community College)
13	90.7	WFUV	AAA/ Americana (Fordham University)
14	91.1	WFMU	Music - Freeform
15	91.5	WNYE(Radio New York)	Music/ Variety
16	92.3	WXRK (92.3 Now FM)	CHR
17	92.7	WQBU(LA Que Buena)	Spanish - Mexican Regional
18	93.1	WPAT(Amor 93.1)	AC-Spanish
19	93.5	WVIP	Carribeon Music
20	93.9	WNYC	News/talk/ Public Afffairs
21	94.7	WFME	Religious
22	95.5	WPLJ	CHR- Rock/ Pop
23	96.3	WXNY(X96.3 FM)	Spanish
24	96.7	WCTZ(The Coast)	AC
25	97.1	WQHT(Hot 97)	CHR- Urban
26	97.9	WSKQ(Mega 97.9)	Spanish
27	98.3	WKJY(K-Joy)	AC
28	98.7	WRKS(Kiss FM)	CHR Urban
29	99.5	WBAI	Variety
30	100.3	WHTZ (Z-100)	CHR
31	100.7	WHUD	AC
32	101.1	WCBS	Oldies
33	101.9	WRXP (101.9 RXP)	Rock
34	102.7	WWFS (Fresh 102.7)	AC
35	103.1	WJUX (W276AQ)	Religion- Christian
36	103.5	WKTU	CHR- Rhythmic Dance
37	103.9	WFAS	Adult Contemporary

38	104.3	WAXQ(Q104)	Classic Rock
39	105.1	WWPR-FM (Power 105.1)	CHR- Urban
40	105.5	WDHA	Rock
41	105.9	WQXR	Classic Music
42	106.7	WLTW (Lite FM)	Adult Contemporary
43	107.1	WXPK (The Peak)	Rock AC
44	107.5	WBLS	Urban AC

List of FM channels in London **Annexure-IV**

London FM				
Sr. No	**Name**	**Freq**	**Place**	**Remarks**
1	Westside 89.6 FM	89.6	West London	- Community station serving the multicultural community, particularly young people, in Southall and surrounding areas
2	91.8 Hayes	*91.8*	West London	- Community station for Hayes
3	NuSound	*92*	East London	Community station - music and speech service for people in the Forest Gate and surrounding area
4	Link FM	*92.2*	North East London	Community radio for Havering
5	Voice of Africa Radio	*93.4*	East London	Community station for the African Community in Newham, East London
6	BBC London	*94.9*	Greater London	- News, music and features
7	BBC Essex	*95.3*	East London	
8	95.8 Capital FM	*95.8*	Greater London	- Chart/pop music
9	Mercury 96.6	*96.6*	North London	- Contemporary and classic hits, local and national news
10	BBC Radio Kent	*96.7*	South East London	- News, music and features
11	Choice FM	*96.9*	South London	Soul, dance, R&B, reggae and local news
12	News Direct 97.3 FM	*97.3*	Greater London	News
13	BBC Radio Kent	97.6	South East London	- News, music and features

14	Kiss 100 FM	*100*	Greater London	- Dance music
15	OnFM	*101.4*	West London	Community station with a focus on Irish and other ethnic groups
16	Ten 17	*101.7*	North East London	- Contemporary and classic hits, local and national news
17	Jazz FM 102.2	102.2	Greater London	Jazz
18	102.2 Smooth Radio	*102.2*	Greater London	Easy listening music and speech
19	London Greek Radio	*103.3*	North London	Greek interest
20	BBC Essex	*103.5*	North London	
21	BANG Radio	103.6	West London	Community station serving residents in Stonebridge, Harlesden and surrounding areas
22	BBC Radio Kent	104.2	South East London	News, music and features
23	Resonance FM	*104.4*	Central London	- Community station targeted at inner London's community of practising artists and those outside the mainstream media
24	Xfm	*104.9*	Greater London	alternative rock
25	Magic 105.4 FM	*105.4*	Greater London	Easy listening
26	Absolute Radio	105.8	Greater London	
27	Absolute Radio	105.8	South East England	
28	Heart 106.2	*106.2*	Greater London	Easy popular music
29	Star FM	*106.6*	West London	Adult contemporary music and local news
30	Choice 107.1	*107.1*	North London	Soul, dance, R&B, reggae and local news
31	Time 107.5	*107.5*	East London	- Music, local news and information

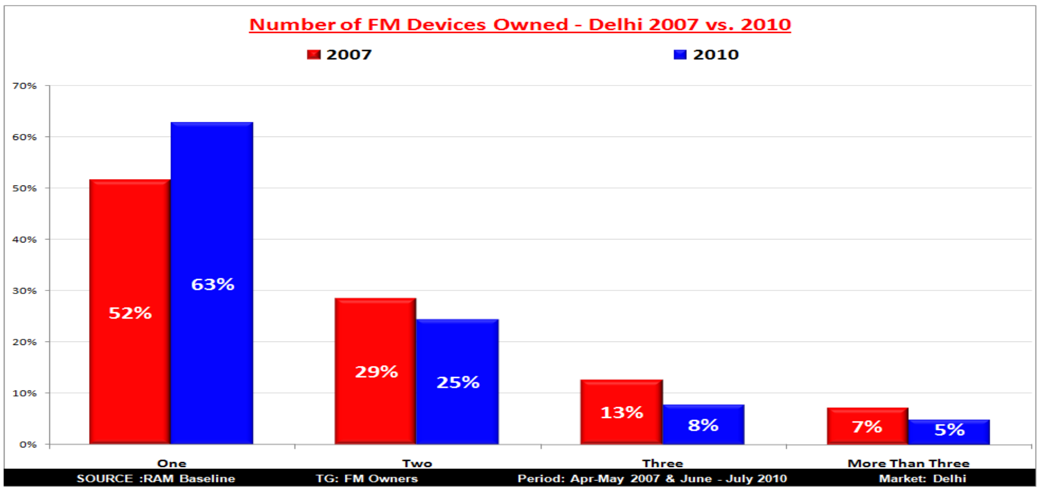
32	Radio Jackie	*107.8*	South West London	
33	BBC Three Counties Radio	*103.8 (Herts)*	North London	News, music and features
34	BBC Three Counties Radio	*104.5 (Bucks)*	North London	News, music and features
35	BBC Surrey	*104-104.6*	Surrey	News, music and features
36	BBC Radio 2	*88-91*	National - Easy listening	
37	BBC Radio 3	*90-93*	National - Classical music	
38	BBC Radio 4	*92-95*	National - News, drama, features, magazine programmes, comedy	
39	BBC Three Counties Radio	*95.5(Beds)*	North London	News, music and features
40	BBC Radio 1	*97-99*	National - Pop and rock	
41	Classic FM	*99.9-101.9*	National - Classical music	
42	BBC World Service	*various frequencies*	International (shortwave), National (1am-5.30am on R4 frequencies) -	News, drama, features, magazine programmes, comedy

Annexure- V

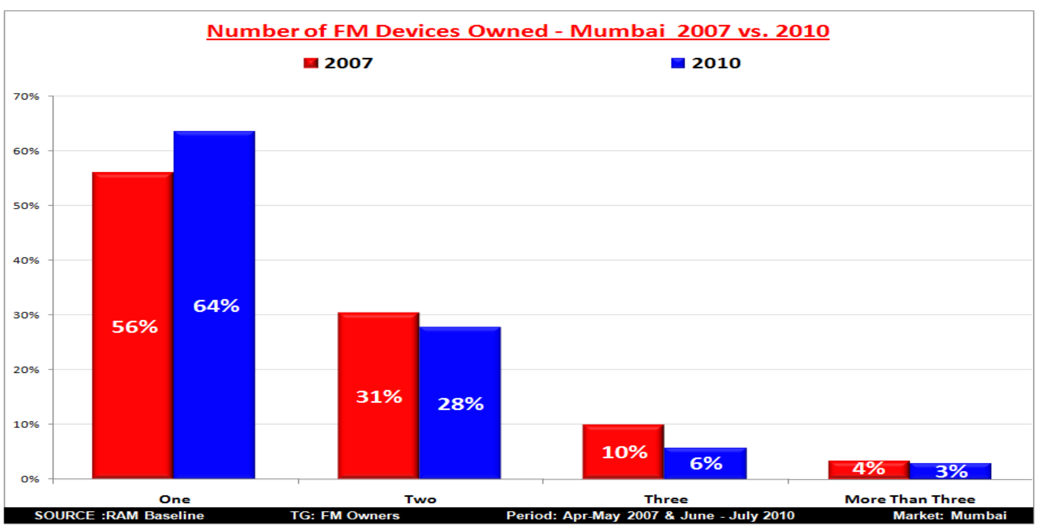
Extract from 'Radio Establishment Survey-Universe Update 2011'

Number of FM devices Owned:

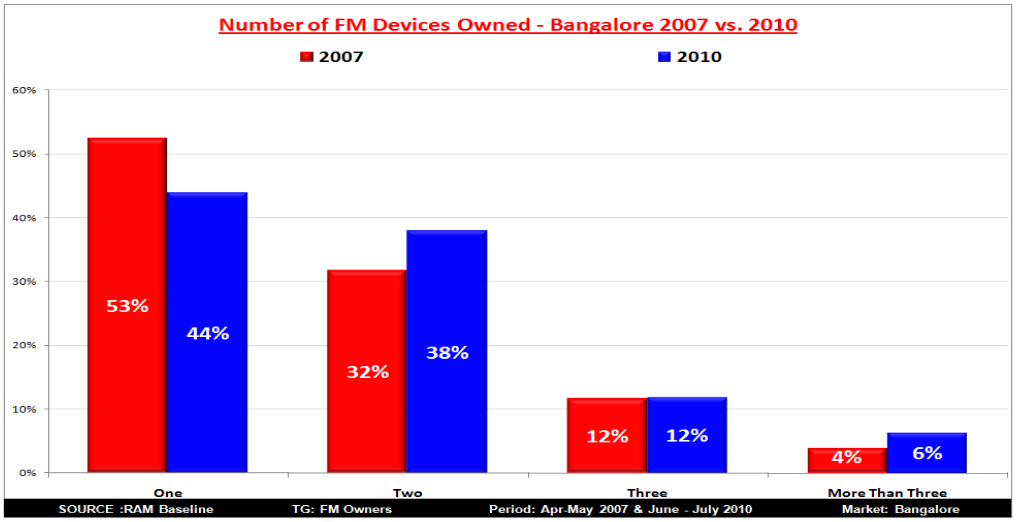
Delhi: Listeners owning only 1 device has seen an increase from 52% in 2007 to 63% in 2010



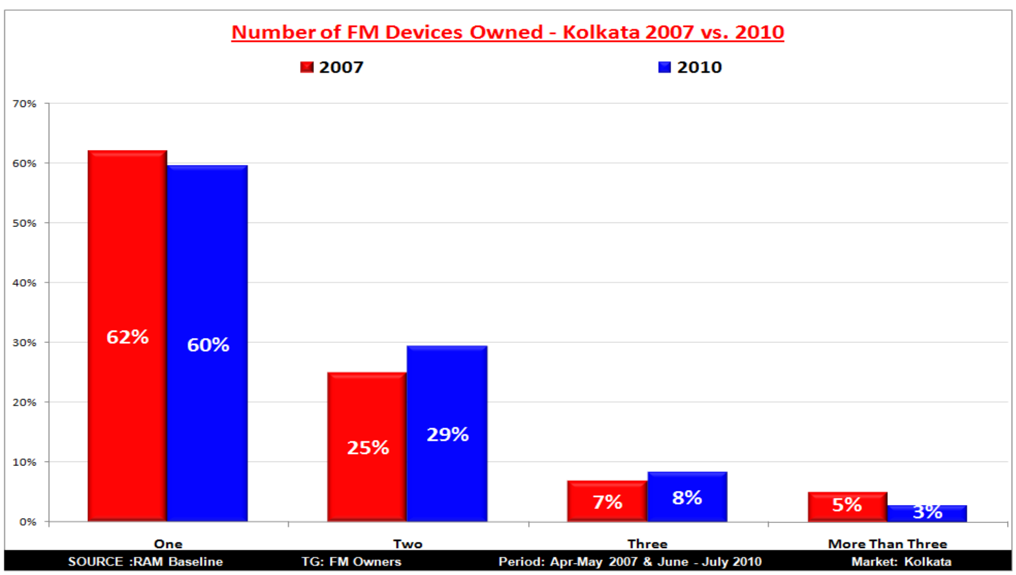
Mumbai: Listeners owning only 1 device has seen an increase from 56% in 2007 to 64% in 2010.



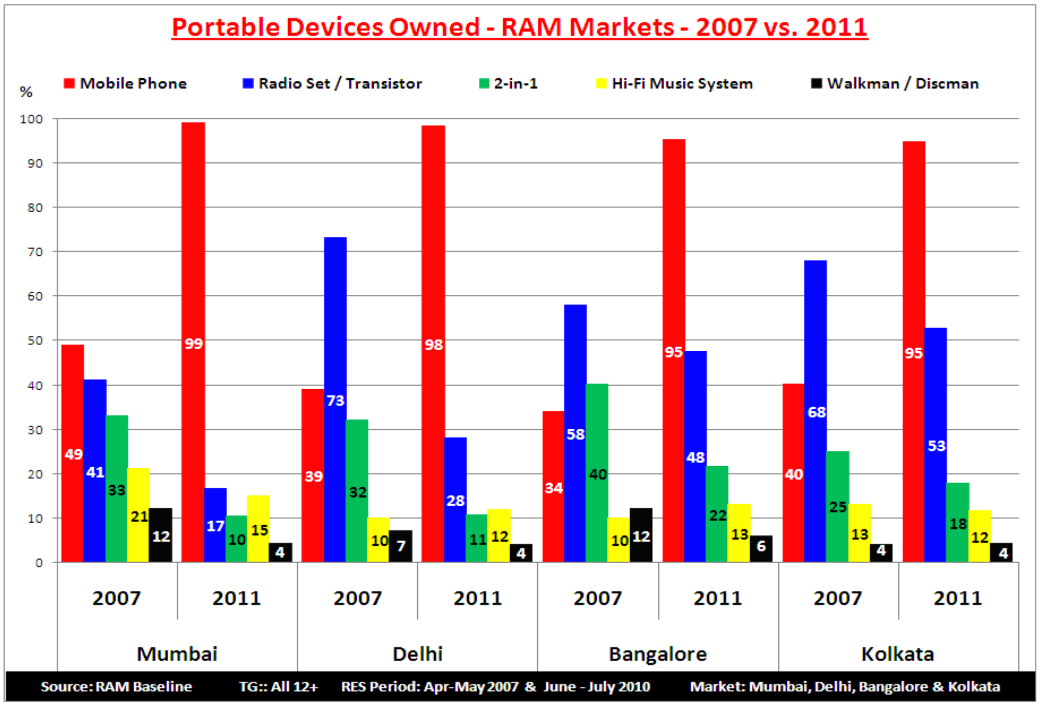
Bangalore: Bangalore is the only market which observes heavy number of listeners owning two devices (38%) for radio listening.



Kolkata: Majority of the listeners have access to FM only through 1 device.

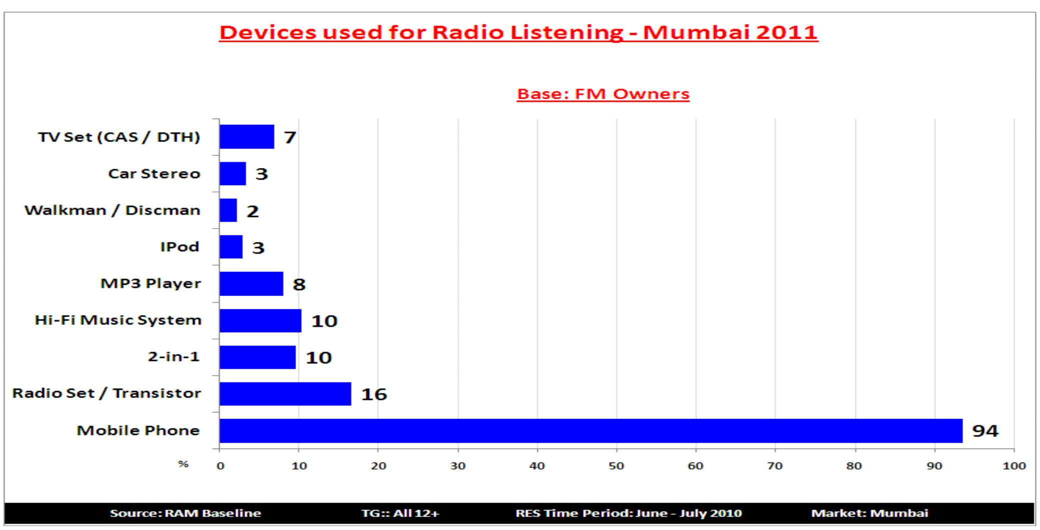


Comparison of devices owned by FM owners between 2007 and 2011:

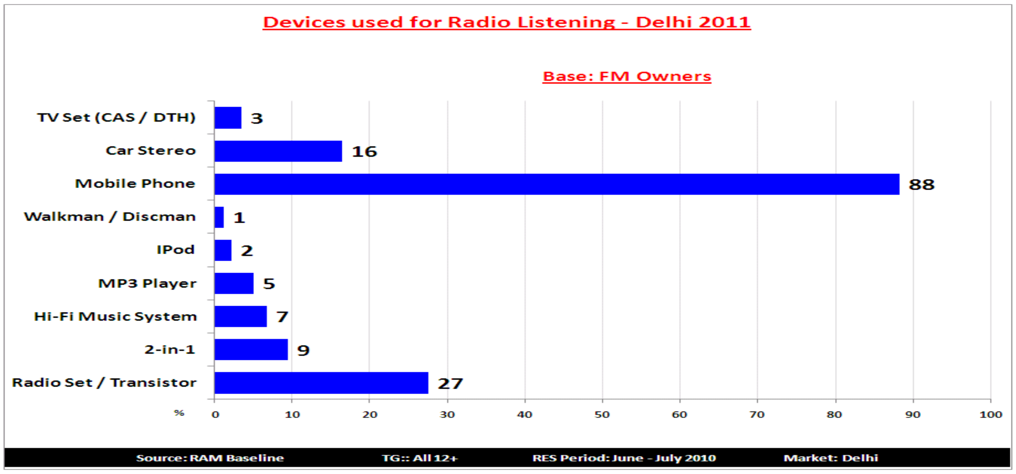


<u>Device used for listening to FM Radio (%):</u>

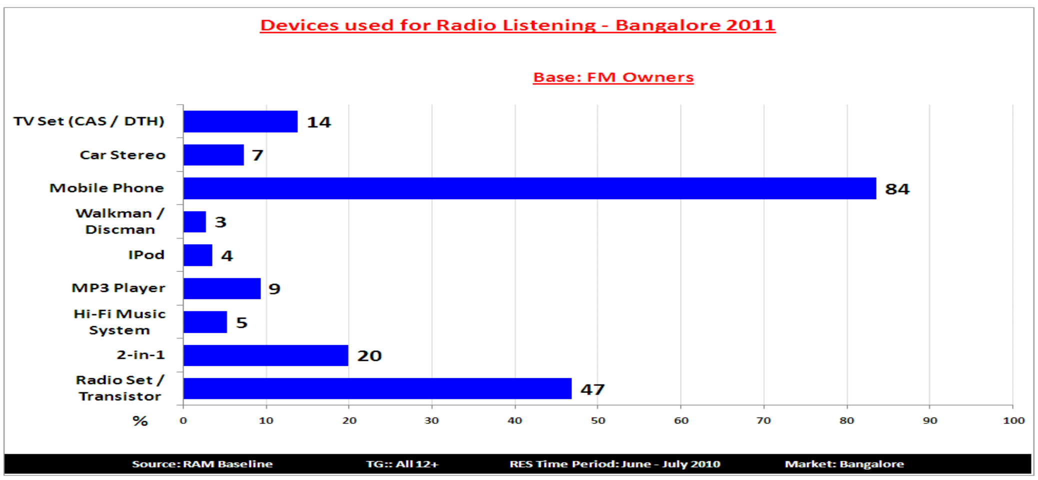
Mumbai: Majority of the radio listening is preferred on Mobile Phones



Delhi: Mobile phones has been used maximum for radio music listening.



Bangalore: Majority of the radio listening is preferred on Mobile Phones.



Kolkata: Mobile phones followed by Radio Set/ Transistors has been preferred maximum for Radio Listening.