

REPORT ITU-R BS.2104*

FM modulator interference to broadcast services

(2007)

Foreword

This Report has been prepared by the Radiocommunication Study Group 6 and the Radiocommunication Working Party (WP) 6E and contains information gathered from a number of external sources as well as from Radiocommunication WP 6E. This Report retains the original text provided by the various Appendices.

1 Introduction

Recent growth in a variety of personal audio and satellite devices on a global basis, such as flash-players and various other consumer electronic devices has led to an extraordinary international proliferation of short-range FM modulators for home and mobile use. These devices are used in the broadcasting channels in the VHF frequency band allocated for sound broadcasting in the Radio Regulations. Although the RF emission levels of these devices may be compliant with regulatory standards as manufactured, the growing number of complaints by radio listeners tuned to FM radio stations raises serious concerns about interference. Unwanted radiation and emissions from these devices can cause objectionable interference to licensed FM broadcast stations. Broadcast systems are designed to take into account intrinsic receiver noise and external radio noise including atmospheric, man-made and galactic noise. The radiation from these short-range devices increases the level of other man-made radio noise, causing an increase in the total external radio noise. The increase of external radio noise results in an increase in the minimum usable field strength and in the degradation of the reception quality of the broadcasting services. The reception environment of broadcasting services needs to be protected from this interference.

2 Summary

The increasing proliferation of short-range FM modulators for consumer use with automobile and personal audio devices has led to the studies described in this report. Four Appendices are provided that address the concerns for interference.

Appendix 1: This text studies the emissions from various FM modulators currently available to the consumer. These modulators are intended to be connected to consumer audio devices for subsequent transmission into the FM radio band from 88 to 108 MHz. At 3 m from the FM modulator, the majority of the modulators tested exceeded the recommended minimum usable field strength for rural environments and many for urban and large city environments expected at 10 m based upon Recommendation ITU-R BS.412-9 – Planning standards for terrestrial FM sound broadcasting at VHF.

Considering that the automobile antenna is located 1.5 m above ground, it is expected that automobile receivers must operate with minimum usable field strengths at least 10 dB below the values measured at 10 m. The consequence is that automobile FM radios may be more susceptible to interference from FM modulators especially when these FM modulators are used within a nearby vehicle.

* This Report should be brought to the attention of Radiocommunication Working Parties 1A and 1B.

Appendix 2: This text studies further the emissions from FM modulators that are wired devices. These supplemental measurements were conducted to determine the compliance of devices commonly used in automobiles for modulating the audio from satellite radio receivers and MP3 or personal audio players onto frequencies that can be received on a standard automobile FM receiver. The measurements show that the use of a “Y” cable with a “Wired” device yield field strengths at 3 m that are in excess of the prescribed FCC Part 15 limits.

Appendix 3: This text reports on a study to measure the field strength of signals emitted from a variety of highways in the Washington, DC area. The results indicate that nearly one percent of vehicles were found to have operating modulators on one of two broadcasting channels. Of these, approximately one-third are operating with emissions exceeding the regulatory limit that could result in objectionable co-channel interference to broadcast services

Appendix 4: This text addresses concerns in Europe for interference from FM modulators. The European Broadcast Union (EBU) recommends guidelines for countries intending to allow the use of low-power FM modulators. The guidelines include strict enforcement of minimum radiated power limits, limited frequency modulation, full range tuning, and a prohibition on direct connection to external antennas.

3 Conclusions

Broadcasting services are particularly susceptible to interference emanating in the vicinity of the receive antenna under low signal conditions. The increase in FM modulators has brought about a need for further protection to the FM sound broadcasting service.

- 1 The results of field strength measurements of various FM modulators support the need for recommendations on the use of FM modulators.
- 2 Since FM sound receivers are vulnerable to co-channel interference, it is possible to avoid the interference by assigning a default FM modulator frequency of operation to a frequency typically receivable on commercial VHF radio receivers, but where possible, one not generally assigned.
- 3 Where short-range FM modulators are allowed, emission limits need to be restricted to a minimum that avoids interference in FM receivers.
- 4 In addition, the FM modulators should be capable of full band frequency selection to avoid interference to stations on channel, or on an adjacent channel to, the frequency of modulator operation.
- 5 Administrations should encourage manufacturers of FM modulators, for automotive installations with direct connections to automobile antenna systems, to provide permanent connectors that avoid the possibility of inadvertent reverse connection to the external antenna.
- 6 Where direct connection of short-range FM modulators to automotive radios and antenna systems is permitted by administrations, administrations should provide enforcement safeguards to avoid retransmission and disruption to licensed FM broadcasting stations.

Appendix 1

Regarding study and measurement of FM modulator devices operating in the FM broadcast band¹

1 Introduction

A series of measurements were conducted on 17 “wireless” devices as well as 4 “wired” devices. Measurements of the field strength of the FM Broadcast Band signal transmitted by these devices were made. In addition, verification of the required FCC ID numbers and verification of the compliance with the antenna rules was also performed. This report describes recent measurements of measured field strengths from the devices and outlines the compliance of these devices with other Part 15 requirements.

2 FCC Part 15 operation

The FCC’s Office of Engineering and Technology (OET) issued a Bulletin Number 63 in October 1993, which provides the correct method for calculation of the Maximum Emission Limit or Maximum Field Strength that is permissible from the subject Part 15 device. For frequencies in the FM Broadcast Band (88-108 MHz) there are four limits depending upon the type of emission that the device transmits.

Intermittent Control Signals that do not have high duty cycles are allowed higher emission limits than those devices that are used to continuously transmit (such as an FM audio transmitter). For the devices under study the limit is 250 µV/m at a distance of 3 m from the device. The FCC limit can also be expressed as follows:

$$20 \log (250 \mu\text{V/m}) = 47.95 \text{ dB}\mu\text{V/m}$$

For comparison purposes in the charts of the report we have rounded the FCC Part 15 limit to 48 dBµV/m. This limit is applied to devices that are equal to or less than 200 kHz in bandwidth. This is detailed in 47 C.F.R. § 15.239 of the FCC Rules.

For devices with bandwidths in excess of 200 kHz, or as the Rules describe “Any” bandwidth, the limit is 150 µV/m (43.5 dBµV/m) at a distance of 3 m from the device (47 C.F.R. § 15.209).

It is also noted that devices that operate pursuant to the Part 15 rules are required to provide to the FCC a “Certification” that the device complies with the requirements of Part of the FCC Rules. This certification is to include data from measurements conducted on the device as well as documentation regarding the measurement facilities, test procedures, and test results of the measurements. This data will be reviewed by the FCC and an appropriate FCC ID number assigned to the device by the FCC OET.

3 Part 15 label requirements

The FCC Rules require that these devices have two labels attached to them. The first label required is the FCC ID number as described previously. Once certification is granted by the FCC this assigned ID number must be marked on the device. However, there is also the requirement that the device must have a “Compliance” label. The “Compliance” label serves as an indication to

¹ National Association of Broadcasters, The original text can be found at http://www.nab.org/xert/corpcomm/NAB_Part15_Study.pdf

consumers that the device has been authorized by the FCC. As noted later in this Report, the majority of these devices did not have a “Compliance” label affixed to them.

4 Antenna requirements of Part 15

Another requirement of devices that operate pursuant to Part 15 of the rules is the restriction on the type of antennas that may be provided with the device. In §15.203 of the FCC Rules, the Commission requires that the device be certified with the antenna that is to be provided with the device. And, the Commission adopts restrictions on the types of connectors that can be used for antenna connections to prevent consumers from using antennas other than those provided with the unit. The intent of these requirements is to prevent the use of an antenna that may allow the device to exceed the emission limits of the rules. (Antennas other than those used during the Certification Measurements for the device.) Essentially, the requirement is that these devices should have permanently attached antennas, or “unique connectors” that is not of a “standard” type found at an electronics store.

In the case of the devices that were studied there appear to be three devices that do not comply with these requirements. Device No. 9 is provided with a “rod” antenna with a standard “threaded” end for connection. But, more disturbing is that this device also has a standard “F” connector output for connection to an external antenna (or power amplifier). Devices No. 15 and No. 16 are provided with standard 2.5 mm audio connectors for connection to the supplied external antenna. The supplied antenna is simply a piece of No. 20 gauge wire approximately 12 inches in length. This connector would also not comply with the Commission’s requirements for using “unique” connectors as 2.5 mm audio plugs are standard connectors that can be found in any electronics store.

5 Devices under test

The Devices under Test (DUT) are listed in the Tables 1 and 2. These devices were obtained in the standard commercial marketplace and are generally available to all consumers. The devices were chosen to represent a variety of manufacturers, device type, price, and features. These devices are believed to be fairly representative of the Part 15 FM devices that are commonly available to consumers and are representative of devices in general use by consumers.

The devices are broken into two different categories to allow a better comparison of various FM devices. The first group is called “Wireless” devices. These devices are wireless in nature and do not connect to the FM receiver being used to listen to the audio transmission other than by mutual RF coupling to the receiver from the transmitter. The second group of devices is called “Wired” devices. These units are designed to be inserted between the antenna input on an automobile radio receiver and the automobile antenna. Hence, they are directly “wired” to the automobile radio receiver.

The FCC Rules at 47 C.F.R. § 2.925 and § 15.19 require that the FCC ID number as well as a “Compliance” label be permanently marked on the device. An inspection of each device was conducted to determine the FCC ID number marked on each device as the FCC Rules require. In two cases of the “wireless” devices, no such FCC ID was marked on the device. In the case of the “wired” devices none of them were marked with an FCC ID number. Only a few of the devices were marked with the appropriate “Compliance” label as required.

TABLE 1
“Wireless” devices under test

Device No.	Manufacturer	Model No.	FCC ID #
1	Akron	SF-150a	ME2-SF150
2	Akron	SF-250	ME2-SF250
3	Belkin	Tune Cast F8V367-APL	K7SF8V367
4	Belkin	Tune Cast II F8V3080	K7SF8V3080
5	C Crane Co.	FMT	BYG006
6	Dynex	DX-AC101	POSEF6208
7	Dynex	DX-MP3FM	POSEF6215
8	Griffin Technology	iTrip 9500 TRIPDA	PAV4026
9	Hobbytron	FM25B	NO FCC ID # On Case
10	iRiver	AFT-100	RKVATB350
11	iRock	450FM	QDNDGT201
12	Lenmar	AI-MODAM	NO FCC ID # On Case
13	Monster iCar Play	AI IP FM-CH	RJE160732-00
14	RCA	MM70FM	POSPC-7207
15	Sirius	S50	O6ZS50-C1
16	Sirius	Sportster SP-TK2	P3HSP-R2
17	Starvision	FT-07	RJX93FMT07

TABLE 2
“Wired” devices under test

Device No.	Manufacturer	Model No.	FCC ID #
18	Delphi	SA10003	NO FCC ID # On Case
19	Pyle	PLMD2	NO FCC ID # On Case
20	Scosche	FM-MOD01	NO FCC ID # On Case
21	Starvision	FM-07	NO FCC ID # On Case

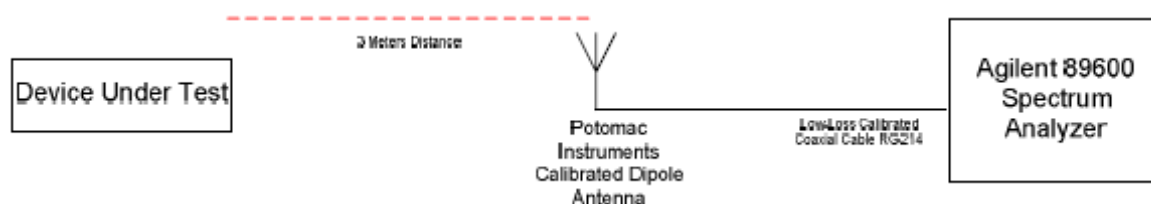
6 Description of test setup

The FCC outlines the specific measurement procedures to be used for Part 15 Compliance measurements in both the FCC Rules and in a document authored by the FCC OET in Bulletin No. 63. Further, the FCC released a Public Notice on October 1993, further clarifying the applicable rules to these devices.

The tests conducted for this study utilized the methods described in these documents. A test location was chosen that was free from discernable co-channel FM Broadcast Stations to allow accurate measurements of the signals from the Device under Test (DUT). The test setup included the use of a NIST-Traceable Calibrated VHF Dipole Antenna (Potomac ANT-71) mounted on a tri-pod and connected via low-loss coaxial cable to an Agilent 89600 series spectrum analyzer (see Fig. 1).

FIGURE 1

Test setup



For the first series of tests, the Device under Test (DUT) was placed on a wooden stand at a distance of 3 m from the calibrated dipole antenna (see Fig. 2). The antenna element lengths were set to the corresponding frequencies based upon the chart supplied with the antenna (see Appendix A).

A series of measurements were made with the spectrum analyzer on the FM carrier emitted by the DUT. First, a measurement of the un-modulated FM carrier was made and a plot of the corresponding spectrum was made. Next, the device was modulated with audio and an additional measurement and spectrum plot were made. Finally, with the audio modulating the FM Carrier, a spectrum plot was made with the spectrum analyzer in the “peak-hold” mode, to establish the approximate deviation (occupied bandwidth) of the device when operating.

FIGURE 2

Test location



7 Measurement results

The measurements summarized in this Report were conducted during the time period 14 May-2 June 2006. In Fig. 3, based on Table 3, a graph of the measured field strength emitted from the device at the prescribed distance of 3 m is shown. *You'll note that 76.5% of the devices exceed the 48 dB μ V/m limits of Part 15 operation. Only four devices were found to be compliant with the emission limits. (Only 24.5% were compliant).*

The devices that were found to be compliant with the emission limits were device No. 5, 6, 8, and 13. All the other "wireless" devices were found to be above the limits. The worst offender was device No. 9 with the highest field strength of 99.9 dB μ V/m. If we ignore this as a statistical "outlier" and use the other field strength for this device of 86.9 dB μ V/m and 88.5 dB μ V/m, the device exceeds the Part 15 limit by approximately 40 dB. The average of all the measurements was 62 dB μ V/m (1,259 μ V/m) which exceeds the Part 15 limit by 14 dB (5 times the limit).

FIGURE 3
"Wireless" device field strength at 3 m
(measured values shown with the FCC limit of 48 dB μ V/m)

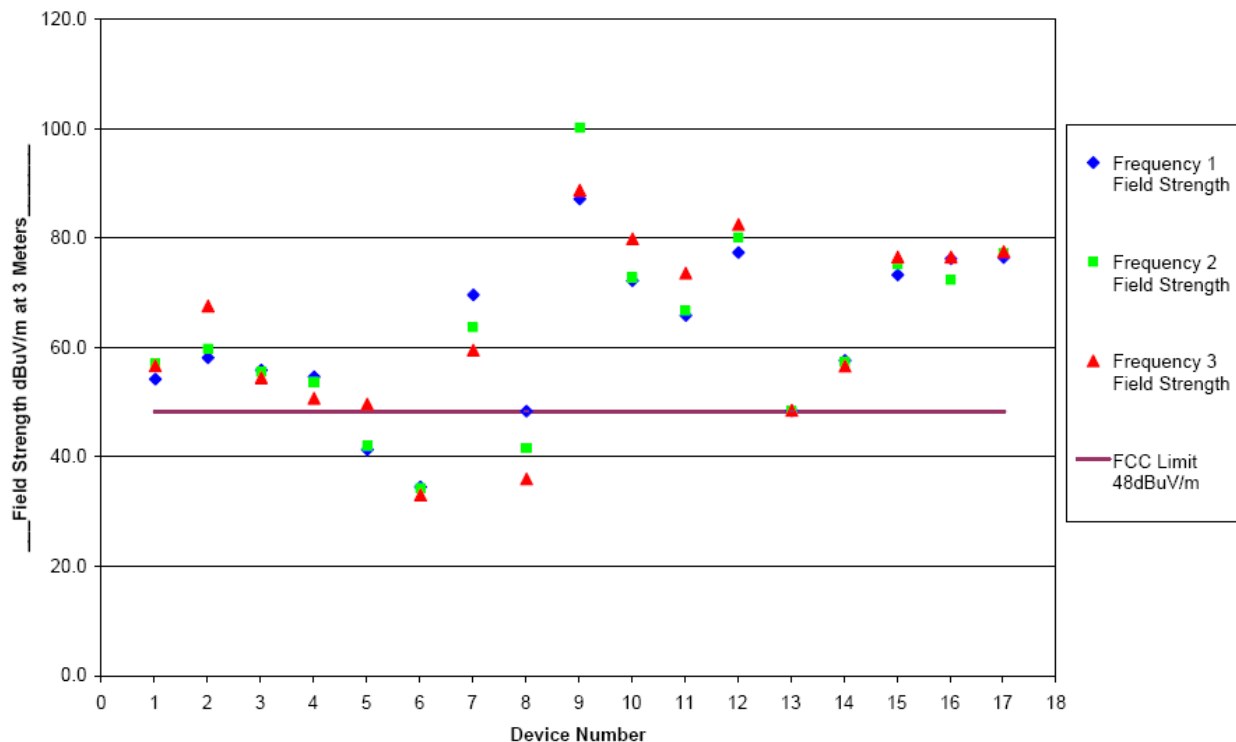


TABLE 3
“Wireless” devices measurement results (devices highlighted in yellow are above limits, compliant devices highlighted in green)

Device	Frequency 1	Field strength w/K factor (dB μ V/m)	Frequency 2	Field strength w/K factor (dB μ V/m)	Frequency 3	Field strength w/K factor (dB μ V/m)
1	88.3	54.0	93.5	56.8	95.1	56.4
2	88.3	57.9	88.7	59.5	107.7	67.3
3	88.3	55.5	88.5	55.2	88.7	54.2
4	88.3	54.4	98.5	53.4	107.7	50.5
5	88.3	41.1	98.5	41.7	107.7	49.4
6	88.1	34.2	88.3	34.0	88.5	32.8
7	88.3	69.4	98.5	63.4	107.7	59.3
8	88.3	48.1	98.5	41.3	107.7	35.7
9	88.3	86.9	98.5	99.9	107.7	88.5
10	88.3	72.0	98.5	72.5	107.7	79.6
11	88.3	65.6	98.5	66.5	107.7	73.4
12	88.3	77.1	100.5	79.8	106.5	82.2
13	88.3	48.2	88.7	48.1	89.1	48.2
14	88.1	57.4	88.3	57.1	88.5	56.3
15	88.1	73.0	98.5	74.9	107.7	76.3
16	88.3	76.0	98.5	72.0	107.7	76.3
17	87.9	76.1	88.3	77.0	88.7	77.2

For the “Wired” devices, the tests indicate that the devices are generally compliant with the Part 15 limits (see Table 4 and Fig. 4). The highest measured field strength of these devices was No. 18 with a field strength of 49.1 dB μ V/m which is within 1dB of the prescribed limit. For the purposes here, it was determined that these devices were compliant. It is noted that the average field strength for these devices was 46.96 dB μ V/m, well within 1 dB of the limit.

TABLE 4
“Wired” devices measurement results

Device	Frequency 1	Field strength w/K factor (dB μ V/m)	Frequency 2	Field strength w/K factor (dB μ V/m)	Frequency 3	Field strength w/K factor (dB μ V/m)
18	87.9	49.1	88.1	45.4	88.5	43.3
19	88.5	48.3	88.9	42.7	NA	NA
20	87.9	48.0	88.3	48.0	NA	NA
21	87.9	48.8	88.3	48.2	88.7	47.8