IEEE 802.4L

Through-the Air Physical Media, Radio

FCC Rules on Direct Sequence Spread Spectrum

Summary of current and projected FCC regulations

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The attached report is a summary of a brief study of the current and projected FCC regulations on Dirct Sequence Spread Spectrum (DSSS). An attachment is pertinent parts of CISPR 16 describing the quasi-peak detector which I agreed to send at the Atlanta meeting.

FCC RULES ON DIRECT SEQUENCE SPREAD SPECTRUM

1.0 Summary

The attached documents were put together to summarize the current regulatory status of Direct Sequence Spread Spectrum (DSSS) within the FCC. DSSS was authorized in 1985 and resulted in section 15.126 of the Code of Federal Regulations (FCC part 15). Recently section 15.247 defining some new requirements was included in an FCC First Report and Order and will probably become an accepted rule.

These current rules are brief and simple. However, there are many issues still outstanding. The attached documents are copies of selected parts of pertinent regulatory documentation.

The issues are:

1. Field Strength vs. Absolute Power Level
2. If Field Strength, How Measure (Average, Quasi Peak or Peak)
3. Multiple Intentional Radiators (Parameters to Regulate)
4. Further Regulations on Spreading (Processing Gain and Spectrum Smoothness)

2.0 References

The attached pages are selected from the following Documents.

1. Part 15 of the Code of Federal Regulations
2. FCC Document 87-300, Notice of Proposed Rule Making, General Docket No. 87-389, In the Matter of Revision of Part 15 of the rules regarding the operation of radio frequency devices without an individual license, Released October 2, 1987.
3. FCC Document 89-103, First Report and Order, In the Matter of Revision of Part 15 of the rules regarding the operation of radio frequency devices without an individual license, Released April 18, 1989.
4. C.I.S.P.R. 16, C.I.S.P.R. specification for radio interference measuring apparatus and measurement methods, Second edition, 1987.

These will be abbreviated in the rest of the paper.

1. as Part 15
2. as the Notice of Proposed Rule Making or NPRM
3. as The First Report and Order or R&O
4. as CISPR 16

3.0 Summary of Issues

3.1 Field Strength vs. Absolute Power Level

The NPRM proposed that field strength limits be imposed instead of just a maximum power limit. See pages 7 and 8 of the NPRM.

The R&O left the issue unresolved for now and stated that it would be addressed in the near future in another rulemaking proceeding. See page 24 of the R&O.

Since the R&O left the matter unresolved and stated that it would come up later, it is worthwhile to try to understand what has been proposed. The limit proposed was 500 mv/meter at 3 meters with 100 KHz bandwidth but with the detector technique unclear.

The detector technique proposed in the NPRM is CISPR quasi-peak below 1000 MHz and peak above 1000 MHz. Although these techniques were not adopted, the meaning or interpretation of the proposed field strength limits should be assessed assuming the proposed measurement techniques are used. This is done in the attached appendix.

This appendix shows a large discrepancy in the power permitted, with the 802.4 modulation and bandwidth, between the 915 MHz band and the bands above 1000 MHz (2.4 and 5.8 GHz). It also shows that either a quasi-peak or peak detector assumption reduces the permitted power considerably.

The NPRM claims that the proposed field strength limits are equivalent to 1 watt into a dipole antenna. Field strength is a measure of power density (per unit bandwidth) since the measurement bandwidth is low compared to the signal bandwidth. With field strength limits, the permitted power depends on bandwidth so "equivalent of 1 watt --" doesn't have a clear meaning.

Clarification is needed.

3.2 Detector Functions

Part 15 required an averaging detector (RMS voltage) for most field strength measurements before the current rulemaking. The NPRM proposed to change this to CISPR quasi-peak below 1 GHz (see attached CISPR 16 pages) and to peak above 1 GHz. See pages 5 and 6 of the NPRM.

The R&O adopted the CISPR 16 quasi-peak detector for measurements below 1 GHz and continued the use of average power detectors above 1 GHz. See R&O page 16, 17 and 44. A maximum peak limit of 20 dB above the specified average is also required.

3.3 Multiple Radiators

The NPRM proposed to prohibit the use of multiple intentional radiators to extend the range in most cases including Spread Spectrum. See the NPRM page 27.

There was a considerable number of objections to the proposal and multiple intentional radiators were not prohibited by the R&O. See R&O page 25.

The FCC said "We concur with the comments that multiple devices be permitted provided the individual transmitters comply with the rules." This would seem to imply that each antenna of a multiple antenna system can emit 1 watt provided that it is driven by a separate transmitter.

But what is a transmitter? Is a single output stage a transmitter? Can the transmitters all transmit the same signal?

From an interference control standpoint, it seems reasonable that antennas should be considered separate emitters if their signal emissions are uncorrelated from a field strength measurement standpoint. The FCC would probably accept a head-end antenna system where each antenna emits up to 1 watt providing each antenna emission is uncorrelated with the others (field strengths add RMS). However, it is difficult to imagine a head-end system in which all emissions are uncorrelated at all points since all antennas must send the same data sequence.

3.4 Future Spread Spectrum Changes

The FCC is considering further rules on processing gain and spectrum smoothness. See the R&O page 24. They are also considering additional unspecified rules on spread spectrum above 900 MHz. See the R&O page 27.

The FCC is currently requiring at least 10 dB of processing gain in DSSS transmitters although this is not included in the regulations.

There is an unofficial agreement that the 802.4 spreading and bandwidth meets this processing gain requirement.

There is also an unofficial rule on spectrum smoothness which can be satisfied with a 127 bit scrambler. The FCC considered a Public Notice which would require a uniformity of the spectrum equivalent to that provided by a 127 chip spreading code. The public notice was not issued, but it can be taken as a likely component of the eventual resolution of the processing gain question.

At 11 chips/symbol and 500 Ksymbols/sec, as planned for 802.4, there is a potential for repeated dibits creating a spectrum with discrete lines separated by 500 KHz. Such a concentration of energy at discrete frequencies to some extent defeats the objective of spread spectrum. The FCC was particularly concerned about long sequences of all 1s or all 0s (repeated 11 or 00 dibits) since these sequences are very likely to occur.

The FCC notice would have required that the shortest repeated line signal (with repeated dibit data) be at least 127 pseudo-random chips in length. At the 5.5 Mchip/sec rate of 802.4, this would be about 43 Khz between discrete spectral lines.

It is also possible that field strength limits will be used to control spectrum smoothness. Thus, a scrambler should be chosen that would create a minimum response of the CISPR 16 quasi-peak meter. This detector has a 1 ms charge time and a 550 ms discharge time. A sequence that creates a strong line for about 1 ms (1000 bits) will cause a nearly full indication.

Appendix: Field Strength Limits and Measurement Technique

If field strength limits are imposed, it makes a great difference whether average, quasi-peak or peak limits are specified. This difference is compared here.

A uniform field of 500 mv/meter RMS (average power) at 3 meters in 100 KHz bandwidth corresponds to a transmitted power of 75 mw per 100 KHz bandwidth. This would correspond to a flat spectrum power of 1 watt in 1.33 MHz of bandwidth, or potentially 19.5 watts in the 26 MHz available in the 915 MHz band. However, applying the quasi-peak or peak requirement reduces the power allowance.

Consider the 915 MHz quasi-peak case. A 100 KHz wide sample of a DSSS signal appears approximately as random noise, thus the CISPR quasi-peak instrument will indicate a power level about $1.85^2 = 3.42$ times the actual power (CISPR 16, page 157). On this basis, the allowance would be 75/3.42 mw = 22 mw per 100 KHz of bandwidth. 1 watt would be permitted in 4.56 MHz of bandwidth and 26 MHz would permit up to 5.7 watts. Thus, the field strength proposal would allow more than 1 watt EIRP with either detection technique. Directional antennas would be restricted though, depending on the actual bandwidth used.

For the bands above 1 GHz, the peak of a 100 KHz wide sample of a DSSS signal relative to the RMS must be considered. This can be approximated as follows for the IEEE 802.4 modulation and symbol rate:

> The response time of a 100 KHz filter is about 2 το 4 υs or 1 to 2 symbol times. The peak response to 1 symbol (or to 1 or 2 repeated symbols) is approximately the same magnitude as the peak response to a long sequence of repeated symbols. Since repeated symbols are sure to occur, the peak can be assessed based on the long sequence spectrum even though scrambling prevents long sequences of repeated dibits from occuring.
>
> A long sequence of repeated symbols has a spectrum envelope described by the chip code (11 chips) and has discrete frequencies spaced at the symbol rate (500 KHz). Thus, there are about 11 discrete lines separated by 500 KHz. During the response time of the 100 KHz filter, only one line will be in-band.
>
> First, assume that each line has the same energy. In this case 1/11 th. of the total energy will be in-band when the test receiver is tuned to any line. The field strength limit of 75 mw/100 KHz corresponds to 75 mw per spectral line. The total allowed power is thus approximately 11X75 mw = 825 mw EIRP. In the actual case, there will be one or more lines stronger than the average, so the allowed power will be less than 825 mw. 400 mw would allow the strongest line to be just over 3 dB higher than the average.
>
> The above assumes a 3 dB correction factor in the peak measurement receiver. That is, the meter indicates the RMS value (3 dB below the peak) when a constant amplitude signal is sensed and also indicates 3 dB below the peak in other cases.

On the basis of the above, the IEEE 802.4 modulation scheme would be limited to about 400 mw EIRP or about 6 dB antenna gain at 100 mw.

In Summary:

Allowable Power
with 500 mv/meter at 3 meters

	RMS (Current)	Detector Quasi-Peak (Proposed < 1 GHz)	Peak (Proposed > 1 GHz)
EIRP Power IEEE 802.4 Modulation and BW	4.5 W	1.3 W	0.4 W
Allowable Power 26 MHz Bandwidth	19.5 W	5.7 W	1.7 W (Note 2)
Antenna Gain at 100 mw with 802.4 Modulation and BW	16.5 dB	11 dB	6 dB

Note 1: The field strength limits were proposed at the same time that the quasi-peak and peak techniques were proposed. Thus, peak and quasi-peak must be assumed to be intended in the NPRM.

Note 2: This is based on increasing the spreading and keeping the symbol rate the same.

The bands above 1 GHz have more bandwidth available than does the 915 MHz band. For example, there is 85 MHz available at 2.4 GHz. 5.7 watts would be permitted with a peak detector if this whole band is used (at .5 x 10^6 symbol rate). This may be the justification for stating that the field strength limits are equivalent to 1 watt even with the peak requirement in the upper bands. Each would allow 1 watt in about 1/6 the available bandwidth.

(Secs. 4, 303, 307, 48 Stat., as amended, 1066, 1082, 1083; 47 U.S.C. 154, 303, 307)

[46 FR 55527, Nov. 10, 1981, as amended at 47 FR 51760, Nov. 17, 1982]

§ 15.126 Operation of spread spectrum systems.

Spread spectrum systems may be operated in the 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz frequency bands subject to the following conditions:

(a) They may transmit within these bands with a maximum peak output power of 1 watt.

(b) RF output power outside these bands over any 100 kHz bandwidth must be 20 dB below that in any 100 kHz bandwidth within the band which contains the highest level of the desired power. The range of frequency measurements shall extend from the lowest frequency generated in the device (or 100 MHz whichever is lower) up to a frequency which is 5 times the center frequency of the band in which the device is operating.

(c) They will be operated on a noninterference basis to any other operations which are authorized the use of these bands under other Parts of the Rules. They must not cause harmful interference to these operations and must accept any interference which these systems may cause to their own operations.

NOTE: Spread spectrum systems using the 902-928 MHz, 2400-2500 MHz and 5725-5850 MHz bands should be cautioned that they are sharing these bands on a noninterference basis with systems supporting critical government requirements that have been allocated the usage of these bands on a primary basis. Many of these systems are airborne radiolocation systems that emit a high EIRP which can cause harmful interference to other users. For further information about these systems, write to: Director, Office of Plans and Policy, U.S. Department of Commerce, National Telecommunications and Information Administration, Room 4096, Washington, D.C. 20230.

Also, future investigations of the effect of spread spectrum interference to Government operations in the 902-928 MHz band may require a future decrease in the power limits.

(d) For frequency hopping systems, at least 75 hopping frequencies, separated by at least 25 kHz, shall be used, and the average time of occupancy on any frequency shall not be greater than four-tenths of one second within a 30-second period. The maximum bandwidth of the hopping channel is 25 kHz. For direct sequence systems, the 6 dB bandwidth must be at least 500 kHz.

(e) If the device is to be operated from public utility lines, the potential of the RF signal fed back into the power lines shall not exceed 250 microvolts at any frequency between 450 kHz and 30 MHz.

[50 FR 25239, June 18, 1985]

§ 15.131 Certification required for devices that are marketed or built in a quantity greater than 5 and not marketed.

A low power communication device manufactured after October 1, 1975 which is marketed or built in a quantity greater than 5 and not marketed shall be certificated pursuant to Subpart B of this part.

[41 FR 7398, Feb. 18, 1976, as amended at 50 FR 5755, Feb. 12, 1985]

§ 15.132 Labelling and identification requirements.

(a) A device subject to certification by the Commission for which an application is received on and after May 1, 1981, shall be identified pursuant to §§ 2.925 and 2.1045. In addition, the nameplate or label shall contain the following statement:

This device complies with Part 15 of FCC Rules. Operation of this device is subject to the following two conditions: (1) This device may not cause harmful interference. (2) This device must accept any interference that may cause undesired operation.

(b) A device subject to certification by the Commission for which an application is filed between April 1, 1976 and May 1, 1981, shall have permanently and visibly affixed an identification label containing information shown on the sample below.

FCC IDENTIFICATION DATA

Name ____________________

Model No.

Unique identifier ____________________

"This device complies with FCC Rules Part 15 as of date of manufacture."

Date [illegible]anufacture ____________________

(1) *Name.* This shall include the trade name, if any, and the name and address of the manufacturer or of the vendor provided the name of the latter was included in the application for certification.

(2) *Identifier.* This is the model number assigned to the device by the manufacturer or applicant for certification and must be identical to that shown on the application for certification. This identifier must be preceded by the words "MODEL NO."

(3) *Date.* This is the month and year when the device was manufactured. If desired, this may be coded, provided the code therefor is filed with the application for certification.

(c) A device subject to certification by the Commission for which an application was filed before April 1, 1976 may be identified in any manner: *Provided,* The name, number and date required by paragraph (b) of this section are clearly identifiable and distinct from any other number or designator on the device.

(d) When it is not practicable to affix the label required under this section due to the size, use of the device, or other factors, the wording specified under paragraph (a) or (b) above and the FCC identifier (when applicable) shall, as an alternative, be placed on the first page of the instruction manual or a pamphlet given to the user.

(Secs. 4, 303, 307, 48 Stat., as amended, 1066, 1082, 1083; 47 U.S.C. 154, 303, 307)

[44 FR 17180, Mar. 21, 1979, as amended at 45 FR 71356, Oct. 28, 1980; 51 FR 4366, Feb. 4, 1986]

§ 15.133 Certification and identification required for home built device.

A person who constructs not more than five low power communication devices for his own use, and not for sale, need not meet the requirements of § 15.131 and § 15.132. In lieu thereof, he shall attach to each such device a signed and dated label that reads as follows:

I have constructed this device for my own use. I have tested it and certify that it complies with the applicable regulations of FCC Rules Pa[illegible]. A[illegible]py of my measurements is in my possession and is available for inspection.

____________________ (Signature)

____________________ (Date)

§ 15.141 Measurement procedure.

(a) Any procedure acceptable to the Commission may be used to measure the RF energy emitted or conducted by a low power communication device. For swept frequency equipment, measurements shall be made with the frequency sweep stopped. Field strength measurements shall be made, to the extent possible, on an open field site.

(b) The procedure used at the FCC Laboratory for type approval testing of a wireless microphone operating in the band 88-108 MHz is given in FCC Bulletin OCE 19 available from the Commission.

(c) The measurement techniques set out in FCC Measurement Procedure MP 1 "FCC Methods of Measurements for Determining Compliance of Radio Control and Security Alarm Devices and Associated Receivers" is used by the FCC to determine compliance of devices operating under § 15.122 with the technical specifications.

(d) For devices operating between 1.705 and 10 MHz, the following shall be observed:

(1) The minimum bandwidth of the measuring instrumentation shall be:

- 200 Hz for measurements below 150 kHz
- 9 kHz for measurements from 150 kHz to 30 MHz
- 100 kHz for measurements from 30 to 30 MHz

(2) The antenna to be used for field strength measurements shall be:

- below 18 MHz, a shielded balance loop
- from 18 to 30 MHz, a shielded balance loop or calibrated tuned half-wave dipole
- from 30 to 300 MHz, a calibrated tuned half-wave dipole.

(Secs. 4, 303, 307, 48 Stat., as amended, 106[illegible] 1082, 1083; 47 U.S.C. 154, 303, 307)

[28 FR 12521, Nov. 22, 1963, as amended [illegible] 46 FR 55527, Nov. 10, 1981; 51 FR 4366, Fe[illegible] 4, 1986]

—limits proposed for unintentional radiators are as follows:

Frequency Band (MHz)	Field Strength (μV/m)	Measurement Distance [17] (meters)
30 - 88	100	3
88 - 216	150	3
216 - 960	200	3
Above 960	500	3

Two exceptions to the general field strength limits are proposed:

- Class A digital equipment may continue to meet the present standards for the same reasons given above in the case of conducted limits.
- Receivers manufactured or imported prior to June 1, 1997, may continue to comply with the present limits of Section 15.63 of the rules.

26. In addition to the above field strength limits, we propose that receivers without permanently attached antennas be tested for compliance with the antenna terminals connected to a shielded termination and that such receivers be subject to an additional emission power limit at the antenna terminals. This requirement is similar to that now applied to CB receivers [18] and is intended to prevent interference from radio frequency energy emitted from the antenna connected to the receiver. Under the present rules, most receivers are required to be tested with a "standard" antenna connected to the antenna terminals. The use of a "standard" antenna has caused some confusion in the past and has led to inconsistent test results. We believe that the proposed procedure should simplify the testing of receivers and provide better repeatability of the test measurements.

27. Field strength limits above 1000 MHz are proposed for all unintentional radiators in order to account for the higher frequency emissions being produced by these devices. At the same time, field strength limits would apply to CB receivers, receivers that operate within the 30-1000 MHz band, and all other unintentional radiators. [19] The rapidly increasing clock frequencies of digital devices, as well as the increasing popularity of such consumer devices as home satellite receivers [20], have led to increases in the types of devices capable of producing unwanted emissions above 1000 MHz. So as to reduce the probability that interference could be caused to the authorized radio services above 1000 MHz, we propose the establishment of higher frequency field strength limits and the inclusion of higher frequency receivers under the regulations. Comments are requested as to the appropriateness of the frequency range proposed for receivers. Should the frequency range be expanded to a higher frequency, such as 1215 MHz?

28. We recognize that higher field strength limits could be permitted for certain types of emissions without increasing the potential for interference. For example, the proposed limits may impose unnecessary costs if they were applied to some of the emissions from superheterodyne receivers, such as TV broadcast receivers. Superheterodyne receivers generally produce narrow band emissions corresponding to the oscillator frequency and its harmonics. However, these receivers also emit signals on the intermediate frequencies and on the frequencies of received subcarriers. The narrowband emissions from the receiver oscillator are not as prone to causing interference problems. Thus, comments are requested as to whether the Commission could permit higher signal limits on the oscillator frequency. If so, what should those limits be? Should this relaxation apply only to the specific oscillator frequency or should it also apply to the harmonics of that oscillator?

29. The Commission is aware that the proposals contained within this item for unintentional radiators entail some costs to the manufacturers of this equipment that could be borne by consumers. We request comments as to the magnitude of these costs. We also request comments on the degree to which the proposed grandfather period could offset any impact to the manufacturers of unintentional radiators.

30. The adoption of these proposals for unintentional radiators could affect both the manufacturers of Part 15 unintentional radiators and the users of authorized radio services. The users of authorized radio services should experience a reduction in background noise levels, *i.e.*, a decrease in the level of interference to their operations. A large number of Part 15 unintentional radiator manufacturers, particularly receiver manufacturers, could be required to redesign their equipment in order to comply with these specifications. However, it should be noted that the Commission's recent testing of TV broadcast receivers indicated that some TV receivers already comply with the limits proposed in this Notice. At this juncture, we believe that the 10 year grandfather period would permit equipment manufacturers to comply with the proposed standards as they introduce new designs. This would allow the impact to these manufacturers to be minimized.

D. Measurement Techniques

31. Updated measurement procedures for all intentional and unintentional radiators will be published for public comment soon. These procedures will be based, insofar as practicable, on American National Standards Institute (ANSI) Standards C63.2 and C63.4 as well as on current FCC practices. Our proposed measurement procedures will detail those procedures employed by the Commission to evaluate equipment.

32. *Measurement of Power Line Conducted Emissions.* We are proposing to standardize the measurement of conducted emissions by specifying a standard Line Impedance Stabilization Network (LISN). The present regulations are divided between the use of an old test method based on a 50 Ohm/5 uH LISN and a newer test method based on a 50 Ohm/50 uH LISN. The use of the 50 Ohm/50 uH LISN is in conformance with ANSI Standard C63.4 and the standards recommended by the International Special Committee on Radio Interference (CISPR) and was was requested by the computing device industry. The impedance of the 50 Ohm/5 uH LISN falls off rapidly at lower frequencies and is not as effective as the 50 Ohm/50 uH LISN. Therefore, in this revision of Part 15 we are proposing to require the use of the 50 Ohm/50 uH LISN, as described in ANSI Standard C63.4, for all measurements of power line conducted emissions. The 50 Ohm/5 uH LISN may continue to be used for grandfathered receivers.

33. *Detector Functions of Measuring Instruments.* The existing rules in Part 15 express most field strength limits in terms of the average value of the emission. For a pulsed emission, it is necessary to determine this value by calculation. This process can be time consuming to perform and increases the time for the FCC to review test data or

evaluate devices. Also, for very brief pulses, the currently used averaging time of 0.1 second permits peak emissions of very high levels that may increase the interference potential of the device. In addition, the complexity of this test procedure makes it difficult to obtain repeatability of measurement results.

34. With the widespread implementation of digital systems within both intentional and unintentional radiators, the use of emission limits expressed as an average value may not provide a suitable indication of the interference potential of the device under test due to the high peak emissions. However, the use of a CISPR quasi-peak detector, as described in CISPR Publication 16, gives a better indication of the interference potential of a signal since it provides a closer representation of the power density of the radiated signal, accounting for the peak emissions. It also provides a reliable and repeatable method of measurement. In addition, the interference potential of the general emission limits in this proposal was established based on CISPR quasi-peak measurements. For these reasons, we are proposing to employ the use of a CISPR quasi-peak detector for emissions below 1000 MHz. Since the CISPR quasi-peak measurement procedure standard currently applies only to frequencies below 1000 MHz, we are proposing to require peak measurements above 1000 MHz.

35. The use of CISPR quasi-peak measurements could result in a reduction of the permitted signal levels of some devices, particularly those employing pulsed emissions. This may be a reasonable trade-off since the CISPR quasi-peak measurements appear to provide a better indication of the potential of the emission level to cause interference, are easier to perform and provide better repeatability. However, it is realized that such a change in the measurement techniques could significantly impact the users and manufacturers of pulsed modulation devices, particularly garage door opener controls and wireless security alarm systems. For this reason, this Notice proposes to permit intentional radiators operating under the provisions for periodic transmitters above 70 MHz, including control and security alarm devices, to continue to measure their emissions to comply with average limits, except for those emissions occurring within the restricted frequency bands. At the same time, a limit on the peak-to-average ratio, restricting peak emissions to no higher than 20 dB above the maximum average field strength, is proposed to reduce potential interference problems. The use of CISPR quasi-peak measurements is optional for these devices. At the same time, we request comments on the suitability of requiring periodic transmitters, *i.e.*, pulsed modulation devices, to comply with the emission limits when measured in the CISPR quasi-peak and peak modes. Comments are requested on the relationship between peak, CISPR quasi-peak and average emission measurements for these pulsed modulation devices. Based on these relationships, comments also are requested on suitable adjustments to the emission limits that could be applied to control and security alarm devices operating above 70 MHz, allowing the majority of these devices to continue to employ the same operating range as under the present regulations, should the Commission adopt CISPR quasi-peak and peak (above 1000 MHz) emission specifications for these devices.

AUTHORIZATIONS AND APPLICATIONS

A. Equipment Authorization Program.

36. We recognize that this Notice is proposing a number of new frequency bands and standards that would allow for the development of new devices with which this Commission has no prior experience. For this reason, except for placing FM wireless microphones and telemetry transmitters in the 88-108 MHz band under the certification procedure instead of type approval, no changes to the equipment authorization requirements are being proposed. Certification would continue to be applied to all intentional radiators and some unintentional radiators. Other unintentional radiators would continue to be authorized under the notification and verification procedures.

B. Kits.

37. We also are proposing to place RF devices marketed in kit form under our regulations. Measurements demonstrating compliance with the relevant technical standards for verification or an application for Commission authorization shall be performed using assembled representative kits. The lack of technical regulations for mass-marketed kits has resulted in a number of non-authorized devices being offered in kit form. Such devices have a high potential for causing harmful interference to the authorized radio services. By placing kits under our standards, this interference potential could be controlled. Home-built units not constructed from kits that are produced in quantities of five or less and that are not marketed would continue to be verified for compliance by the parties assembling them. For more detail on the authorization program, see the proposed Sections 15.23, 15.25, 15.101, 15.103 and 15.201.

C. Exemptions for Digital and Test Equipment.

38. The Commission has exempted five categories of computing devices from the technical standards in Subpart J of Part 15 of the regulations. These are: 1) computing devices that are utilized in a transportation vehicle; 2) electronic control or power systems used by a public utility or in an industrial plant; 3) industrial, commercial and medical test equipment; 4) computing devices used in appliances; and, 5) specialized medical computing devices. This item proposes to retain these exemptions. In addition, we propose to exempt all digital devices that require a power input of 6 nW or less. This level was chosen based on the power needed to cause radiated emissions to exceed the general field strength limits when radiated over free space from an isotropic antenna. That amount of power was calculated to be 3 nW. The 6 nW figure assumes a 50 percent efficiency of converting supply voltage into radio frequency energy. Further, we propose to exempt the following digital devices: musical greeting cards, quartz watches and clocks, modules of quartz watches and clocks, and battery operated hand-held calculators and electronic games not requiring connection to the AC power lines.

39. The devices newly proposed to be exempted from the technical standards are currently subject to verification to the standards in Subpart J of Part 15 as computing devices before they can be marketed within the U. S. However, these devices generate such low levels of radio frequency emissions that they have virtually no potential for interfering with the authorized radio services. By delet-

ing the technical regulations for low powered digital devices. the Commission would remove a large regulatory burden for a considerable number of consumer devices. Comments also are requested on the feasibility of exempting from the technical standards portable. battery operated personal computers operating below a specified clock rate and power input limit and portable. battery operated peripherals used solely with such computers. Comments are requested on the maximum 1.0 MHz clock rate and 0.1 W power consumption limits proposed in the regulations, qualifying such computers and peripherals as calculators.

D. Importation.

40. Under Part 2. Subpart K of the Rules, the Commission requires the use of FCC Form 740 for each shipment into the United States of radio frequency devices. Based on the reasoning shown in the preceding paragraphs, we propose to discontinue the requirement for FCC Form 740 for all radio frequency devices with a power input to the radio frequency stage of no greater than 6 nW, musical greeting cards, quartz watches and clocks, modules of quartz watches and clocks. and battery powered hand-held calculators and electronic games not requiring connection to the AC power lines. [21] At the present time. it appears that the relaxation of the importation regulations for devices with a power input to the radio frequency stage of less than 6 nW would affect only digital devices. Comments are requested as to any other devices that may fall within this exemption.

MISCELLANEOUS PROPOSALS

A. TV Interface Devices

41. The limits applied to RF signals that are conducted over the output connecting cable of a TV interface device are proposed for deletion. The interference from a TV interface device is controlled primarily by the radiated limits. the power line conducted limits. and the limit on RF energy to any receiving antenna connection. It does not appear that the RF output signal limits significantly affect the interference potential of the equipment. Therefore, it is believed that the imposition of such a limit places unnecessary restrictions on TV interface devices that may impede design innovations. However, we are concerned that the deletion of the output signal limits could inadvertently permit the authorization of transmitters that exceed the general field strength limits being marketed for operation on the television broadcast frequencies. Comments addressing this concern are requested.

B. Antenna Connections for Intentional Radiators.

42. The present rules require some intentional radiators to be self contained with the antenna permanently attached to the enclosure of the device, and prohibit the use of any antenna other than that furnished by the manufacturer. These requirements apply primarily to 49 MHz transmitters operated under Sections 15.118 or 15.119, 88-108 MHz transmitters operated under Sections 15.162, 15.174. or 15.335, devices that measure the characteristics of a material under Section 15.192, and cordless telephones operated under Section 15.233 of the regulations. Since the antenna characteristics directly affect the field strength of the radio frequency emissions, this regulation was found necessary originally to prevent the use of another antenna that could increase the range of the equipment by increasing the radiated emissions. This regulation has previously been applied only to intentional radiators that are mass marketed for consumer applications or operate on frequencies within the FM broadcast frequency band. However. this item is proposing to delete a number of the current operating restrictions, making operation on most frequencies available for general consumer applications. Since the Commission would no longer be able to base its technical standards on public comments regarding the interference potential of specific devices. more conservative intentional radiator system parameters seem appropriate. For that reason. we are proposing to require that any antenna used with a Part 15 intentional radiator subject to a field strength limit be either permanently attached or use a unique coupler. This action should ensure that only the antenna provided by the manufacturer could be used with the equipment and that the intentional radiator, therefore, would comply with the permitted field strength limits.

C. External Connections for Intentional Radiators.

43. The present regulations do not permit external inputs for some low power transmitters such as cordless telephones and 88-108 MHz wireless microphones. The rationale for this restriction is to limit the usability of the devices, thereby reducing the number of units in the market. Because of the high level of proliferation that already exists for these devices, restrictions on the ability to provide external input signals no longer has any meaningful bearing on the interference potential of the equipment. Thus, we feel that these input limitations could be deleted. This additional flexibility would allow manufacturers to provide features such as cordless telephones with computer modem connections. Manufacturers would be required to provide users with information on the type of accessories that may or may not be utilized to maintain the device in compliance. We request comments on the need to continue to restrict external inputs for some intentional radiators.

D. Special Applications for Intentional Radiators.

44. *Spread Spectrum Systems*. The provisions under the present rules for the use of direct sequence and frequency hopping spread spectrum systems in the 902-908, 2400-2483.5, and 5725-5850 MHz bands are retained in the proposed revision to the regulations without modification except to clarify certain receiver requirements. However, we request comments on the feasibility of changing these standards to reflect a field strength limit, instead of the current transmitter power limit. The use of a field strength limit allows the regulations to be stated in a manner consistent with those applied to other Part 15 devices. It also provides additional control on interference potential. Field strength measurements would be required to demonstrate compliance with the limits in the restricted bands and for spread spectrum operation in any other bands. As no manufacturer to date has obtained authorization for a spread spectrum system, the Commission has no experience with the possible interference impact of permitting spread spectrum systems to operate at the power level stated in the current regulations. Indeed, Section 15.126(c) of the existing regulations states that " . . . future investigations of the effect of spread spectrum interference to Government operations in the 902-928 MHz band may

require a future decrease in the power limits." The use of a field strength limit specification could avoid future changes by the Commission to the permitted power limits.

45. Although we are proposing to retain the present limits in terms of output power for frequency hopping and direct sequence systems, specific comments are requested on the suitability of the following field strength limits for such spread spectrum intentional radiators. The field strength of any emissions appearing within the specified frequency bands would be limited to 500 millivolts/meter at 3 meters with harmonics limited to 1.6 millivolts/meter at 3 meters. Emissions outside of the specified frequency bands, excluding harmonics, would be required to be attenuated at least 50 dB below the level of the unmodulated carrier or to the general field strength limits, whichever is the lesser attenuation. These limits would be offset by allowances in the measurement procedures. Those allowances would delete the requirement in the proposed Section 15.31(m) for adjusting the measured level of wideband emissions at frequencies below 1000 MHz, would specify a 6 dB measurement bandwidth of 100 kHz for frequencies above 1000 MHz, and, for frequency hopping spread spectrum, would allow the signal to be averaged according to the time that the signal is within a specified hopping channel. The proposed field strength limits and these allowances to the measurement procedures should provide the equivalent of a one watt signal into a dipole antenna.

46. No special provisions or additional standards are being proposed for spread spectrum operations other than frequency hopping and direct sequence systems. However, any form of spread spectrum would be allowed under the general field strength limits or the higher field strength limits permitted in certain frequency bands as proposed in this Notice. We do not have sufficient information at this time as to the interference potential of various spread spectrum operations to permit their widespread use at higher power limits. Because of our proposal to allow general, unrestricted operation on most frequencies, some degree of caution must be exercised to reduce the risk of interference to the authorized radio services.

47. *Specialized Field Disturbance Sensors (Vehicle Radar Systems).* The regulations proposed in the attached Appendix for field disturbance sensors operating above 900 MHz are identical to those currently contained in Subpart F of Part 15 with the exception that the measurements are performed at a distance of 3 meters. However, it is noted that the Commission has issued a waiver of the field strength limit for the frequency band of 24075-24175 MHz to Vehicle Radar Safety Systems, Inc. (VRSS) to permit the operation of a collision avoidance system, a device used to warn drivers of a possible collision source.[22] Under the terms of that waiver, VRSS was permitted to employ a field strength of 750,000 uV/m at 30 meters instead of 250,000 uV/m at 30 meters as required under the regulations. (These limits would be 7,500 mV/m and 2,500 mV/m at 3 meters under this proposed rule making.) We are concerned about the possibility of increasing the potential for interference to the authorized radio services should this field strength limit be raised for all field disturbance sensors. However, we wish to solicit comments as to whether higher field strength limits, such as the limit granted to the VRSS device, should be permitted for field disturbance sensors that are used in specialized operations requiring additional range, provided the need for that additional range can be demonstrated to the Commission and the likelihood of increased interference is negligible.

48. *Automatic Vehicle Identification Systems.* We propose to delete the special provisions for automatic vehicle identification systems (AVIS) operating in the frequency band of 2.9-4.1 GHz. The Commission has proposed to designate the frequency bands 3.26-3.267, 3.332-3.339, 3.3458-3.358, and 3.4-4.4 GHz as restricted bands in order to protect various satellite down links and radio astronomy operations. Sensitive receivers employed by U. S. Government radiolocation systems in the 2.9-3.6 GHz range raise additional interference concerns should the AVIS be retained at 2.9-4.1 GHz. This change to the regulations should have a minimal impact as it appears that the AVIS is lightly used. We request comments concerning the practicability of retaining AVIS at 2.9-4.1 GHz, its ability to continue to coexist with authorized radio services, and its ability to function in the new frequency bands proposed herein. Those comments should also address the extent to which the AVIS currently is being employed.

INTERFERENCE CONCERNS

49. The proposals advanced above represent our best judgments as to the trade off between beneficial low power spectrum use and possible interference to primary radio services. Nevertheless, we recognize that certain risks may attach to altering our regulations along the lines proposed. The operation of authorized and non-authorized low power devices now accounts for about 10 percent of the interference complaints we receive annually, and this number is growing. The changes proposed herein may foster a greater proliferation of these devices. While greater numbers could result in an increase in the instances of interference, we have taken steps to reduce this effect. The field strength limits proposed for general operation on the frequencies allocated to aviation, public safety, land mobile, television broadcast, and most other frequency bands used by the authorized services are the same as those now applied to residential computer products, and these devices have not appeared to be a major source of interference complaints. In addition, this rule making proposes to establish a number of restricted frequency bands, applicable to all Part 15 intentional radiators, and to decrease the radiated emissions from receivers in order to provide additional protection to the allocated radio services. On balance, we believe that the public interest benefits of the rule changes we propose outweigh the potential for increases in interference. We invite comments on the potential risks of this rule making proposal. We also encourage the submission of any empirical interference data that is available and will help us in evaluating this rule making.

SUMMARY

50. As discussed in the preceding paragraphs and as shown in the appendix, this item proposes to remove most of the device-specific regulations contained in Part 15, deleting many of the restrictions on bandwidth, modulation or application. General field strength limits are proposed to permit the operation of an intentional radiator on any frequency with the exception of the restricted bands. Consumer bands at higher field strength limits also

Section 15.209 Radiated emission limits, general requirements.

(a) Except as provided elsewhere in this Subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Fundamental Frequency (MHz)	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009 - 0.490	2400/F(kHz)	300
0.490 - 1.705	24000/F(kHz)	30
1.705 - 30.0	30	30
30 - 88	100	3
88 - 216	150	3
216 - 960	200	3
Above 960	500	3

(b) The tighter limit applies at the band edges.

(c) The level of any unwanted emissions from an intentional radiator operating under these general provisions shall not exceed the limits in paragraph (a). The limits are based on the frequency of the emission.

Section 15.211 Use of multiple intentional radiators.

Except for biomedical telemetering devices, the use of multiple intentional radiators for the purpose of extending transmission range or for increasing the area of coverage is prohibited. The use of multiple biomedical telemetering devices to extend transmission range is restricted to a localized area such as a hospital or residence.

Section 15.213 Tunnel radio systems.

An intentional radiator utilized as part of a tunnel radio system may operate on any frequency provided it meets all of the following conditions:

(a) Operation of a tunnel radio system (intentional radiator and all connecting wires, excluding an outside system used to receive signals rebroadcast within the tunnel) shall be contained solely within a tunnel, mine or other structure that provides attenuation to the radiated signal due to the presence of naturally surrounding earth and/or water.

(b) Any receiving system external to the tunnel, mine or other structure, as described, shall be subject to the regulations applicable to unintentional radiators.

(c) The total electromagnetic field on any frequency or frequencies appearing outside of the tunnel, mine or other structure shown in paragraph (a) shall not exceed the limits shown in Section 15.209. Particular attention shall be paid to the emissions from any opening in the structure to the outside environment.

(d) The conducted limits in Section 15.207 apply to the radio frequency voltage on the public utility power lines outside of the tunnel.

(e) A grant of equipment authorization is not required for a tunnel radio system. In lieu thereof, a tunnel radio system shall be verified for compliance with the regulations.

(f) The provisions of Section 15.5 apply to any tunnel radio system operated under this Section.

Radiated Emission Limits, Additional Provisions

Section 15.215 Additional provisions to the general radiated emission limitations.

(a) The regulations subsequent to this Section provide alternatives to the general radiated emission limitations for specified frequency bands. Emissions from intentional radiators operating within those specified frequency bands shall comply with either the specified standards or the general radiated emission standards in

Section 15.209. In most cases, unwanted emissions outside of the frequency bands shown in these alternative provisions must be attenuated to the emission limits shown in Section 15.209. In no case shall the level of the unwanted emissions from an intentional radiator operating under these additional provisions exceed the field strength of the fundamental emission.

(b) For those alternative radiated emission limitations which are applied to a band of frequencies and for which a frequency stability is not specified, it is recommended that the carrier frequency be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

Section 15.217 Operation in the band 160 - 190 kHz.

(a) The total input power to the final radio frequency stage (exclusive of filament or heater power) shall not exceed one watt.

(b) The total length of the transmission line, antenna, and ground lead (if used) shall not exceed 15 meters.

(c) All emissions below 160 kHz or above 190 kHz shall be attenuated at least 20 dB below the level of the unmodulated carrier.

Section 15.219 Operation in the band 510 - 1705 kHz.

(a) The total input power to the final radio frequency stage (exclusive of filament or heater power) shall not exceed 100 milliwatts.

(b) The total length of the transmission line, antenna and ground lead (if used) shall not exceed 3 meters.

(c) All emissions below 510 kHz or above 1705 kHz shall be attenuated at least 20 dB below the level of the unmodulated carrier.

Section 15.221 Operation in the band 535 - 1705 kHz.

(a) The provisions of this Section are restricted to the operation of an AM broadcast station on a college or university campus or on the campus of any other educational institution. Operation is restricted to the grounds of the campus. Operation is permitted on any unused frequency in the above band.

(b) On the campus, the field strength of emissions appearing outside of this frequency band shall not exceed the general radiated emission limits shown in Section 15.209 as measured from the radiating source. There is no limit on the field strength of emissions appearing within this frequency band except that the provisions of Section 15.5 continue to apply.

(c) At the perimeter of the campus, the field strength of any emissions shall not exceed the general radiated emission limits shown in Section 15.209.

essary information will become available in a manner worked out in that agreement. The agreement is not being constrained by this rule making proceeding.

C. Measurement Techniques

90. The *Notice* proposed a number of measurement techniques which would apply to Part 15 devices. These measurement techniques are discussed in the following paragraphs. While several comments object to the Commission establishing new standards without interested parties being able to simultaneously review the updated measurement procedures, the *Notice* addressed the measurement standards that could affect substantially the level of the emission being measured. Further, it was indicated in the *Notice* that updated measurement procedures for all intentional and unintentional radiators would be proposed soon for public comment. Thus, interested parties will have the opportunity to comment on any changes to the measurement procedures that may apply to their equipment.

91. *Detector Functions of Measuring Instruments.* The current Part 15 regulations express most field strength limits, and some conducted limits, in terms of the average value of the emission. In the *Notice*, we proposed the use of measurement instrumentation with a CISPR quasi-peak detector for radiated and conducted measurements below 1000 MHz. We indicated that the use of such a detector would provide a better indication of the interference potential of an emission. Further, the general emission limits were established based on CISPR quasi-peak measurements. We also proposed that emissions above 1000 MHz would be measured using a peak detector. [41] However, we recognized that control and security alarm devices and other periodic operations conducted under the current rules, would be significantly impacted by a change to quasi-peak measurements due to the extensive use of pulsed emissions by those devices. Therefore, the *Notice* proposed to retain average limits for such devices, except for emissions within the restricted bands. The *Notice* also proposed to place an associated limit on peak emissions for periodic transmitters, equal to 20 dB above the maximum permitted average limits.

92. A number of objections were raised against the required use of CISPR quasi-peak and peak measurements, mostly by the manufacturers of control and security alarm devices. Many of the comments state that the quasi-peak detector function was designed to measure the degradation of broadcast signals and that it was not necessarily intended for signals at the frequencies used by Part 15 devices. DORCMA and individual control and security alarm device manufacturers contend that average measurements provide a better indication of the interference potential of a device. DORCMA adds that the change to peak measurements above 1000 MHz would result in a reduction in permitted signal levels of 5 to 15 dB and that such a reduction is unreasonable, unnecessary and would cause unjustifiable economic hardship. SEIA and others argue that if average measurements are acceptable to reduce the potential for interference by the fundamental and spurious emissions of control and security alarm devices to services on non-restricted bands, they should also be acceptable to prevent interference to the authorized services in the restricted bands. Further, SEIA alleges that narrow band receivers tend to be immune to peak emissions. SEIA requests that the emission limits above 1000 MHz be increased by 20 dB if peak detectors are required. SEIA also states that eliminating average measurements in the restricted bands would require manufacturers to reduce output power to comply with the quasi-peak limits. Genie and Linear state that quasi-peak detectors will not provide uniform and neutral results, are inherently equipment sensitive, and are capable of yielding inaccurate measurements. CBEMA requests that average measurements be applied to digital devices for broadband emissions. NEMA requests that average measurements continue to be used for measurements of the emissions of field disturbance sensors. NEMA and GE state that quasi-peak measurements are appropriate for the European regulatory approach that permits the operation of equipment that complies with the limits even if interference is caused. They argue that such measurements are not appropriate for the U. S. where operation must cease if interference is caused. Thus, they contend that the limits for Part 15 devices do not need to be as strict.

93. In contrast, a number of comments support the change from measurement instrumentation using an average detector to instrumentation using a CISPR quasi-peak or peak detector. CDC states that the quasi-peak detector was designed to correlate best with the perceptibility of noise, i.e., interference, and, unlike average detectors, prevents systems from using shorter duty cycles to obtain higher emission levels which are not indicated with average measurements. NTIA states that average measurements were appropriate when amplitude and frequency modulation with constant carriers were the only types of non-licensed devices in use. NTIA in support of the use of CISPR quasi-peak and peak measurements, adds that current equipment uses suppressed carrier, pulsed and spread spectrum modulation. Hence, more sophisticated measurement techniques are required. Digital, while also requesting higher limits on conducted emissions, wants the standards to be stated in terms of average and quasi-peak and to require measurements for both.

94. We continue to believe that the use of measurement instrumentation employing a CISPR [42] quasi-peak detector is appropriate for measuring emissions from Part 15 devices below 1000 MHz. As indicated by CDC and NTIA, the parameters of the CISPR quasi-peak detector were designed to consider the interference potential of radio frequency emissions to the authorized radio services, including those services allocated on the frequency bands employed by control and security alarm devices. The quasi-peak detector provides a better indication of the energy being radiated by the Part 15 device that could be detected as interference by a receiver in the authorized radio services than would be provided by average or peak detectors. [43] As an alternative to CISPR quasi-peak measurements, we will permit the measurement of emissions with instrumentation employing a peak detector with a measurement bandwidth equivalent to that of a CISPR quasi-peak detector. This is appropriate since peak measurements will result in levels equal to or greater than those obtained by the quasi-peak detector. However, we remain concerned that implementing CISPR quasi-peak measurements below 1000 MHz for all Part 15 devices would result in a need for many manufacturers to discontinue the production of a several existing devices which have not been demonstrated to be sources of interference. For that reason, we are retaining the use of measurement instrumentation employing an average detector, as was applied to periodic transmitters, for all operations currently permitted under Part 15 except for

operation in the band 0.51-1.705 MHz and non-periodic operation in the band 40.66-40.70 MHz. e.g.. perimeter protection systems. [44] The application of measurements with a CISPR quasi-peak detector is being employed within these bands to provide additional interference protection to AM broadcast stations and because the band 40.66-40.70 MHz is being expanded to permit general types of Part 15 operation. The impact to perimeter protection systems. the only non-periodic system presently being operated in the band 40.66-40.70 MHz. from the change in measurement technique is minimized by the increased field strength limit that is being adopted. However. we also recognize that allowing the continued application of average measurements could permit high level peak emissions that could interfere with the authorized radio services. For this reason. we are adopting a corresponding limit on peak emissions of 20 dB above the maximum permitted limit on average emissions which will be applied wherever average emission limits are specified in the rules. This is the same peak limit that we proposed and are adopting for control and security alarm devices and other periodic transmitters. We also recognize that pulse modulated systems subject to measurement with a CISPR quasi-peak detector can generate excessive peak emissions if the pulse-repetition frequency is extremely low. For that reason. we are requiring pulse modulated systems for which a CISPR quasi-peak measurement is specified to demonstrate compliance with the standards based on the peak level of their emissions if their pulse-repetition frequency (PRF) is 20 Hz or less. There do not appear to be any existing devices with a PRF of 20 Hz or less that would be impacted by this change to the measurement requirements.

95. Our proposal to use measurement instrumentation employing peak detectors for frequencies above 1000 MHz was based on the general availability of peak-reading measurement equipment and the lack of CISPR agreement of specifications for a quasi-peak detector at those frequencies. However. we agree with the comments that the proposed limits above 1000 MHz. especially the general radiated emission limit. are too restrictive when measured with a peak detector. Instead. we believe that the emission limit recently adopted in the previously cited *Report and Order* in Docket No. 86-422 is appropriate for the general limit and measurement instrumentation employing an average detector should continue to be employed. In order to prevent possible interference from high level peak emissions and to provide additional interference protection to operations in the restricted bands above 1000 MHz. we are adopting a corresponding limit on peak emissions of 20 dB above the maximum permitted average limits. the same as we are applying where average measurements are used below 1000 MHz. While this is a compromise made necessary by the lack of quasi-peak measurement procedures for frequencies above 1000 MHz. we believe that it offers sufficient interference protection to the authorized radio services. Further. this standard addresses most of the objections from the manufacturers of control and security alarm devices. field disturbance sensors. and other equipment for which measurements above 1000 MHz are required.

96. *Frequency Range of Radiated Measurements for Intentional Radiators.* In the *Notice.* we generally proposed measuring emissions from intentional radiators to at least the tenth harmonic of the highest fundamental frequency of the device. Measurements would be limited by the state of the art in measurement techniques. The present rules do not require emissions from most intentional radiators to be measured above 1000 MHz. DORCMA and other manufacturers of control and security alarm devices object to this proposal due to the increased cost of testing and test equipment. They state that no rationale was provided for this change and there is no need for measuring emissions at higher frequencies. Genie requests 2000 MHz to be the upper limit for measuring emissions. Linear states that the FCC does not have procedures for the calibration of measurement test sites above 1000 MHz. Pittway adds that at frequencies above 2000 MHz the level of emissions attenuates so significantly that there is virtually no likelihood of harmful interference and it is unlikely that signals at the higher order harmonics could be detected above the typical noise floor of available test equipment.

97. NTIA. in its comments. notes that the spectrum above 1000 MHz contains a number of restricted bands and many critical systems. NTIA adds that the risk of interference from intentional radiators is increased by the sophisticated modulation techniques employed in newer Part 15 devices as well as by advances in radio frequency technology that permit the use of higher carrier frequencies. NTIA concludes that these technologies make it likely that spurious emissions will be produced above 1000 MHz and that the proposal to test to the tenth harmonic is reasonable.

98. In addition to the view expressed by NTIA. we see several additional reasons for requiring a demonstration of compliance with the emission limits at higher frequency ranges. First. authorized radio services are increasingly using frequency bands above 1000 MHz. Second. the equipment used by the authorized radio services. including equipment used above 1000 MHz. similarly is growing more sensitive. The cost to manufacturers of Part 15 devices for new test equipment and for the additional time needed to perform such tests is not sufficient justification for limiting the frequency range of required measurements to a fixed frequency such as 2000 MHz. The necessary test equipment is readily available. We also note that most manufacturers of control and security alarm transmitters already are required to test to 2000 MHz. Generally. test equipment that can be used to measure to 2000 MHz also can be used to test up to the tenth harmonic of currently manufactured control and security alarm devices. Thus. we reject the argument that our proposal will impose high costs by requiring the purchase of additional test equipment. Further. while manufacturers of Part 15 devices have been required to test above 1000 MHz for some time. the lack of specific test site calibration procedures from the Commission for frequencies above 1000 MHz has not caused problems with these tests in the past. Thus. we do not consider the argument that there is no published test site calibration information for testing above 1000 MHz to be sufficient reason to adopt an alternate requirement for the range of frequencies to be measured. Finally. a demonstration of compliance with the regulations at frequencies to the tenth harmonic is required for most equipment operating under the other Commission rule parts. e.g.. equipment which is authorized under our type acceptance procedure. This testing requirement does not appear to cause substantial burdens to the manufacturers of equipment used in the authorized services. For these reasons we are adopting the proposal to require testing of Part 15 intentional radiators

marketing exemptions do not apply to digital devices subject to certification is consistent with the existing construction of the rules, and we will amend Section 2.806 to avoid further misunderstandings. We also are amending Section 2.805 to specifically state that this section applies to the marketing of equipment subject to verification. We are continuing to limit the marketing exceptions in Sections 2.806(a) and (c)(2) to apply only to verified equipment subject to Section 2.805, as clarified, to prevent possible interference to the authorized services that could result from the marketing of Class B personal computers and peripherals that have not been authorized and may not comply with the standards. We concur with the comments from IBM that the facilities of the manufacturer should include the facilities of those entities working under the authorization of the party responsible for the development and manufacture of the equipment. Thus, the new rules will permit digital devices that have not been authorized to be operated at the facilities of other parties associated with the manufacturer/developer of the equipment. However, we do not agree that the marketing regulations should be amended to permit the taking of orders, including orders from distributors or retailers, or pre-authorized delivery of equipment. Such actions could result in the marketing to the public of non-complying equipment.

V. MISCELLANEOUS ISSUES

128. *Campus Radio Systems*. The *Notice* proposed permitting Part 15 AM radio broadcast systems operating in the band 535-1705 kHz to be installed on the campuses of educational institutions. The general emission limits would apply at the boundary of the campus. IBS and LPB comment that this restriction would pose difficulties for city-bound institutions since they have no actual campus. They also argue that no conducted limits should apply outside of the campus as it is highly impracticable to measure or to prevent such emissions. IBS and LPB request that the operating authority for these stations be expanded. In particular, they request that the frequency band be expanded to cover 525-1705 kHz to permit operation at 530 kHz and that operation be permitted on any frequency outside of the protected field strength contours of licensed AM stations. IBS and LPB state that there is no showing of a need to require verification of these systems. Finally, they argue that data to be kept on file should be retained at the studio/office location rather than the location of the transmitting equipment.

129. We recognize the requirement that campus radio stations meet the general emissions at the boundary of the campus may pose certain problems for institutions located in cities. However, operators of campus radio stations will have the option of meeting the emissions standards at the boundary of the institution or of using transmitters that have been authorized for use in this band under the general standards provided (Sections 15.219 or 15.221). We believe the potential for interference to licensed AM stations is too great, particularly in urban areas, to allow campus stations to exceed the standards provided under these options. To simplify verifying compliance with the conducted emissions limits, we will permit measurement of conducted emissions of each individual transmitter used in the system, rather than the system as a whole. We find it desirable to expand the frequency range over which campus stations may operate to include 525 kHz for the reasons indicated by IBS and LPB. The new rules will permit operation of these stations in the band 525-1705 kHz. However, the new rules will specify that campus stations must not operate within the protected field strength contour of licensed AM stations operating on the same frequency. With regard to verification of campus systems, we maintain that it is necessary to perform the required measurements to ensure that the system complies with the emissions standards. Finally, we find it acceptable to permit the verification records to be kept at the station studio, office, control room or transmitter location, as may be preferred by the station operator, and are providing for this discretion in the new rules.

130. *Spread Spectrum Systems*. In the *Notice*, we proposed to retain the current provisions for direct sequence and frequency hopping spread spectrum operation within the frequency bands 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz. We also proposed to clarify the requirements on the gain processing and bandwidth employed by receivers used with spread spectrum systems to ensure that an actual spread spectrum system, and not just a spread spectrum transmitter, is employed. Further, comments were requested on the feasibility of designating field strength limits instead of the current limit on transmitter output power.

131. While a number of comments addressed the questions raised in the *Notice* concerning the bandwidth of the receiver, the level of gain processing that should be employed in the receiver and the application of field strength limits, we are not resolving these issues in this Order. These issues and the use of spread spectrum modulation techniques other than direct sequence and frequency hopping will be addressed in the near future in another rule making proceeding.

132. *Specialized Field Disturbance Sensors (Vehicle Radar Systems)*. The *Notice* observed that the Commission has issued a waiver to Vehicle Radar Safety Systems, Inc. (VRSS) to permit the operation of a collision avoidance system with a field strength limit 9.5 dB higher than permitted for field disturbance sensors under the current rules. [53] Comments were solicited as to whether higher field strength limits should be permitted for field disturbance sensors used in specialized operations requiring additional range, provided the need for additional range can be demonstrated and the likelihood of increased interference is negligible. While the comments addressing this issue generally support our proposal, we are not adopting a specific regulation concerning waivers of the emission limits for field disturbance sensors. We will continue, as in the past, to entertain waiver requests on a case-by-case basis. This will allow requests for waivers to be considered on their individual merits, including whether operation under one of the licensed radio services is feasible. Further, this review will permit coordination with NTIA when an operation is conducted on frequency bands allocated to the U. S. Government.

133. *Automatic Vehicle Identification Systems*. The *Notice* proposed to delete the provisions for automatic vehicle identification systems (AVIS) in the 2.9-4.1 GHz band. The deletion of AVIS was proposed due to the lack of use of these provisions and the inclusion of a number of restricted bands within the currently employed frequency range. Since issuance of the *Notice*, the Commission has been contacted informally by the Arizona Department of Transportation (AZDOT) regarding a multi-state AVIS system it has under development. As stated in the *Notice*,

we are concerned about possible interference to sensitive receivers employed by the U. S. Government for radiolocation systems in those portions of the 2.9-3.6 GHz band that are not listed as restricted bands. On the basis of these considerations, we will continue to permit AVIS systems in those portions of the 2.9-4.1 GHz band that have not been designated as restricted bands. However, we intend to revisit the need for retaining provisions for AVIS in a future rule making proceeding.

134. *Tunnel Radio Systems.* The *Notice* proposed to allow operation under Part 15 within tunnels or mines without the specification of emission limits except for radio frequency energy radiated outside of the tunnel or mine. While none of the comments object to the provisions for a tunnel radio system, Spectrum Measurement Corp. questions why it is necessary to exclude from the tunnel radio provisions an outside system used to receive signals rebroadcast within a tunnel. The reason for exempting RF devices employed within a tunnel or mine from the technical standards, including the individual equipment authorization requirements, was based on the premise that the natural earth and/or water boundaries of the tunnel or mine would tend to act like a screen room, attenuating the signals radiated from that tunnel or mine. Emissions from equipment located outside of the tunnel or mine would not be so attenuated. Thus, RF equipment located outside of the tunnel or mine must still demonstrate compliance with the necessary standards and must comply with the appropriate equipment authorization requirements.

135. *Antenna Connections for Intentional Radiators.* The *Notice* proposed to require Part 15 intentional radiators to be designed in such a manner that only the antenna furnished by the manufacturer could be employed. It stated that the use of a permanently attached antenna or an antenna which employs a unique coupler would satisfy this requirement. This was proposed because the antenna characteristics directly affect the field strength of the radio frequency emissions. A number of comments object to this proposal, citing that such a regulation would make it difficult for the user to replace a broken antenna. The Commission agrees with the comments and is revising the proposed language to permit a manufacturer to design the equipment so that a broken antenna can be replaced by the user. However, in order to ensure that only an antenna of the type originally furnished by the manufacturer is used and to preclude replacement of the original antenna with one that increases the radiated signals, we are prohibiting the use of a standard antenna jack or electrical connector, similar to the regulation presently applied to cordless telephones. In addition, we are exempting from this requirement devices that have standards expressed only in terms of transmitter output power levels instead of field strength limits, devices that must be measured for compliance with our emission standards at the installation site, and devices that must be professionally installed.

136. *Use of Multiple Intentional Radiators.* In the *Notice*, we proposed to prohibit the use of multiple radiators for the purpose of extending transmission range or for extending the area of coverage. Biomedical telemetry devices were proposed to be excluded from this requirement as long as such devices were restricted to a localized area such as a hospital or residence. The comments in this proceeding generally object to this proposal. For example, AT&T states that it sees no need to exclude multiple emitters because the field strength limits will prevent significant interference from any given radiator and the authorization of such operation might enable the provision of a cellular-type building paging system under Part 15. AT&T adds that multiple intentional radiators should be permitted in commercial environments when installed in accordance with the manufacturer's instructions, provided the field strength at a distance of 30 meters outside of the commercial property boundary does not exceed the limits in the proposed Section 15.109(c). Sensormatic objects to the proposal since they use multiple antennas with their field disturbance sensors used for anti-theft tag sensors for the coverage of exits. GM expresses similar concerns about applying this requirement to field disturbance sensors. PA Consulting Group indicates that Part 15 multiple digital spread spectrum repeaters are desirable to permit high throughput coverage of an area. Manufacturers of control and security alarm devices request the deletion of this provision to allow RF link relays for life-safety applications.

137. We are not adopting a prohibition on the use of multiple transmitters to extend transmission range or coverage area. [54] We concur with the comments that multiple devices should be permitted provided the individual transmitters comply with the rules. However, we are denying the request by AT&T to allow multiple intentional radiators in a commercial environment with field strength limits measured 30 meters beyond the property boundary. The higher field strengths used by such systems would pose unacceptable potential for interference to authorized services.

138. *TV Interface Devices.* The *Notice* proposed to delete the limits applied to RF signals that are conducted over the output connecting cable of a TV interface device. Additional changes to TV interface devices, such as the type of equipment authorization that should be applied to cable system terminal devices and the level of attenuation needed for transfer switches were addressed in the comments. However, regulations concerning TV interface devices, including output signal limits, cable terminal devices and transfer switches, were recently finalized by the Commission in Docket No. 85-301 [55] and Docket No. 87-107. [56] As the regulations applicable to TV interference devices were considered in those earlier proceedings, the rules adopted in those proceedings will be incorporated into this Order.

139. *TV Broadcast Receivers.* Upon further consideration, we have decided to retain the definition contained in our current rules for a television broadcast receiver. Our proposed definition would have required that TV receivers be designed to receive both television pictures and sound, whereas the current definition requires only the reception of television pictures. We recognize that in the future some television broadcast receivers may be designed to receive only the video transmission, with the audio signal being provided by a separate receiver. Under such circumstances, the video-only receiver would not fall within our proposed definition of a television broadcast receiver and, therefore, the all-channel tuning requirements [57] would not apply. We continue to believe that it is important to require television receivers to comply with the all-channel tuning regulations, even if those receivers are not designed to receive the audio portion of the television transmission. This is accomplished by retaining the current definition of a television broadcast receiver.

receiver is associated with a transmitter operating under regulations that were not in effect prior to the adoption of this Order. no transition period is being implemented for that receiver. Obviously. such receivers must be designed concurrently with the transmitters and matters such as redesign and retrofitting are not relevant.

147. We are not adopting the ten year transition provisions specifically proposed in the *Notice* for cordless telephones or intentional radiators operating at 27 or 49 MHz. Paragraph 46. *supra*. provides the reasons why this lengthy transition provision is no longer needed for cordless telephones and intentional radiators operating in the 49 MHz band. For intentional radiators operating in the 27 MHz band. the regulations being adopted would not require significant modifications to existing devices. allowing the implementation of a shorter transition provision. For operation in the 27 MHz band. we are retaining the current application of average emission measurements. as indicated in paragraph 34. *supra*. In addition. while we have reduced the levels of unwanted emissions permitted from these devices. we have expanded the existing frequency band to permit operation anywhere within the band 26.96-27.28 MHz. This expansion provides "guard bands". within which currently designed equipment would no longer be required to reduce unwanted emissions. These "guard bands" facilitate the ability of currently designed equipment to comply with the limits on unwanted emissions that are being adopted.

148. We do not believe that it is necessary to provide a ten year period for implementation of the new Part 15 rules for Part 15 devices other than receivers. First. the new rules permit transmitters to operate with higher levels of radiated emissions and therefore a greater potential for causing interference. Second. technical standards for transmitters and unintentional radiators (other than receivers) have not been significantly changed. Thus. the degree of redesign needed to bring these devices into compliance with the new rules is not great. The major change to the regulations that would most likely require the redesign of a product is the adoption of additional restricted bands. The interference protection to be provided to services operating in the restricted bands should be instituted as soon as feasible. Third. in the previously cited *Report and Order* in Docket No. 86-422. the manufacturers of control and security alarm devices. in response to a Commission proposal to adopt emission limits for their devices. indicated that transition times of 24 months on obtaining a new grant of equipment authorization and 30 months on manufacturing and importation was acceptable. Thus. we believe that a general ten year transition period for intentional radiators is unreasonable.

149. Based on these considerations. except for receivers. we will continue to grant authorizations and permit verification of Part 15 devices that meet the previous standards for a period of three years after the effective date of this *Report and Order*. However. except for receivers. within five years of the effective date of this action. any Part 15 equipment that is manufactured domestically or imported must comply with the new rules. These transition provisions are not expected to present any substantial hardships to the manufacturers of Part 15 devices. However. delegated authority is being granted to the Chief Engineer to provide limited extensions of no more than two years to the transition provisions for those situations where it is shown that additional time is needed.

CONCLUSION

150. The actions being taken in this *Report and Order* represent the Commission's best judgements as to the trade-offs between beneficial low power spectrum use and possible interference to the authorized radio services. We recognize that certain increased risks of interference to authorized devices may result from altering our regulations. However. the rules we are adopting are intended to minimize this interference potential. The field strength limits being adopted for general operation on the frequencies allocated to aviation. public safety. land mobile and most other frequency bands used by the authorized services are the same as those now applied to residential computer products. and those products have not proven to be a major source of interference complaints. In addition. this Order establishes a number of restricted frequency bands. applicable to all Part 15 intentional radiators. in order to provide additional protection to the allocated radio services. Further. except for non-residential perimeter protection systems currently allowed under the rules. we are not permitting the operation under the general limits of transmitters in the TV broadcast bands. On balance. we believe that the public interest benefits of the rule changes being adopted outweigh the potential for increased interference. Since we will be allowing large numbers of new devices on new frequencies. we will be closely monitoring. through the equipment authorization process. the interference potential of these devices. If this discovery process reveals potential interference problems. the limits adopted in this proceeding will be revisited.

151. Certain matters either raised in the *Notice* or subsequently brought to our attention require further review. Additional proceedings may be expected to address such issues as standards that should be applied to kits of radio frequency devices. definitions applicable to digital equipment. spread spectrum operation above 900 MHz. the labelling of verified devices to indicate the identity of the responsible party. and expedited proceedings to resolve cases of widespread interference.

PROCEDURAL MATTERS

152. Pursuant to the Regulatory Flexibility Act of 1980. 5 USC 601 *et seq*.. the following final flexibility analysis has been prepared:

I. Need for and purpose of the rules.

The regulations pertaining to the operation of a radio frequency device without an individual license were incrementally promulgated over the last 35 years resulting in device-specific regulations. inequities in technical standards between devices with similar interference potentials. standards that may be too strict or that have become too lax. and regulations that appear to be confusing to the general public. The existing regulations also prohibit a number of radio frequency operations that could be permitted without unduly increasing the potential for interference to authorized radio services. The Commission is adopting a comprehensive revision of the Part 15 rules to resolve these problems in the existing rules.

(e) For intentional radiators. measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission. as appropriate. shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage. For battery operated equipment. the equipment tests shall be performed using a new battery.

(f) To the extent practicable. the device under test shall be measured at the distance specified in the appropriate rule section. The distance specified corresponds to the horizontal distance between the measurement antenna and the closest point of the equipment under test. support equipment or interconnecting cables as determined by the boundary defined by an imaginary straight line periphery describing a simple geometric configuration enclosing the system containing the equipment under test. The equipment under test. support equipment and any interconnecting cables shall be included within this boundary.

(1) At frequencies equal to or above 30 MHz. measurements may be performed at a distance closer than that specified provided this does not result in measurements taken in the near field. When performing measurements at a closer distance than specified. the results shall be extrapolated to the specified distance using an inverse linear distance extrapolation factor (20 dB/decade). Measurement at a distance greater than specified is not permitted unless the responsible party can demonstrate that measurements at the specified distance are impractical because of the size of the equipment. the location of the equipment. or other factors. or unless the responsible party can demonstrate that such a measurement would take place in the near field. as could occur when performing measurements on some large digital devices and perimeter protection systems. Measurements shall not be performed at a distance greater than 30 meters unless it can be demonstrated that measurement at a distance of 30 meters or less is impracticable and. further. that the signal level needed to be determined at the distance employed can be detected by the measuring equipment. When performing measurements at a distance greater than that specified. the results shall be interpolated to the specified distance using an inverse linear distance interpolation factor (20 dB/decade).

(2) At frequencies below 30 MHz. measurements may be performed at a distance closer than that specified in the regulations: however. an attempt should be made to avoid making measurements in the near field. Pending the development of an appropriate measurement procedure for measurements performed below 30 MHz. when performing measurements at a closer distance than specified. the results shall be extrapolated to the specified distance by either making measurements at a minimum of two distances on at least one radial to determine the proper extrapolation factor or by using the square of an inverse linear distance extrapolation factor (40 dB/decade).

(3) The applicant for a grant of certification shall specify the interpolation or extrapolation method used in the application filed with the Commission. For equipment subject to notification or verification. this information shall be retained with the measurement data.

(4) When measurement distances of 30 meters or less are specified in the regulations. the Commission will test the equipment at the distance specified unless measurement at that distance results in measurements being performed in the near field. When measurement distances of greater than 30 meters are specified in the regulations. the Commission will test the equipment at a closer distance. usually 30 meters. extrapolating the measured field strength to the specified distance using the methods shown in this
Section.

(5) Measurements shall be performed at a sufficient number of radials around the equipment under test to determine the radial at which the field strength values of the radiated emissions are maximized. The maximum field strength at the frequency being measured shall be reported in an application for certification.

(g) Equipment under test shall be adjusted. using those controls that are readily accessible to or are intended to be accessible to the consumer. in such a manner as to maximize the level of the emissions. For those devices to which wire leads may be attached by the consumer. tests shall be performed with wire leads attached. The wire leads shall be of the length to be used with the equipment if that length is known. Otherwise. wire leads one meter in length shall be attached to the equipment. Longer wire leads may be employed if necessary to interconnect to associated peripherals.

(h) For a composite system that incorporates devices contained either in a single enclosure or in separate enclosures connected by wire or cable. testing for compliance with the standards in this Part shall be performed with all of the devices in the system functioning. If an intentional radiator incorporates more than one antenna or other radiating source and these radiating sources are designed to emit at the same time. measurements of conducted and radiated emissions shall be performed with all radiating sources that are to be employed emitting.

(i) If the device under test provides for the connection of external accessories. including external electrical input signals. the device shall be tested with the accessories attached. The device under test shall be fully exercised with these external accessories. The emission tests shall be performed with the device and accessories configured in a manner that tends to produce maximized emissions within the range of variations that can be expected under normal operating conditions. In the case of multiple accessory external ports. an external accessory shall be connected to one of each type of port. Only one test using peripherals or external accessories that are representative of the devices that will be employed with the equipment under test is required. All possible equipment combinations do not need to be tested. The accessories or peripherals connected to the device being tested shall be unmodified. commercially available equipment.

(j) If the equipment under test consists of a central control unit and an external or internal accessory(ies) (peripheral) and the party verifying the equipment or applying for a grant of equipment authorization manufactures or assembles the central control unit and at least one of the accessory devices that can be used with that control unit. testing of the control unit and/or the accessory(ies) must be performed using the devices manufactured or assembled by that party. in addition to any other needed devices which the party does not manufacture or assemble. If the party verifying the equipment or applying for a grant of equipment authorization does not manufacture or assemble the central control unit and at least one of the accessory devices that can be used with that control unit or the party can demonstrate that the central control unit or accessory(ies) normally would be marketed or

Highest frequency generated or used in the device or on which the device operates or tunes (MHz)	Upper frequency of measurement range (MHz)
Below 1.705	30
1.705 - 10	400
10 - 30	500

(3) Except for a CB receiver, a receiver employing superheterodyne techniques shall be investigated from 30 MHz up to at least the second harmonic of the highest local oscillator frequency generated in the device. If such receiver is controlled by a digital device, the frequency range shall be investigated up to the higher of the second harmonic of the highest local oscillator frequency generated in the device or the upper frequency of the measurement range specified for the digital device in paragraph (b)(1) of this Section.

(c) The above specified frequency ranges of measurements apply to the measurement of radiated emissions and, in the case of receivers, the measurement to demonstrate compliance with the antenna conduction limits specified in Section 15.111. The frequency range of measurements for AC power line conducted limits is specified in Sections 15.107 and 15.207 and applies to all equipment subject to those regulations. In some cases, depending on the frequency(ies) generated and used by the equipment, only signals conducted onto the AC power lines are required to be measured.

(d) Particular attention should be paid to harmonics and subharmonics of the fundamental frequency as well as to those frequencies removed from the fundamental by multiples of the oscillator frequency. Radiation at the frequencies of multiplier stages should also be checked.

Section 15.35 ***Emission limits.***

The conducted and radiated emission limits shown in this Part are based on the following, unless otherwise specified elsewhere in this Part:

(a) On any frequency or frequencies below or equal to 1000 MHz, the limits shown are based on measuring equipment employing a CISPR quasi-peak detector function and related measurement bandwidths, unless otherwise specified. The specifications for the measuring instrument using the CISPR quasi-peak detector can be found in Publication 16 of the International Special Committee on Radio Interference (CISPR) of the International Electrotechnical Commission. As an alternative to CISPR quasi-peak measurements, the responsible party, at its option, may demonstrate compliance with the emission limits using measuring equipment employing a peak detector function, properly adjusted for such factors as pulse desensitization, as long as the same bandwidths as indicated for CISPR quasi-peak measurements are employed.

Note: For pulse modulated devices with a pulse-repetition frequency of 20 Hz or less and for which CISPR quasi-peak measurements are specified, compliance with the regulations shall be demonstrated using measuring equipment employing a peak detector function, properly adjusted for such factors as pulse desensitization, using the same measurement bandwidths that are indicated for CISPR quasi-peak measurements.

(b) On any frequency or frequencies above 1000 MHz, the radiated limits shown are based on the use of measurement instrumentation employing an average detector function. When average radiated emission measurements are specified in the regulations, including emission measurements below 1000 MHz, there is also a limit on the radio frequency emissions, as measured using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit for the frequency being investigated. Measurements of AC power line conducted emissions are performed using a CISPR quasi-peak detector, even for devices for which average radiated emission measurements are specified.

(c) When the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measured field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in those cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value. The exact method of calculating the average field strength shall be submitted with any application for certification or shall be retained in the measurement data file for equipment subject to notification or verification.

Section 15.37 ***Transition provisions for compliance with the rules.***

Equipment may be authorized, manufactured and imported under the rules in effect prior to (insert date 60 days after date of publication in the Federal Register) in accordance with the following schedules:

(a) *For all intentional and unintentional radiators, except for receivers:* Radio frequency equipment verified by the responsible party or for which an application for a grant of equipment authorization is submitted to the Commission on or after (insert date 3 years after effective date of the R&O) shall comply with the regulations specified in this Part. Radio frequency equipment that is manufactured or imported on or after (insert date 5 years after effective date of the R&O) shall comply with the regulations specified in this Part.

(b) *For receivers:* Except as shown in paragraph (b)(2), receivers subject to the regulations in this Part that are manufactured or imported on or after (insert date 10 years after effective date of the R&O) shall comply with the regulations specified in this Part. However, if a receiver is associated with a transmitter that could not have been authorized under the regulations in effect prior to (insert date 60 days after date of publication in the Federal Register), e.g., a transmitter operating under the provisions of Sections 15.209 or 15.249 (below 960 MHz), the transition provisions in this Section do not apply. Such receivers must comply with the regulations in this Part.

(c) There are no restrictions on the operation or marketing of equipment complying with the regulations in effect prior to (insert date 60 days after date of publication in the Federal Register).

Section 15.245 *Operation within the bands 902 - 928 MHz, 2435 - 2465 MHz, 5785 - 5815 MHz, 10500 - 10550 MHz, and 24075 - 24175 MHz.*

(a) Operation under the provisions of this Section is limited to intentional radiators used as field disturbance sensors, excluding perimeter protection systems.

(b) The field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:

Fundamental Frequency (MHz)	Field of Fundamental (millivolts/meter)	Strength Field Strength of Harmonics (millivolts/meter)
902 - 928	500	1.6
2435 - 2465	500	1.6
5785 - 5815	500	1.6
10500 - 10550	2500	25.0
24075 - 24175	2500	25.0

(1) Field strength limits are specified at a distance of 3 meters.

(2) Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in Section 15.209, whichever is the lesser attenuation.

(3) The emission limits shown in the above table are based on measurement instrumentation employing an average detector. The provisions in Section 15.35 for limiting peak emissions apply.

Section 15.247 *Operation within the bands 902 - 928 MHz, 2400 - 2483.5 MHz, and 5725 - 5850 MHz.*

(a) Operation under the provisions of this Section is limited to frequency hopping and direct sequence spread spectrum intentional radiators that comply with the following provisions:

(1) For frequency hopping systems, at least 75 hopping frequencies, separated by at least 25 kHz, shall be used. The average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 30 second period. The maximum bandwidth of the hopping channel is 25 kHz.

(2) For direct sequence systems, the minimum 6 dB bandwidth shall be at least 500 kHz.

(b) The maximum peak output power of the intentional radiator shall not exceed one watt.

(c) Radio frequency output power outside these frequency bands over any 100 kHz bandwidth shall be at least 20 dB below that in any 100 kHz bandwidth within the band that contains the highest level of the desired power.

Note: Spread spectrum systems are sharing these bands on a noninterference basis with systems supporting critical Government requirements that have been allocated the usage of these bands, secondary only to ISM equipment operated under the provisions of Part 18 of this Chapter. Many of these Government systems are airborne radiolocation systems that emit a high EIRP which can cause interference to other users. Also, investigations of the effect of spread spectrum interference to U. S. Government operations in the 902-928 MHz band may require a future decrease in the power limits allowed for spread spectrum operation.

Section 15.249 *Operation within the bands 902 - 928 MHz, 2400 - 2483.5 MHz, 5725 - 5875 MHz, and 24.0 - 24.25 GHz.*

(a) The field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:

Fundamental Frequency	Field Strength of Fundamental (millivolts/meter)	Field Strength of Harmonics (microvolts/meter)
902 - 928 MHz	50	500
2400 - 2483.5 MHz	50	500
5725 - 5875 MHz	50	500
24.0 - 24.25 GHz	250	2500

(b) Field strength limits are specified at a distance of 3 meters.

(c) Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in Section 15.209, whichever is the lesser attenuation.

(d) As shown in Section 15.35(b), for frequencies above 1000 MHz, the above field strength limits are based on average limits. However, the peak field strength of any emission shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation.

Section 15.251 *Operation within the bands 2.9 - 3.26 GHz, 3.267 - 3.332 GHz, 3.339 - 3.3458 GHz, and 3.358 - 3.6 GHz.*

(a) Operation under the provisions of this Section is limited to automatic vehicle identification systems (AVIS) which use swept frequency techniques for the purpose of automatically identifying transportation vehicles.

(b) The field strength anywhere within the frequency range swept by the signal shall not exceed 3000 microvolts/meter/MHz at 3 meters in any direction. Further, an AVIS, when in its operating position, shall not produce a field strength greater than 400 microvolts/meter/MHz at 3 meters in any direction within ±10 degrees of the horizontal plane. In addition to the provisions of Section 15.205, the field strength of radiated emissions outside the frequency range swept by the signal shall be limited to a maximum of 100 microvolts/meter/MHz at 3 meters, measured from 30 MHz to 20 GHz for the complete system. The emission limits in this paragraph are based on measurement instrumentation employing an average detector. The provisions in Section 15.35 for limiting peak emissions apply.

(c) The minimum sweep repetition rate of the signal shall not be lower than 4000 sweeps per second, and the maximum sweep repetition rate of the signal shall not exceed 50,000 sweeps per second.

(d) An AVIS shall employ a horn antenna or other comparable directional antenna for signal emission.

(e) Provision shall be made so that signal emission from the VIS shall occur only when the vehicle to be identified is within the radiated field of the system.

(f) In addition to the labelling requirements in Section 15.19(a), the label attached to the AVIS transmitter shall contain a third statement regarding operational conditions, as follows:

C.I.S.P.R. 14 (1985): Limits and methods of measurement of radio interference characteristics of household electrical appliances, portable tools and similar electrical apparatus.

C.I.S.P.R. 15 (1985): Limits and methods of measurement of radio interference characteristics of fluorescent lamps and luminaires.

C.I.S.P.R. 18-1 (1982): Radio interference characteristics of overhead power lines and high-voltage equipment.

C.I.S.P.R. 20 (1985): Measurement of the immunity of sound and television broadcast receivers and associated equipment in the frequency range 1.5 MHz to 30 MHz by the current-injection method. Guidance on immunity requirements for the reduction of interference caused by radio transmitters in the frequency range 26 MHz to 30 MHz.

C.I.S.P.R. 22 (1985): Limits and methods of measurement of radio interference characteristics of information technology equipment.

SECTION ONE – MEASURING APPARATUS

1. Fundamental characteristics

In the following specification:

Band A refers to the frequency range 10 kHz to 150 kHz.
Band B refers to the frequency range 0.15 MHz to 30 MHz.
Band C refers to the frequency range 30 MHz to 300 MHz.
Band D refers to the frequency range 300 MHz to 1000 MHz.

The normal response to pulses of the quasi-peak instrument in Clause 2 is calculated on the basis of a measuring apparatus having the following fundamental characteristics (see Appendix A). Special characteristics for instruments having other types of detectors are dealt with in Section Five. The use of a spectrum analyzer in the frequency range 0.3 GHz to 18 GHz is discussed in Appendix B.

	Frequency band		
	A	B	C and D
Bandwidth at 6 dB	200 Hz	9 kHz	120 kHz
Electrical charge-time constant of quasi-peak voltmeter	45 ms	1 ms	1 ms
Electrical discharge-time constant of quasi-peak voltmeter	500 ms	160 ms	550 ms
Mechanical time constant of critically damped indicating instrument	160 ms	160 ms	100 ms
Overload factor of circuits preceding the detector (above the level of sine-wave signal which produces the maximum deflection of the indicating instrument)	24 dB	30 dB	43.5 dB
Overload factor of the d.c. amplifier inserted between the detector and the indicating instrument (above the d.c. voltage level corresponding to full-scale deflection of the indicating instrument	6 dB	12 dB	6 dB

Notes 1. – The mechanical time constant assumes that the indicating instrument is linear, i.e. equal increments of current produce equal increments of deflection. The use of an indicating instrument having a different law relating current and deflection is not precluded provided that the apparatus satisfies the requirements of the specification.

2. – For Band A, an unbalanced input connection is required. The preferred input impedance is 50 Ω. A balanced input transformer is required to permit symmetrical measurements. The preferred input impedance is 600 Ω.

3. – For all bands, the interference measuring apparatus should have an intermediate frequency output for the measurement of the duration of clicks. The load of this output should not have any influence on the indication of the interference measuring apparatus.

2. Normal response of measuring apparatus to pulses

2.1 *Amplitude relationship*

The response of the measuring apparatus to pulses of *a* μVs (microvolt second) having a uniform spectrum up to at least *b* MHz, repeated at a frequency of *c* Hz shall, for all frequencies of tuning, be equal to the response to an unmodulated sine-wave signal at the tuned frequency having an e.m.f. of r.m.s. value 2 mV (66 dB(μV)) from a signal generator having the same source impedance as the pulse generator.

It follows that if this source impedance is equal to the input impedance of the measuring apparatus, the r.m.s. value of the signal at the input to the measuring apparatus will be 1 mV (60 dB(μV)) (see table below).

For the various bands, the constants are as follows:

Band	*a* (μVs)	*b* (MHz)	*c* (Hz)	Notes
A	13.5	0.15	25	1 and 2
B	0.316	30	100	2
C	0.044	300	100	2
D	0.044	1 000	100	2

Notes 1. – The value 13.5 μVs is an experimental value with a tolerance of ± 1.5 dB.

2\. – A tolerance of ± 1.5 dB is allowed on the sine-wave voltage levels prescribed above.

2.2 *Variation with repetition frequency*

The response of the measuring apparatus to repeated pulses shall be such that for a constant indication on the measuring apparatus, the relationship between amplitude and repetition frequency shall be in accordance with Figures 1a, 1b or 1c, pages 196 and 197.

The response curve for a particular measuring apparatus shall lie between the limits defined in the same figure and quoted in the table below.

Repetition frequency (Hz)	Relative equivalent level of pulse (dB)		
	Band A	Band B	Bands C and D
1 000	--	−4.5 ± 1.0	−8.0 ± 1.0
100	−4.0 ± 1.0	0 (reference)	0 (reference)
60	−3.0 ± 1.0		--
25	0 (reference)	--	—
20	—	+6.5 ± 1.0	+9.0 ± 1.0
10	+4.0 ± 1.0	+10.0 ± 1.5	+14.0 ± 1.5
5	+7.5 ± 1.5	---	—
2	+13.0 ± 2.0	+20.5 ± 2.0	+26.0 ± 2.0
1	+17.0 ± 2.0	+22.5 ± 2.0	+28.5 ± 2.0
Isolated pulse	+19.0 ± 2.0	+23.5 ± 2.0	+31.5 ± 2.0

Notes 1. – It is not possible to specify a definite response above 100 Hz in Band A because of the overlapping of pulses in the intermediate frequency amplifier.

2\. – Appendix C deals with the determination of the curve of response to repeated impulses and with the related problem of amplitude correspondence in Sub-clause 2.1.

Notes on the pulse generator required for the tests and on the determination of the pulse spectrum are given in Appendix D.

APPENDIX A

DEFINITIONS AND METHODS OF MEASURING THE FUNDAMENTAL CHARACTERISTICS OF THE RECEIVER

A1. Bandwidth

The bandwidth is the width of the overall selectivity curve of the receiver at a level 6 dB below the mid-band response.

Note. – For impulsive signals, the bandwidth of an idealized rectangular filter giving the same peak value of response as a receiver comprising a cascade of circuits with less than critical coupling is approximately equal to the bandwidth at a level 7 dB below the mid-band response.

For such a receiver, the bandwidth of the rectangular filter giving the same peak values of response will be approximately 1.05 times its 6 dB bandwidth; this is the case corresponding to the reference pulse areas quoted in Sub-clause 2.1. See Appendix O and Figure 39, page 221. The 6 dB definition of bandwidth, given above, has however been adopted in accordance with current usage.

A2. Electrical charge-time constant

The charge-time constant is the time needed, after the instantaneous application of a constant sine wave voltage to the stage immediately preceding the input of the quasi-peak voltmeter, for the output voltage of the voltmeter to reach 63% of its final value.

This time constant is measured as follows:

A sine wave signal of constant amplitude and frequency equal to the mid-band frequency of the intermediate frequency amplifier is applied to the input of the last stage of the intermediate frequency amplifier. The indication D of an instrument having no inertia (cathode-ray oscilloscope) connected at a point in the d.c. amplifier circuit so as not to affect the behaviour of the detector, is noted. The level of the signal shall be such that the response of the stages concerned remains within the linear operating range. A sine wave signal of this level is then applied for a limited time only (wave train of rectangular envelope); the duration of this signal, for which the deflection registered is 0.63 D, is equal to the charge-time constant of the quasi-peak voltmeter.

A3. Electrical discharge-time constant

The discharge-time constant is the time needed, after the instantaneous removal of a constant sine wave voltage applied to the input of the apparatus, for the output voltage of the voltmeter to fall to 37% of its initial value.

The method of measurement is analogous to that for the charge-time constant, but instead of a signal being applied for a limited time, the signal is interrupted for a definite time. The time taken for the deflection to fall to 0.37 D is the discharge-time constant of the quasi-peak voltmeter.

A4. Mechanical time constant of the indicating instrument

The mechanical time constant of a critically-damped instrument is equal to $T_L/2\pi$, T_L is the period of free oscillation of the instrument with all damping removed.

For a critically-damped instrument, the equation of motion of the system may be written as:

$$T^2 \frac{d^2\alpha}{dt^2} + 2T \frac{d\alpha}{dt} + \alpha = ki$$

where:
α is the deflection
i is the current through the instrument
T is the time constant of the instrument

It can be deduced from this relation that this time constant can also be defined as being equal to the duration of a rectangular pulse (of constant amplitude) which produces a deflection equal to 35% of the steady deflection produced by a continuous current having the same amplitude as that of the rectangular pulse.

Note. – The methods of measurement and adjustment are deduced from these definitions:

a) The period of free oscillation having been adjusted to 0.63 s, damping is added so that $\alpha_T = 0.35\ \alpha_{max}$.

b) When the period of the oscillation cannot be measured, the damping is adjusted to be just below critical such that the overswing is not greater than 5% and the moment of the inertia of the movement such that $\alpha_T = 0.35\ \alpha_{max}$.

A5. Overload factor

The maximum level at which the steady-state response of a circuit (or group of circuits) does not depart by more than 1 dB from ideal linearity defines the range of practical linear function of the circuit (or group of circuits).

The ratio of this level to that which corresponds to full-scale deflection of the indicating instrument is called the overload factor of the circuit (or group of circuits) considered.

A6. Influence of the receiver characteristics upon its pulse response

The level of the pulse response curve for high repetition frequencies depends essentially on the magnitude of the bandwidth.

On the other hand, for low repetition frequencies, the time constants play the more important role.

No tolerance has been stated for these time constants, but it is suggested for guidance that a value of 20% is considered reasonable.

It is also at the very low repetition frequencies that the effect of lack of overload factor will be most noticeable. The values required for the two overload factors are those necessary for the accurate measurement of an isolated pulse using the bandwidth and time constants prescribed.

Examination of the pulse response-curve at the two ends of the range of the indicating instrument provides a check on possible non-linear behaviour of the detector (referred to in earlier C.I.S.P.R. publications as the "uncertainty effect").

The most critical repetition frequencies in this respect will most probably be in the neighbourhood of 20 Hz to 100 Hz.

APPENDIX M

CORRELATION BETWEEN MEASUREMENTS MADE WITH APPARATUS HAVING CHARACTERISTICS DIFFERING FROM THE C.I.S.P.R. CHARACTERISTICS AND MEASUREMENTS MADE WITH C.I.S.P.R. APPARATUS

M1. Introduction

M1.1 C.I.S.P.R. standards for instrumentation and methods of measurement have been established to provide a common basis for controlling radio interference from electrical and electronic equipment in international trade.

M1.2 The basis for establishing limits is that of providing a reasonably good correlation between measured values of the interference and the degradation it produces in a given communications system. The acceptable value of signal-to-noise ratio in any given communication system is a function of its parameters including bandwidth, type of modulation and other design factors. As a consequence, various types of measurements are used in the laboratory in research and development work in order to carry out the required investigations.

M1.3 The purpose of this appendix is to analyze the dependence of the measured values on the characteristics of the measuring apparatus and on the waveform of the measured interference.

M2. Critical interference measuring apparatus characteristics

M2.1 The most critical factors in determining the response of an apparatus for measuring interference are the following: the bandwidth, the detector and the type of interference being measured. Considered to be of secondary importance, but, nevertheless, quite significant in correlating apparatus under particular circumstances, are: overload factor, AGC design (if used), image and other spurious responses, and meter time constant and damping.

M2.2 For purposes of discussion, reference is made to three fundamental types of radio noise: impulse, random and sine wave. The dependence of the response to each of these on the bandwidth and the type of detector is given in Table V. In this table, δ is the magnitude of the impulse strength, Δf_{imp} is the impulse bandwidth, Δf_{rn} is the random noise bandwidth, $P(\alpha)$ is the pulse response for the quasi-peak detector, f_{PR} is the pulse repetition rate and E' is the spectral amplitude of the random noise. The relative responses of various detectors to impulse interference for one apparatus are shown in Figure 38, page 221.

M2.3 Table V shows that the dependence of the noise meter response on bandwidth is different for all three types of interference. If the waveform being measured can be defined as being any of the three types listed in Table V, and if a standard source provides that type of waveform, then by using the substitution method, a satisfactory calibration can be obtained for any apparatus with adequate overload factor independent of its bandwidth. Thus, with a purely random interference or a purely impulsive interference of known repetition rate, calibration can be made using a corresponding source, or a correlation factor calculated on the basis of known circuit parameters.

TABLE V

Comparative response of slideback peak, quasi-peak, average, and r.m.s. detectors to sine-wave, periodic pulse and with Gaussian amplitude distribution

Input waveform	Detector type			
	Slideback peak (sb)	Quasi-peak: 1 600 (qp)	Field intensity (average)	R.M.S.
C.W. sine-wave	e[1]	e	e	e
Periodic pulse (no overlap)	[4] $1.41\ \delta\ \Delta f_{imp}$	$1.41\ \delta\ \Delta f_{imp}\ P(\alpha)$[2]	$1.41\ \delta\ f_{PR}$[4]	$1.41\ \delta \sqrt{f_{PR}\ \Delta f_{imp}}$
Random[5] Gaussian amplitude distribution	—	$1.85 \sqrt{\Delta f_{rn}\ E'}$[3]	$0.88 \sqrt{\Delta f_{rn}\ E'}$	$\sqrt{\Delta f_{rn}\ E'}$

[1] e is the r.m.s. value of the applied sine-wave.
[2] $P(\alpha)$ is given in Figure 39, page 221.
[3] E' is spectral strength in r.m.s. volts cycle bandwidth.
[4] δ is impulse strength. It is assumed that the instrument is calibrated in terms of the r.m.s. value of a sine-wave.
[5] It is assumed that characteristics of the *envelope* are measured by the detector on random noise.

If a particular interference waveform is of a type intermediate between these three types, then the correction or correlation factors will also be intermediate. In any given case, it will be necessary to classify the noise waveform in such a manner that a significant correlation factor can be established. Hence, it will be necessary to examine typical interference sources and to determine the extent to which they are of impulsive, random, or sine-wave type.

M2.4 If an interference measuring apparatus with several types of detectors is available, for example, peak, quasi-peak and average, the type of interference can be assessed by measuring the ratios of the readings obtained with these detectors. These ratios will, of course, depend upon the bandwidth and other characteristics of the apparatus being used for the measurement.

M3. Impulse interference – Correlation factors

M3.1 The quasi-peak detector response of any interference measuring set to regularly repeated impulses of uniform amplitude can be determined by the use of the "pulse response curve" which is shown in Figure 39. This figure shows the response of the detector in percentage of peak response for any given bandwidth and value of charge resistance and discharge resistance. Applying this curve, it should be noted that the peak value itself is dependent upon the bandwidth, so that as the bandwidth increases, peak value increases, but the percentage of peak, which is read by the detector, decreases; over a narrow range of bandwidth, these effects tend to counteract each other. The bandwidth used in this curve is the 6 dB bandwidth which, for the pass band characteristics typical of most interference measuring apparatus, is about 5% less than the so-called impulse bandwidth. A theoretical comparison of apparatus having various bandwidths and detector parameters with the C.I.S.P.R. apparatus is shown in Figure 40, page 222.

M3.2 The response of the average detector to impulsive noise is an interesting case.

The reading of an average detector for impulsive noise is independent of the bandwidth of the predetector stages. It is, of course, directly proportional to the repetition rate. In most cases, the reading obtained with an average detector for impulsive noise is so low as to be of no practical value unless the noise meter bandwidth is exceedingly narrow, such as of the order of a few hundred hertz. For a repetition rate of 100 Hz and a bandwidth of the order of 10 kHz, the average value would be approximately 1% of the peak value. Such a value is too low to measure with any degree of precision. Furthermore, for many communication systems, the annoyance effect may be well above the reading obtained with the average meter. This, of course, is one of the justifications for the use of the quasi-peak apparatus.

M4. Random noise (Gaussian amplitude distribution) —

The response of a noise meter to random noise is proportional to the square root of the bandwidth. This result is independent of the type of detector used. The ratio of the random noise bandwidth to the 3 dB bandwidth is a function of the type of filter circuit. On the other hand, it has been shown that for many circuits typical of those used in interference measuring apparatus, a ratio of effective random noise bandwidth to the 3 dB bandwidth of about 1.04 is a reasonable figure.

M5. The r.m.s. detector

M5.1 One of the advantages of the r.m.s. detector in correlation work is that for broadband noise the output obtained from it will be proportional to the square root of the bandwidth, i.e. the noise power is directly proportional to the bandwidth. This feature makes the r.m.s. detector particularly desirable and is one of the main reasons for adopting the r.m.s. detector to measure atmospheric noise. Another advantage is that the r.m.s. detector makes a correct addition of the noise power produced by different sources, for example, impulsive noise and random noise, thus for instance allowing a high degree of background noise.

M5.2 The r.m.s. values of noise often give a good assessment of the subjective effect of interference to a.m. sound and television reception. However, the very wide dynamic range needed, when using very wide band apparatus for measuring impulsive noise, limits the use of r.m.s. detectors to narrow band apparatus.

M6. Discussion

M6.1 The preceding sub-clauses have indicated the theoretical basis for comparing measurements obtained with different apparatus. As mentioned previously, the possibility of establishing significant correlation factors depends upon the extent to which noise can be classified and identified so that the proper correlation factors may be used. In many frequency ranges, impulsive interference appears to be the most serious; however, for power lines where corona interference is the primary concern, random interference would be expected to be more characteristic. Additional quantitative data are needed on typical interference characteristics.

M6.2 Another important parameter is the overload factor*.

* See C.I.S.P.R./WG1 (U.K./Jackson) 1.
See C.I.S.P.R./WG1 (U.K./Jackson) 4.

M7. Application to typical noise sources

M7.1 *Commutator motors*

The noise generated by commutator motors is usually a combination of impulse and random noise. The random noise originates in the varying brush contact resistance, while the impulse noise is generated from the switching action at the commutator bars. For optimum adjustement of commutation, the impulse noise can be minimized. However, where variable loading is possible, measurements have confirmed that for the peak and quasi-peak detectors, the dominant noise is of impulse type and the random component may be neglected. While the repetition rate may be of the order of 4 kHz, the effective rate is lower because the amplitude of the impulses is usually modulated at twice the line frequency*. Hence, experimental results have shown that quasi-peak readings are consistent with bandwidth variations if the repetition rate of the impulses is assumed to be twice the frequency of the supply mains.

M7.1.1 Peak measurements show fluctuating levels on such noise because of the irregular nature of the commutator switching action.

M7.1.2 The quasi-peak to average ratio is lower than would be obtained for pure impulse noise for two reasons:

1) The modulation of the commutator switching transients by line frequency produces many pulses below the measured quasi-peak level. These pulses do not contribute to the quasi-peak value but do contribute to the average.

2) The relatively low level, but continuous, random noise can likewise contribute substantially only to the average value. Experimental values of quasi-peak to average ratio range from 13 dB to 23 dB with the highest ratios for the widest bandwidths (120 kHz).

M7.2 *Impulsive sources*

Tests on an ignition model, commutator motor appliances and appliances using vibrating regulators showed reasonable agreement on measuring apparatus with the same nominal bandwidth, but with discharge time constant ratios of the order of 3 to 1 on restricted portions of the output indicator scale. Deviations at higher scale values are without explanation. Relatively poor correlation was obtained on sources producing very low repetition rate pulses (see C.I.S.P.R. WG1 (U.K./Jackson)1).

M7.3 *Ignition interference*

C.I.S.P.R. Recommendation 18/2 recognizes that correlation between quasi-peak and peak detectors can be established as a practical matter. The conversion factor of 20 dB is explained partly on the basis of theory for uniform repeated impulses, and partly on the basis of the actual irregularity of the amplitude and wave-shape of such impulses.

* See C.I.S.P.R./WG1 (de Jong–Netherlands)4.

M7.4 *Dependence on bandwidth*

Comparisons of measurements made in the United Kingdom with two instruments having bandwidths of 90 kHz and 9 kHz respectively have been reported to show that for most interference sources, the values obtained are in the ratio 14–18 dB. This figure is consistent with the concept that the interference is dominated by impulse type noise but that some random components are present.

M8. Conclusions

M8.1 Analysis of data comparing the responses of various instruments shows that it is possible to explain in almost every case the differences in measured values on the basis of theoretical and practical considerations. In many instances, it is indicated that waveform characteristics are known to predict correlation factors adequately with an accuracy of 2 dB to 4 dB.

Further studies are needed:

1) to characterize in some detail the waveforms of various sources of interference; and
2) to correlate these waveform characteristics with measured values and the instrument characteristics.