

Spectrum Management

Electromagnetic Compatibility Advisory Bulletin

Immunity of Electrical/Electronic Equipment Intended to Operate in the Canadian Radio Environment (0.010-10,000 MHz)

Foreword

In 1977, EMCAB 1, Issue 1, was released by the Department of Communications to draw attention to Electromagnetic(EM) immunity of electrical/electronic apparatus intended for use in the Canadian EM environment. A second Issue was released in 1982 updating the previous information and describing in depth the radio environment which can be encountered in typical urban and suburban communities.

Since the publication of Issue 2, significant changes in electronic technology have occurred and the usage of spectrum for personal communications has increased extensively. Furthermore, urban development has given rise to residences being built in close vicinity of high power transmitters. The variety and number of devices using microprocessor controlled circuits have also increased dramatically and have led to the widespread use of digital circuits using very low signal levels (currents) in domestic appliances, audio-video entertainment equipment and other in-home control systems such as furnace and security controls. These devices when exposed to high level electromagnetic field strength can be prone to malfunction.

The combination of these circumstances has brought about an increased awareness of the immunity problem among the Canadian public; over 25% of all complaints recorded by the DOC are related to immunity problems making them the primary cause of reported malfunction of radio receivers. As a result of these developments, Canadian radio users, broadcasters and electronic equipment manufacturers through their representatives on the Radio Advisory Board of Canada (RABC), have asked the Minister of Communication to take some action to resolve or alleviate the problem. These requests have been reflected in the provision of the new enabling powers to the Department to make regulations respecting immunity in the new Radiocommunication Act passed in October 1989.

Internationally, many countries are facing similar problems and the International Special Committee on Radio Interference (CISPR) of the International Electrotechnical Committee (IEC) has produced an immunity standard which is being adopted by numerous countries, notably those of the European Community (EC). The EC Directive on Electromagnetic Compatibility specifically identifies the immunity of all electronic equipment as one of the issues that must be resolved through the application of common standards and performance limits by the end of 1992. Such international efforts can be expected to significantly influence the action of equipment manufacturers and consumer nations over the next few years. The Department is following closely the progress of these issues in other countries.

Purpose

The purpose of this new Issue is threefold: first, to identify the concerns which have arisen from the changes in both the electromagnetic environment and equipment technology, second, to further quantify the electromagnetic environment, and finally, to provide information on the Department's intended plan of action on immunity problems.

This bulletin, like its predecessors, is pertinent to the design of all equipment, systems, and devices that will be affected inadvertently by, or will respond to, electromagnetic energy in the radio frequency range from .010 to 10,000 MHz or more (Annex I). It is not, however, intended to apply to the design of the frequency response of communication receivers in the immediate vicinity of their intended pass-bands. Specification of this parameter is subject to the requirements of spectrum sharing and the equipment type approval constraints invoked by the Department on receipt of an application for radio equipment approval or a radio system authorization.

This bulletin notwithstanding, the Department may specify, through regulation under the Radiocommunication Act, limits of immunity for receivers and other radio-sensitive equipment which must be met as a prerequisite to their importation, sale and use in Canada.

Introduction

The rapidly increasing use of radio services has led to dramatic increases in the proliferation of high level electromagnetic fields in urban areas. Radios and other electrical/electronic equipment operating in the presence of such fields can malfunction or suffer performance degradation. This causes owner dissatisfaction and many complaints arise which prove, upon investigation, to have occurred because the equipment is insufficiently immune to the radio environment in which it operates.

At this point it is appropriate to define certain terms specific to electromagnetic immunity.

Immunity is defined as the ability of a device to perform without degradation in the presence of electromagnetic disturbances. The opposite of this is susceptibility, which is the tendency of a device to malfunction or exhibit degraded performance in the presence of electromagnetic disturbances.

An apparatus is said to malfunction when it does not perform the tasks it is intended to at any given time. A malfunction also includes the spontaneous operation of the apparatus at a time when it is supposed to be inactive. The degree of malfunction may be related to the risk associated with the malfunction. The Department is carrying out a survey of electronic equipment manufacturers to further characterize the implications of malfunctions.

The Electromagnetic Environment and Immunity Limits

It is obvious that not all electronic equipment requires the same degree of immunity. In selecting an appropriate immunity level, the designer of an electronic device must consider, inter alia, the performance requirements of the device, the potential for hazardous results from its malfunction, the expectations of the customer, the economics of an immune

design and, of particular importance, the electromagnetic environment to which the device may be exposed during its life cycle.

By "electromagnetic environment" (or radio environment) we mean the combined effect of the radio emissions that are created at any given location by normally operating authorized transmitters. It has the dimension of field strength and varies with frequency band, geographical location and time. A great number of factors interact to determine the field strength which may be encountered in a given situation, and so it is not possible to forecast accurately the signal levels in every individual case. It is possible however, to predict the range of field strength levels likely to be encountered in populated areas since the powers normally used by transmitters are known as well as the typical distances to affected devices.

Table 1 presents field strength values characteristic of those attributable to various current radio services. The radio system parameters used in calculating these values are representative of those normally authorized and the transmitter-receptor distances are typical of separations found in populated areas.

Characterization of the environment, to provide the designer with guidance to make the appropriate judgments, should include an indication of the probability that a field level of a specific value will be encountered. The need for this information was recognized at the time Issue 1 was published. Subsequent studies addressing this question have produced the statistical information provided in Annex II.

The data for the AM, FM and TV broadcasting bands are presented as cumulative probability distribution curves of field strength for Toronto and Montreal respectively (Fig 1, Fig 2.). They represent, for each band, the probability that a unit of electrical/electronic equipment, randomly located near ground level in an urban area, would encounter a field greater than a specified value. For a large number of units this would approximate the percentage of a product line which might be expected to experience such field strengths. It should be noted that these curves include only the probability of being exposed to the single, strongest signal of the radio transmitter in the area and that the combined effect of more than one transmitter is not included.

Furthermore, in these curves, no provision has been made for the time probability that a transmitter may or may not be transmitting; obviously, susceptibility malfunctions would occur only while the radiation source was operating. In the case of broadcasting transmitters however, the duty cycle could safely be assumed to be 100% for most applications. The curves are based upon conditions in two major urban centers in Canada, Montreal and Toronto. Because of the spectrum congestion in these two centers it might appear that the results are biased toward a "worst case" situation. However, for the AM, FM and TV broadcast bands, these two cities do not have significantly higher levels of field strength than other Canadian cities with primary broadcast service. On the other hand, these are the two largest market areas in Canada for electrical/electronic devices which are potentially susceptible to the electromagnetic environment and would be expected to influence design requirements for equipment used throughout the country.

The curves are derived by a predictive method developed by Bell Northern Research under contract to the Department. This procedure involved the statistical adjustment of an analytical field strength prediction technique by the results of a large number of field measurements taken in Montreal and Toronto. It is described in G. Costache et al. "Electromagnetic Field Strength Probability Profiles for Canadian Cities". International Electrical and Electronics Conference and Exposition - Toronto, Canada - October 1981.

During the winter of 1986-1987, the Department carried out a study to measure electric field strength in the HF band in the vicinity of amateur stations. The results of the measurements which were taken in five different frequency bands in Toronto and Ottawa, are also presented in Annex II.

The data were reduced to cumulative amplitude probability curves. Figure 3 depicts the statistical distribution of the electric field measured in the immediate vicinity of an operating amateur transmitter. "Immediate vicinity" in this case means at distances ranging from directly below the antenna support structure to those corresponding to the limits of the yards of adjacent and second adjacent neighbors in a typical suburban residential environment. The readings were taken either just inside the property limits of the amateur or on the streets bordering the neighboring properties.

A second set of measurements was taken to evaluate the distribution of voltage, induced in the mains wiring of a residence due to the electric field generated by an amateur transmitter operating in its vicinity. The statistical distribution of the induced voltages is represented in Figure 4, using the same presentation format as Figure 3. In both figures, raw data and their corresponding values normalized to two different transmitter power outputs are shown.

Figure 5 presents a composite envelope of the maximum fields to which electronic equipment may be expected to be exposed throughout the spectrum. This may be viewed as a summary of the other data presented here. The actual field strength levels will vary depending upon many parameters such as power, time, distance, propagation conditions, etc., but a range of 1 V/m to 20 V/m can be expected to occur for most of the frequency bands.

Equipment Affected

Generally all types of electrical/electronic equipment are affected by high level electromagnetic fields. However, these can be broken down into two principal categories. The first is radio equipment. This includes AM, FM and TV receivers and would also include all other types of off-air communication receivers. The second category of susceptible equipment comprises all other electronic/electrical equipment such as analog amplifiers and other associated equipment in the home entertainment area, equipment incorporating microprocessors and other digital circuits which operate at low current levels. This includes, inter alia, domestic appliances such as microwave ovens, cordless telephones, furnace control circuits, and home security systems. In addition, there is a range of medical and commercial equipment using both analog and digital circuits that may be susceptible. Annex I gives further examples of potentially susceptible devices.

There are two distinct modes via which undesired signals are introduced into an equipment. The first mechanism of coupling is by radiated field. Principally, equipment operating in a normal mode is subjected to ambient electromagnetic fields present in its operating environment. The equipment malfunctions because of the unwanted currents induced directly on its internal circuitry by these radiated fields. The second mechanism involves unwanted currents conducted into the equipment via power, signal or control leads which may act as antennae when exposed to the local electromagnetic fields present in the environment. These currents, after processing by internal circuits, may cause malfunction or appear at the output terminals, degrading the performance. The first mechanism is normally dominant at higher frequencies whereas the second one is predominant at lower frequencies, the transition taking place in the range 3 to 30 MHz, the HF band. This is primarily a result of the length of the conductors involved and their ability to act as antennas at different wavelengths.

Since a great number of factors interact to cause malfunctions, it is not possible to forecast accurately the mode by which a malfunction will take place. Therefore, the Department believes that testing is the only means of ensuring the immunity of different types of equipment. Furthermore, the level of protection should be dependent upon the use of equipment. More specifically, the immunity performance required of an equipment should be graded according to the degree of risk associated with its malfunction. For instance, malfunction of a medical equipment, which might endanger lives, would lead one to consider the suitability of a more stringent immunity limit for a medical apparatus than that which might be appropriate for a home entertainment device.

Future Action

The Radiocommunication Act has recently redefined the Department's role in the immunity domain by assigning additional enabling powers to the Minister of Communications. These new powers allow the minister to make determinations as to the existence of and responsibility for harmful interference and to issue orders to the operators of offending radio-sensitive equipment to either cease operation or modify the equipment until such time that it can be operated without being affected by harmful interference. In addition the Act provides for the promulgation of regulations which may address any aspect of the control of electromagnetic immunity.

In order to facilitate the exercise of these powers, should they be required, the Department has recently developed a plan of action which calls for a multi-dimensional resolution of the immunity problem. This plan provides for development of new immunity standards, for voluntary observance by both manufacturers and importers of electronic equipment. Simultaneously, the Department proposes to carry out a program of systematic analysis and measurement of the level of susceptibility of currently available electronic equipment. These studies will be augmented by other measures to help improve consumer and industry awareness of immunity issues and cures, at the designer, user and maintenance and repair levels.

While no mandatory requirements are planned at this time, the Department proposes to promote the formulation and observance of voluntary immunity standards. The first set of these, which are applicable specifically to radio receivers and associated equipment, are being developed via a consultative process with the electronic manufacturing industries in the CSA forum. Nevertheless, they will be consistent with the departmental regulatory authority currently available under the Radiocommunication Act. The objective of the new immunity standards is to provide a common set of measurement methods particularly suitable to the Canadian environment but harmonized to the extent possible with methods developed by the International Special Committee on Radio Interference (CISPR). Should it prove necessary, in the future, to adopt immunity regulations, these standards would then be available to form a basis for the technical requirements with which susceptible electronic devices would have to comply.

These standards are in an advanced state of preparation within the standards-writing process of the CSA, under the aegis of the Standards Steering Committee on Electromagnetic Compatibility.

Electronic devices other than radio receivers are also affected by electromagnetic fields and it is planned that they will be dealt with in a process similar to that described above. Because of the diversity of products and technologies involved, however, consultation and input will be required of a much larger segment of industry than is the case for receivers alone. To this end, the Department is concentrating its initial studies on evaluating the immunity capabilities of a broad range of current equipment to determine the extent of the problem that has to be addressed. The Department also plans to develop guideline immunity criteria to be used in the investigation of immunity complaints involving both receiving and non-receiving devices.

The Radio Advisory Board of Canada (RABC), a non-profit organization of radiocommunication users and manufacturers, recommended to the Department that a mandatory policy for the repair, replacement or refund of purchase price be instituted in Canada for equipment which exhibits insufficient immunity. While the new powers under the Radiocommunication Act would sanction such regulation, it is not deemed necessary to take such action at this juncture. One aspect of the Department's program does address the use of this approach on a voluntary basis and has received endorsement by some elements of the industry. A survey of the equipment manufacturers and their distribution agents is being conducted to acquire information on the specific policies of such organizations, their views on this approach and the support that they are prepared to provide in its practice.

In order to increase the general awareness of the public on this issue, the Department plans to disseminate immunity information both to the manufacturers and consumers via technical publications and information circulars. To start with, the Department is preparing a Radio Information Circular to be distributed to individuals who report problems arising due to susceptibility of their equipment. It will contain general information and guidance as to the nature of the problem and means of recourse. More importantly, however, based on the information gathered in the survey mentioned above, it will contain a listing of the policies of most manufacturers regarding repair, replacement or

refund with respect to their products and the names of the company officers who may be contacted should this type of problem arise.

Other opportunities for information dissemination such as conducting symposia and seminars for technologists/technicians involved in repair and maintenance of electronic equipment are also under consideration and will be addressed in consultation with concerned industrial representatives such as the RABC.

In the meantime, the Department plans, within the constraints of current resources, to continue to monitor and investigate complaints related to immunity and provide assistance in resolving such problems. Furthermore, as the problem is not solely domestic in scope, being strongly influenced by the multinational character of the electronic equipment industry, it is planned to continue the ongoing discussions and negotiations which have been initiated in the international standards-writing fora of the world, seeking economic means for the timely amelioration of what has become a truly global concern.

Issued under the authority of the
Minister of Communications

S.N. Ahmed
Director General
Engineering Programs

Table 1

Service	Frequency Range (MHz)	Effective Radiated Power (dBW)	Usual Range of Separation Distances	Consequent Range of Strengths (V/m)
LF Communications & Nav aids	0.014-0.5	54	5-20 km	0.25-1.0
AM Broadcast	0.5-1.7	47-50	0.5-2 km	0.2-6.0
HF Amateur	1.8-30	30	20-100 m	3.0-15.0
HF Communications	1.7-30	40	4-20 km	0.001-0.25
General Radio	27	11	10-100 m	0.3-3.3
VHF Amateur	30-225	30-39	100-500 m	0.35-5.0
Communications Fixed & Mobile	30-470	17-21	40-200 m	0.2-1.5
TV-VHF	54-216	50-55	0.5-2 km	1.0-7.3
FM-Broadcast	88-108	50	0.25-1 km	2.0-8.3
TV-UHF	470-806	67	0.5-3 km	1.0-3.0
Radar	1000-10000	90-97	2-20 km	0.1-90

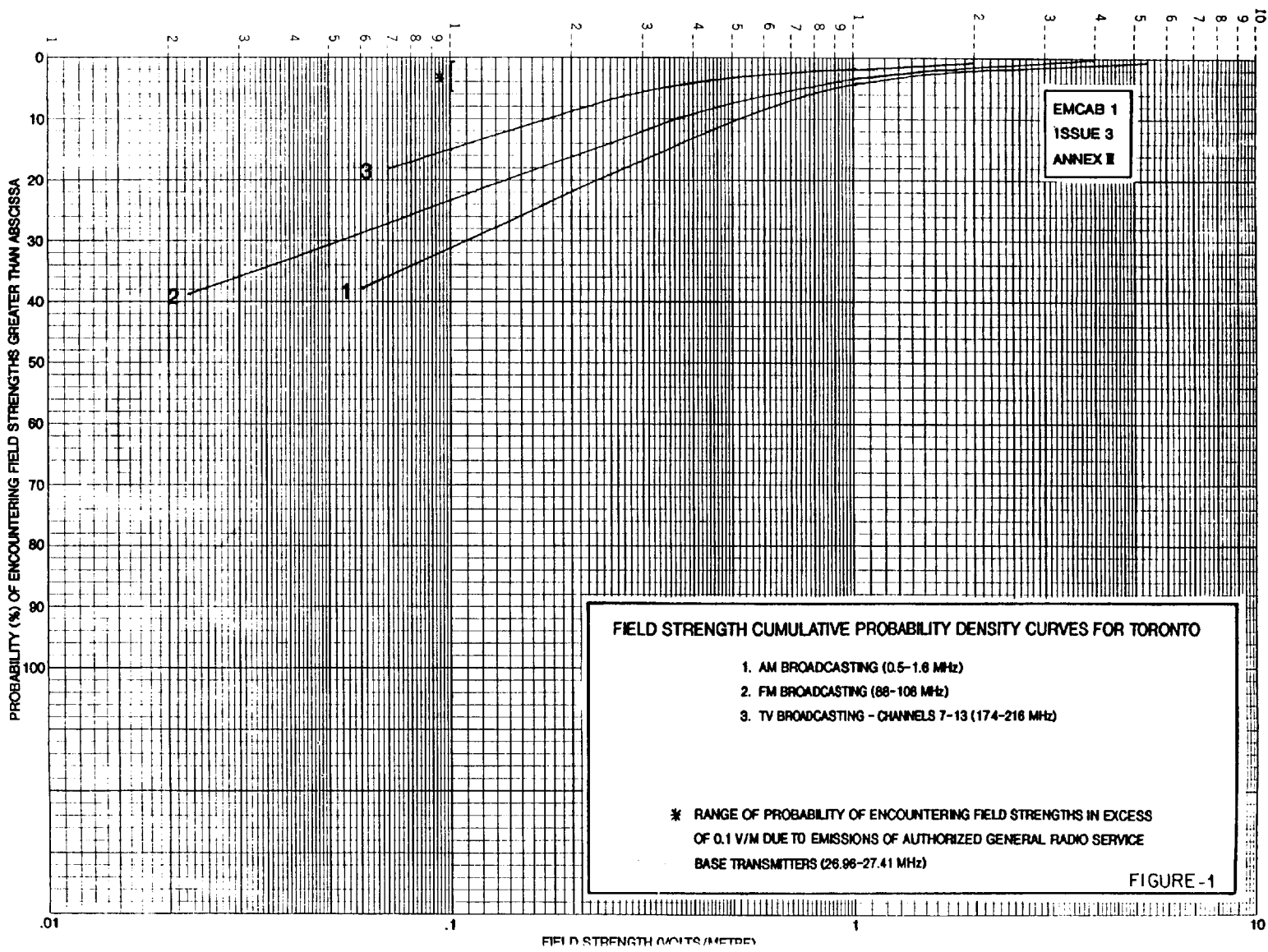
Annex 1 Susceptible Equipment

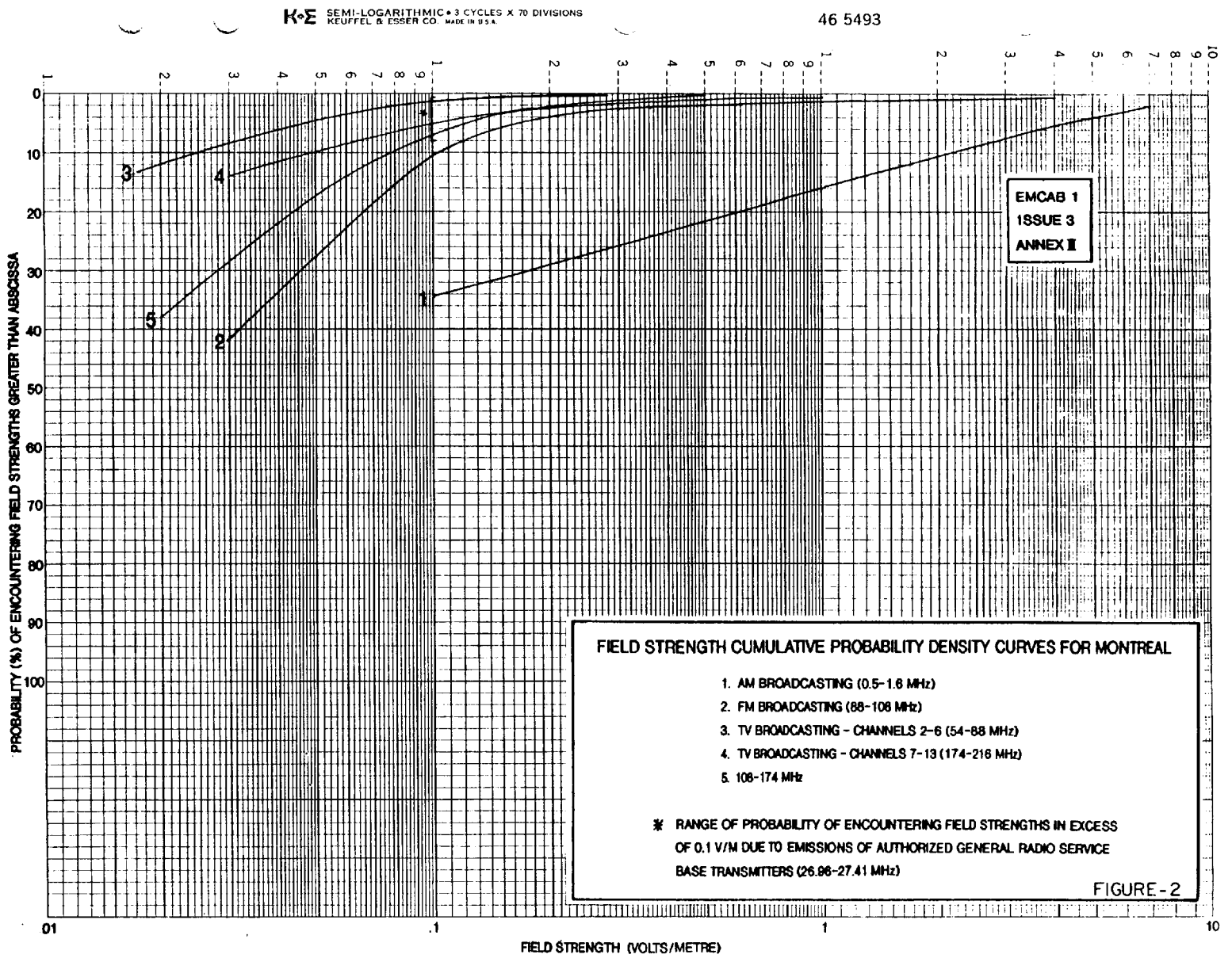
The electronic equipment which may be susceptible to radio frequency energy is not limited to communications receivers or equipment. The following list, by no means exhaustive, is representative of the types of equipment subject to malfunction due to susceptibility to electromagnetic fields.

Broadcast receivers (AM, FM, TV)	Digital timers
Audio systems (Home & Commercial)	Computers
Video games	electro-explosive devices
Closed circuit video systems	Radio controlled models
Telephone switching equipment	Measuring equipment
Electronic calculators	Process control devices
Heart pacemakers	- vehicle ignition
Medical monitoring equipment	- vehicle brakes
Medical test equipment	- photographic
Metal detectors	- manufacturing
Domestic appliances	- elevators
Prosthetic devices	- power distribution
Computer terminal equipment	CATV Systems
Electronic sensors	Cameras
Telephone distribution systems	VCRs

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EMCAB 1
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ANNEX II

DISTRIBUTION OF FIELD STRENGTH
IN THE VICINITY OF HF AMATEUR STATION

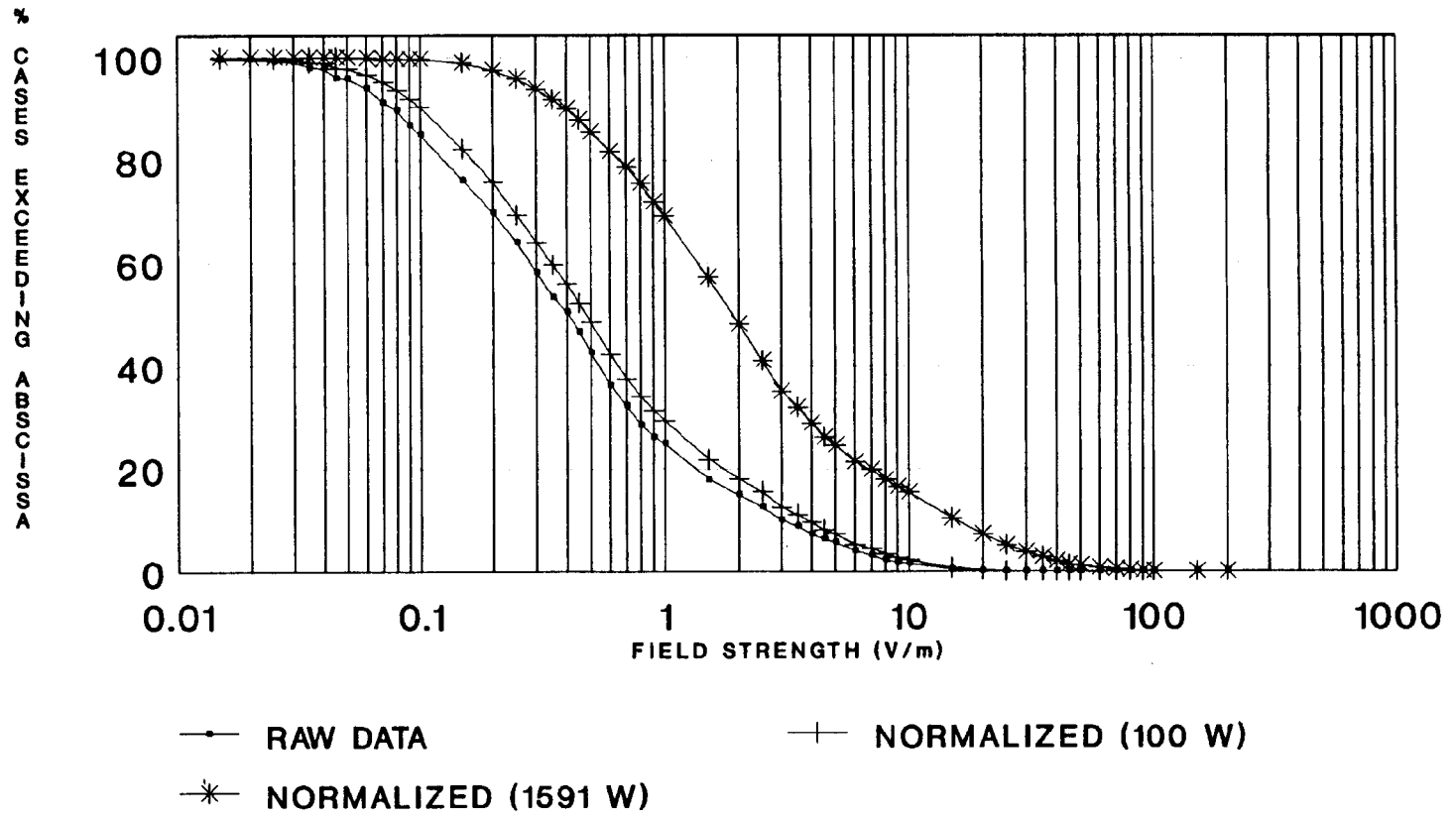


FIGURE 3

EMCAB 1
ISSUE 3
ANNEX II

MAXIMUM EXPECTED FIELD STRENGTH
IN POPULATED AREAS

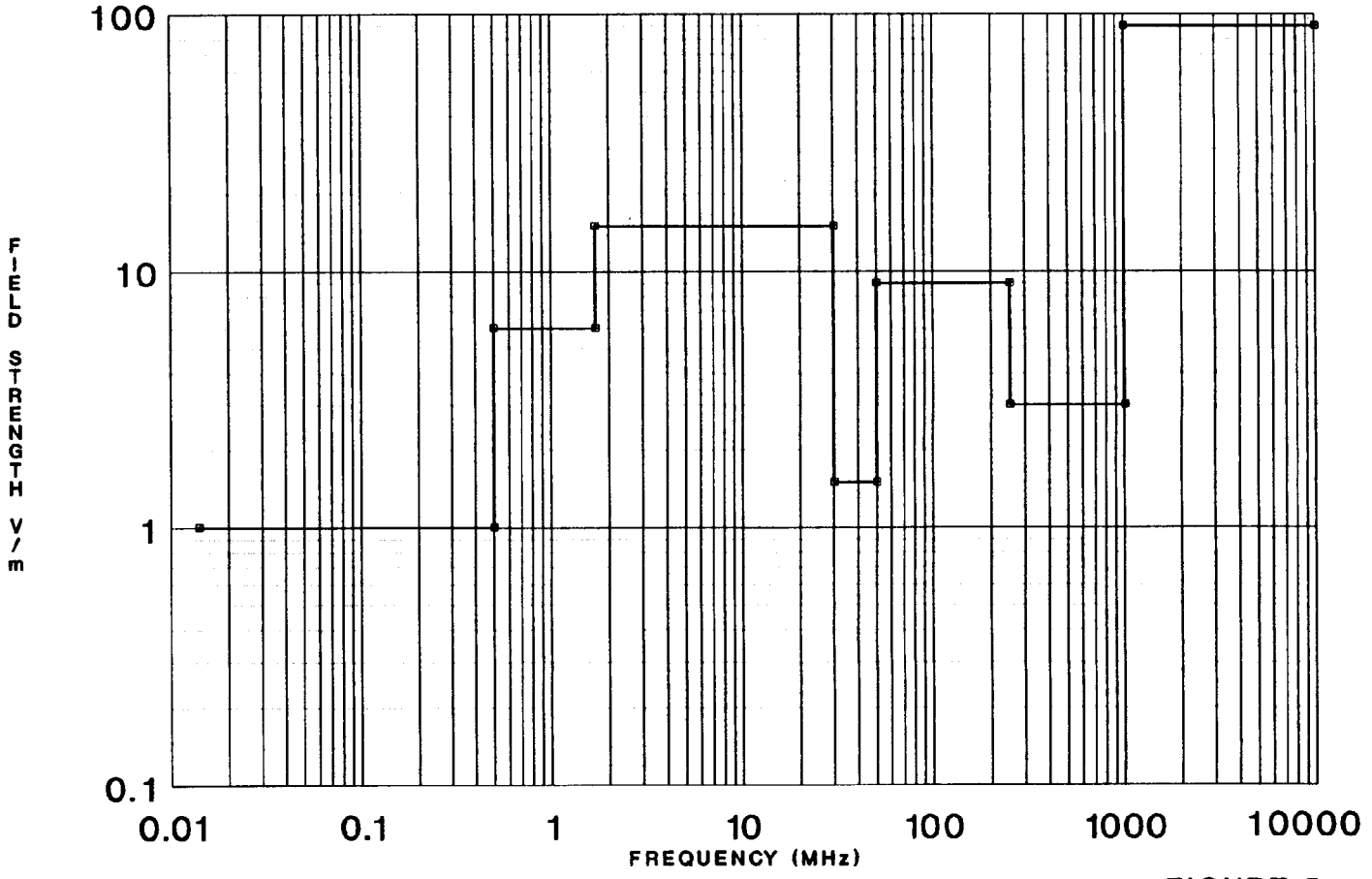


FIGURE 5