

IEEE Recommended Practice for Minimization of Interference from Radio-Frequency Heating Equipment

Sponsor
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IEEE Electromagnetic Compatibility Society**

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Abstract: IEEE Std 140-1990, *IEEE Recommended Practice for Minimization of Interference from Radio-Frequency Heating Equipment*, describes procedures that may be applied in the design and construction of radio-frequency heating equipment used for heating in industrial and other purposes, excluding applications in the field of telecommunication and information technology. These procedures are intended to reduce the amount of radio-frequency energy leaks, which can interfere with other equipment and broadcast services; they may also be used as remedial measures when harmful interference occurs.

Keywords: electromagnetic interference, ISM equipment, radio-frequency energy, radio-frequency heating equipment

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Foreword

(This Foreword is not a part of IEEE Std 140-1990, IEEE Recommended Practice for Minimization of Interference from Radio-Frequency Heating Equipment.)

The purpose of this recommended practice is to provide guidance to those responsible for preventing radio-frequency (rf) heating equipment from interfering with other electrical equipment in its environment. RF energy for heating purposes has found multiple applications in industrial, scientific, and medical equipment. Unfortunately, it is virtually impossible to contain all of the rf energy used within rf heating equipment. This recommended practice seeks to give guidance that will prevent interference with other equipment and broadcast services by limiting the amount of rf energy that escapes to low levels.

When it became necessary to review and revise IEEE Std 140-1950, Jim Maw accepted the chairmanship of the working group and directed the task of updating this standard. The members of the working group contributed their time and energy generously. As this project neared completion, a number of other individuals contributed review and comments, which substantially aided in the completion of the task. These contributors are gratefully acknowledged.

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IEEE Recommended Practice for Minimization of Interference from Radio-Frequency Heating Equipment

1. Introduction

The use of radio-frequency (rf) energy for heating in industrial and other processes is essential to manufacturing technology. RF heating equipment is one category of equipment that generates and/or uses rf energy for industrial, scientific, medical, domestic, and other purposes excluding applications in the field of telecommunication and information technology. Equipment so defined is generally called ISM equipment.

It is economically difficult to completely contain the rf energy generated by rf heating equipment. A certain amount of such energy inevitably leaks into the space around the equipment or is conducted over control power wires to other equipment in the vicinity. This radiated and/or conducted rf energy is capable of causing harmful interference to telecommunication services and to information technology equipment and thus is a very important issue. Accordingly, most governments have issued regulations to limit such unintentional radiated and conducted emissions.

The procedures described should be applied in equipment design and construction. The user should carefully follow the manufacturer's recommendations and keep the specified structure complete and in good condition. These procedures may be used as remedial measures when harmful interference occurs. It is much less expensive, however, to incorporate EMC techniques in the original design than to correct errors after installation.

2. References

This recommended practice shall be used in conjunction with the following publications. A bibliography is included in Section 7 for further information.

[1] ANSI C63.2-1987, American National Standard for Instrumentation—Electromagnetic Noise and Field Strength, 10 kHz to 40 GHz — Specifications.¹

[2] ANSI C63.4-1988, American National Standard Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 10 kHz to 1 GHz.

¹ANSI publications can be obtained from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.

[3] ANSI C95.1-1982, American National Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 300 kHz to 100 GHz.²

[4] ANSI/NFPA 70-1990, National Electrical Code, 1990 ed.³

[5] IEEE Std 100-1988, IEEE Standard Dictionary of Electrical and Electronics Terms — 4th ed. (ANSI).⁴

[6] IEEE Std 139-1988, IEEE Recommended Practice for Measurement of Radio Frequency Emission from Industrial, Scientific, and Medical (ISM) Equipment Installed on User's Premises (ANSI).

[7] IEEE Std 473-1985, IEEE Recommended Practice for an Electromagnetic Site Survey (10 kHz to 10 GHz) (ANSI).

[8] IEEE Std 518-1982, IEEE Guide for the Installation of Electrical Equipment to Minimize Noise Inputs to Controllers from External Sources (ANSI).

[9] US Federal Communications Commission, Title 47, Code of Federal Regulations, pt. 2 — Frequency Allocations and Radio Treaty Matters; General Rules and Regulations.⁵

[10] US Federal Communications Commission, Title 47, Code of Federal Regulations, pt. 18 — Industrial, Scientific and Medical Service.

3. Definitions

Unless otherwise noted, all technical definitions are in accordance with those given in IEEE Std 100-1988 [5].⁶

Poulsen arc (also Poulsen singing arc or singing arc): A type of arc-gap transmitting circuit that uses a resistance-capacitance (rc) circuit to tune the arc. This technique substantially reduces the bandwidth used by the arc-gap transmitter.

4. General

4.1 The Need for Shielding

4.1.1 Local Effects

The electrical behavior of high-frequency power gives the impression that it does not follow electrical laws applicable at lower frequencies, where power capability is typically measured in kilowatts and radiation allowance is only a few milliwatts. Actually, there is no fundamental difference. The difficulty lies only in the fact that effects that were negligible at 60 Hz become very important as the frequency is raised. It becomes increasingly difficult to confine electric currents to desired circuits. Dangerous potentials may exist between apparatus cases that can cause burns to operators as well as serious radiation emissions. High-frequency currents may circulate in control devices and make them inoperative or otherwise impair their functions. Circuits and structures that are not associated with the equipment

²ANSI C95.1-1982 has been withdrawn. Copies can be obtained from ANSI.

³NFPA publications are available from Publications Sales, National Fire Protection Association, Batterymarch Park, Quincy, MA 02269 or from ANSI.

⁴IEEE publications can be obtained from the Service Center, The Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331 or from ANSI.

⁵For sale by the Superintendent of Documents, US Government Printing Office, Washington, DC, 20554.

⁶The numbers in brackets correspond to those of the references listed in Section 2. When preceded by B, they correspond to the bibliography in Section 7..

in any way may pick up high-frequency currents. The solution to all such hazards is the use of shielding and filtering to confine the currents to safe channels.

4.1.2 Remote Effects

High-frequency energy can propagate through free space and through wires, causing interference to equipment at great distances from the source. The energy may travel along the earth's surface or be conducted on wires directly to the remote point, or it may be reflected from the ionosphere to be returned to earth at tremendous distances from its source. Again, the solution lies in adequate shielding and design of the high-frequency circuits. Surprisingly small amounts of radiated power can cause considerable trouble of this nature.

There are always high-frequency currents inside a cabinet. They must be kept inside and not allowed to escape. A poor joint (one that is dirty, loose, etc.) or an opening are places from which currents may escape, so they must be eliminated.

Good shielding includes the following:

- 1) A high-conductivity enclosure
- 2) Good, clean contact between cabinet parts
- 3) Minimum openings
- 4) Shielded openings
- 5) Waveguides where needed
- 6) Use of interlocks
- 7) Filtering of electrical conductors where they penetrate the shield

Shielding integrity is dependent on regular maintenance.

As operating frequencies increase, coupling effects, which are negligible at 60 Hz, become significant. Dangerous potentials may develop between nearby exposed conductors. High-frequency voltage may be induced in control devices, making them inoperative. Electromagnetic fields radiated by the equipment may interfere with other, independent devices, as well as licensed radio communications and navigation systems. To prevent these dangers, adequate shielding, filtering, and grounding are essential.

4.2 Nature of Radiation

4.2.1 Types of Generator Equipment

The oldest type of generating equipment is the rotating machine. However, this device is not generally used above 10 kH. In the range of 10 to 500 kH, common power sources were the spark gap and Poulsen arc. Interference from spark equipment is distributed over a very wide frequency range. For example, a 20 kH generator will radiate a continuous spectrum of noise that is very similar to automobile ignition interference, which may extend well into the very-high-frequency regions.

Even if the operating frequency of the ISM equipment will not cause interference, harmonics can be generated by nonlinear elements in the system, and parasitic oscillations may be generated on nonharmonically related frequencies.

Nonlinear electrical components distort waves, generating frequencies that are harmonics, as well as sideband frequencies that bear no harmonic relation to the fundamental. In addition, such phenomena as moding and parasitic oscillations cause trouble. Moding is a sudden frequency shift or "skip" of the generator during the loading procedure. It is a normal tank circuit characteristic that is present when a tuned load is tightly coupled to the tank. Parasitic oscillations are spurious frequencies generated by a feedback path other than the normal path, resulting in unwanted oscillations in the generator.