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**IEEE Trial-Use Standard
Guide on Solid-State Devices:
Varactor Measurements
Part II — Characterization of
Large-Signal Devices**

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Foreword

(This Foreword is not a part of IEEE Std 351-1972, Trial-Use Guide on Solid-State Devices: Varactor Measurements, Part II — Characterization of Large-Signal Devices.)

The purpose of this guide is to promote the use of uniform and reliable measurement techniques for the characterization of varactors. Part I of this Guide (IEEE Std 318-1971) describes techniques which are primarily appropriate for varactors used in small-signal applications, such as parametric amplifiers. Part II discusses modifications, limitations, and extensions of the techniques described in Part I, as well as other measurements, which are more appropriate for certain large-signal varactors, such as harmonic generator diodes. The design of varactors is advancing at a pace which sometimes outstrips the progress in evaluation techniques. Both diode design and measurement methods are evolving at a rate which exceeds that at which characterization guides can be written. This guide is not intended to discourage innovation but will provide a basis for uniform evaluation of the large class of varactors to which it is applicable.

This guide was prepared by the Varactor Standards Task Group of the IEEE Electron Devices Group Standards Committee. The Task Group had the following membership:

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IEEE Trial-Use Standard

Guide on Solid-State Devices:

Varactor Measurements

Part II — Characterization of

Large-Signal Devices

1. Scope

This standard describes parameters and methods of measurement suitable for the characterization of varactors intended for large-signal application. This will be done by reference to the parameters and methods prescribed in IEEE Std 318-1971, Trial-Use Guide on Solid-State Devices: Varactor Measurements, Part I — Small Signal Measurements, where they are applicable, and by modification and supplementation of them where necessary for use with large-signal devices.

2. Definition of Large Signal

There are two distinct classes of large-signal applications. First, there are those applications in which the utility of the varactor derives from the high-frequency capacitance variation brought about by the signal voltage, that is, in which the high-frequency signal significantly modulates the varactor capacitance. Examples are harmonic generators and frequency converters. (In contrast, parametric amplifiers are usually a small-signal application since the significant capacitance variation is due to a pump voltage and not due to the signal.)

The second class of large-signal applications is one in which the capacitance is determined primarily by a low-frequency or dc bias voltage which is used to control or modify some aspect of a high-frequency signal. The distinction between this and the corresponding small-signal application is that in this case the large-signal voltages can asymmetrically modulate the varactor capaci-

tance and thereby affect the control function of the low-frequency or dc bias voltage.

A further class of large-signal applications involves operation into forward bias. When the capacitance is not a unique function of voltage but also depends on the immediate previous history of the signal, such as the extent and duration of forward drive, then the application is deemed large-signal.

2.1 Applicability of Small-Signal Measurements to Large-Signal Applications. In general, the small-signal varactor measurements described in IEEE Std 318-1971 provide useful characterization for both small-signal and large-signal applications. This view is supported by the analytical work of Penfield and Rafuse (Ref 2), Burckhardt (Ref 3), and others, where the same set of characterization parameters have proved to be appropriate for both classes of application. The validity of these analytical results has been established experimentally for a wide variety of applications.

It is recognized, however, that there are large-signal applications where additional parameters are required for a complete characterization. Parameters that could be justifiably ignored in many small-signal applications may now acquire importance. The transition time, the voltage dependence of the series resistance, punch-through characteristics, and the thermal resistance are examples of such parameters.

2.2 Special Large-Signal Measurements. All measurement procedures yet devised for the systematic evaluation of varactor parameters have required the use of small measurement signals. The use of large measurement signals invariably means nonlinear operation where-by the detailed behavior can be strongly de-