THE USE OF FIELD-EFFECT TRANSISTORS AT HF AND VHF AS TUNED AMPLIFIERS AND MIXERS

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I. AN INTRODUCTION TO FIELD-EFFECT TRANSISTORS

There are two categories of transistors, namely, bipolar (conventional) transistors and unipolar transistors. Almost everybody in electronics is aware of the bipolar transistors, but as aware of unipolar transistors. Therefore, it is perhaps instructive to discuss some aspects of the unipolar transistors.

The field-effect transistor (abbreviated to FET) is a type of unipolar device. It has a long history, much longer than that of the conventional bipolar transistor. In the early 1930's there were already some treatises (by Sommerfeld, Bethe, Frohlich and Wilson) and patents (by Heil[1]). In 1952, the unipolar FET with junction gate was proposed by Schockley[2]. The development of FETs has been considerably slower than that of bipolar transistors. First, publications on bipolar transistors have overshadowed the field-effect device and absorbed most of the technological effect; second, the range of possible applications is more limited than that of bipolar transistors; lastly, the technological difficulties concerned with quantitative manufacture have been encountered.

Recently there has been considerable effect expended in the development of this device so that there are now a number of commercially available types. This has occured for several

1. O. Heil, Brit. Pat. 439, 457, (Sept. 26, 1939).
2. W. Shockley, Proc. IRE 40, 1365 (1952).

reasons, one reason for this development is a better understanding of semiconductor physics and the related advance of semiconductor technology which now makes it possible to fabricate devices with predictable performance. Another reason is the addition of now technological features such as evaporated construction and insulated gates which promise much improved performance over the reverse-biased-junction gate construction. The third reason is the deficient performance of the bipolar transistors in some applications requiring high impedance or lateral symmetry.

II. THE PRINCIPLE AND CHARACTERISTICS OF FIELD-EFFECT TRANSISTORS

The field-effect transistor is far simpler to visualize than an ordinary transistor. Basically, it is a variable resistor whose value is controlled by an input potential. The operation of FETs may even be visualized in terms of rheostats with control knobs that are turned to vary their resistance. The input resistance may thus be much greater than a vacuum tube. There is in fact a considerable similarity between parameters of the FET and of the pentode vacuum tube, and many familiar old circuits are coming back in a new guise. This has brought some circuit designers and manufacturers an ever-increasing interest in the study of FETs.

There are two basic forms of FETs, the Junction Field-Effect Transistor (JFET) and the Insulated Gate Field-Effect Transistor (IGFET). Both types achieve much the same result but by different means. They make use of a semiconductor resistor of constant length, which is subjected to a transverse modulation of the material resistivity. This modulation is so pronounced that the resistor may be regarded as varying in physical width. Such a result is made possible by using a fundamental property of a p-n junction in a semiconductor. This property is the increase of charge stored on both sides of the actual junction when the junction is back biased. This charge is stored by forcing mobile charge carriers away from the junction region, thus causing the large numbers of ionised impurity atoms to be no longer neutralised. The mobile carriers are, of cause, the means of conduc-