**Introduction**

A microwave filter is a two port network used to control the frequency response at a certain point in the microwave system by providing transmission at frequency within the pass band of the filter and attenuation in the stop band of the filter. Typical frequency responses include low pass, high pass, band pass and band stop characteristics. Their frequency responses are shown in Fig. 1.

![Diagram 1](image1.png)

**Fig 1.** Basic types of Filters: (a) low pass (b) high pass (c) band pass (d) band stop.

**Importance of Filters**

Filters play an important role in many RF/microwave applications. They are used to separate or combine different frequencies. The electromagnetic spectrum is limited and has to be shared so filters are used to select or confine the RF/microwave signals within assigned spectral limits. Emerging applications such as wireless communications continue to challenge RF/microwave filters with ever more stringent requirements—higher performance, smaller size, lighter weight and lower cost. Depending on the requirements and specifications, RF/microwave filters may be designed as lumped element or distributed element circuits. They may be realized in various transmission line structures, such as waveguides, coaxial line and microstrip.
Features of efficient Filter design

Filters are required to have small insertion loss, large return loss for good impedance matching with interconnecting components and high frequency-selectivity to prevent interference. If the filter has high frequency-selectivity, the guard band between each channel can be determined to be small which indicates that the frequency can be used efficiently. Also, small group-delay and amplitude variation of the filter in the pass band are required for minimum signal degradation. In mechanical performance aspect, filters are required to have small volume and mass and good temperature stability.

Microstrip/stripline filters are commonly used in wireless communications owing to the attractive features such as easy processing by PCB fabrication technique, good affinity with active circuit elements and low cost. They have a wide applicable frequency range which can be obtained by employing various kinds of substrate material.

General Structure of Microstrip Filter

The general structure of a microstrip is illustrated in Figure 2. A conducting strip (microstrip line) with a width $W$ and a thickness $t$ is on the top of a dielectric substrate that has a relative dielectric constant $r$ and a thickness $h$, and the bottom of the substrate is a ground (conducting) plane.

![General Microstrip Structure](image)

Fig 2. General Microstrip Structure

Designing Microstrip filters using Defected Ground Structure

The design of microstrip filters using defected ground structure (DGS) is increasing day by day. In this technique, the ground plane metal of a microstrip is intentionally modified to enhance performance. The name for this technique simply means that a “defect” has been placed in the ground plane.
DGS is an etched periodic or non-periodic cascaded configuration defect in ground of a planar transmission line (e.g., microstrip, coplanar and conductor backed coplanar wave guide) which disturbs the shield current distribution in the ground plane cause of the defect in the ground. This disturbance will change characteristics of a transmission line such as line capacitance and inductance. In a word, any defect etched in the ground plane of the microstrip can give rise to increasing effective capacitance and inductance.

Defected ground structure (DGS) is usually realized by etching a specific pattern on the ground plane of a microstrip structure. With an additional inductance due to the magnetic flux flow in the etched out apertures and gap capacitance on the ground plane (DGS) or on microstrip surface (DMS), a certain band of frequencies are prohibited.

When transmission line is incorporated with DGS, it yields low pass performance due to change in its surface impedance. This in turn disturbs the shielded current distribution in the plane. This changes the phase velocity of the current. The change in phase velocity leads to change in the apparent effective permittivity.

Advantages of DGS

DGSs have the characteristics of stop band, slow-wave effect and high impedance. DGS has more advantages than PBG (Photonic Band Gap) as follows:

1) The circuit area becomes relatively small without periodic structures because only a few DGS elements have the similar typical properties as the periodic structure like the stop-band characteristic.
(2) For the DGS unit, DGS pattern is simply fabricated and its equivalent circuit is easily extracted.

(3) DGS needs less circuit sizes for only a unit or a few periodic structures showing slow-wave effect.

(4) DGS is more easily to be designed and implemented and has higher precision with regular defect structures.

**Applications in Microstrip Filters**

DGS, which is realized by etching off a defected pattern or periodic structures from the backside metallic ground plane, has been known as providing rejection of certain frequency band, namely, bandgap effects. The stop band is useful to suppress the unwanted surface waves, spurious and leakage transmission. Therefore, a direct application of such frequency selective characteristics in microwave filters is becoming a hotspot research recently.

DGS provides excellent performances in terms of ripples in the passband, sharp-selectivity at the cut-off frequency and spurious free wide stopband. There have been two types of filter design using DGS: one is directly using the frequency-selectivity characteristic of DGS to design filters, the other is using DGS on the conventional microstrip filters so as to improve performance. The second search concerns exploitation both on the conductor plane of the microstrip and the ground plane. Several improvements are obtained using DGS in the metallic ground plane for the response of filter. These improvements are summarized as follows:

(1) More transition sharpness,
(2) Suppressing higher harmonic,
(3) Achieving broader stop band responses,
(4) Improving the stop band and passband characteristics.