The Fundamental of Leaky Wave Antenna

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***Abstract*— The fundamental of leaky-wave antenna (LWAs) that have been compiled and published are presented in this paper. A leaky-wave antenna uses the guiding structural, which support the propagation of waves along the length of the structure. While the basic family of LWAs is dependent on the radiation of a propagative mode in a basic guiding structure (usually a waveguide of some sort), the radiation mechanism changes drastically from one sub-category to another. Such antennas either uniform or periodic appear in various characteristics and performances. The fundamental of the basic operating principles and physics, and discuss the design of types of LWA.**

***Index Terms*— Leaky Wave Antennas LWAs; Period LWA; Periodic Structures; Surface Wave; Uniform Structures.**

I. INTRODUCTION

LWAs are a class of traveling-wave antennas characterized by a wave propagating along a long structure as compared with the wavelength. They are very similar to the surface-wave antennas. Like most traveling-wave antennas, leaky-wave antennas are long in the propagating direction and possess a cross-section with the dimensions about the wavelength of the operation.

A distinguished feature of these antennas is that the electromagnetically field is excited by a wave, which is incident on the interior or the exterior of the guiding structure, which produces currents that propagate along its longitudinal direction. When transmitting, the input traveling wave, often a fast wave, progresses along the guide and leaks out the energy of the structure so that only a negligible field is left at the termination end of the traveling-wave antenna [1]. Planar leaky-wave antennas that have been designed using simple microstrip lines on a dielectric substrate layer and a ground plane behave similarly with the wave propagating along a transmission line and leaks when it encounters a discontinuity in the structure.

Planar leaky-wave antennas can alternatively be classified under the category of Holographic-Surface Antennas. Holographic surfaces that provide specific far-field patterns in practical applications were considered in [2] with the introduction of impedance artificial surfaces. The merit of such surfaces lies in the geometrical manipulation of the surface impedance, which allows for independence near the control of phase and leakage constants [3]. The surface impedance used in the leaky-wave antenna design was designed using a Sinusoidally-Modulated Reactance Surface (SMRS) [4]. This way of modulating the surface impedance is a well-established area of research and has been explored by Oliner & Hessel et al. [5]. The SMRS refers to a surface whose modal impedance surface is sinusoidal modulated. The modal impedance surface is defined as the ratio of the electric field tangential to the magnetic field, which is tangential of the wave surface guided by the surface reactance [6]. By modulating the wave impedance on the surface, the energy of a wave traveling on that surface can be radiated away in the desired direction, intensity and angle. The currents from the source propagate down the microstrip line and they are scattered by the surface modulated impedance to produce the desired pattern of the desired radiation.

Holographic-surface antennas [7] can be interpreted as tapered two-dimensional leaky-wave antennas, where a local modulation of the surface so that impedance leads to a transformation from a surface-wave guided to a leaky wave radiate. It was seen in [8], in which a holographic pattern created using the interference pattern between a plane wave and a surface wave cylindrical is the same as those obtained by applying locally the condition dispersion in the small perturbation regime to a locally tangent grating strip. Planar leaky-wave antennas leak power from the traveling wave's propagation along the surface antenna. Scanning eliminates that involves angle that have phase shifting in the circuit reduces the control of the consumption energy. LWAs are generally simple waveguide structures, in which it reduces the cost of fabrication. Varying the scanning angle with frequency is disadvantageous for point-to-point applications communication [4].

In general, the basic development of LWAs follows the equation [4]:

$$\sin(\theta) \approx \frac{\lambda o}{\lambda} - \frac{\lambda o}{d} * m \qquad (1)$$

where θ refers to the angle between from wave propagation to the direction perpendicular, λo refers to the wavelength air, λ refers to the wavelength in the waveguide, d is the space perturbation and m refers to the integer number.

High values of impedance are obtained with a narrower gap, higher dielectric constant and thicker substrate. Other variables are such as the average surface impedance and the periodicity of the sinusoidally modulated impedance affect [5]

The propagation constant of the wave β controls the beam direction [9], while the modulation depth controls the attenuation constant, α, with larger values of attenuation resulting from higher depths of modulation and consequently broader antenna beam-widths [6]. Thus, we are able to nearly independently control α and β.

II. HISTORY OF LWAs

The first main Leaky waves antenna was created by W.W. Hansen in 1940 [10], which was a rectangular shut waveguide, as presented in Figure 1. It had a uniform long openings that spilled and emanated the engendering wave. Yet, such structures cut over the present lines that result in delivering waves with low spillage troublesome. Upson and Hines [11] proposed a "Holey Waveguide" to address this issue. In this structure, as shown in Figure 2, the waveguide is the gaps and the air-filled, which were put intently. In 1956, Von Trentini presented the idea of two-dimensional LWAs [12], in which the utilization of an occasional somewhat intelligent screen over the ground arrangements to get mandate shafts. This structure is related to the characterization of semi-uniform broken wave that receives a wire.

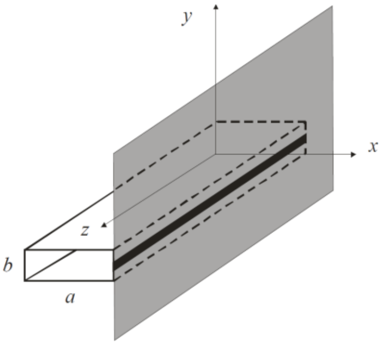

Figure 1: First Known Leaky Wave Antenna [10].

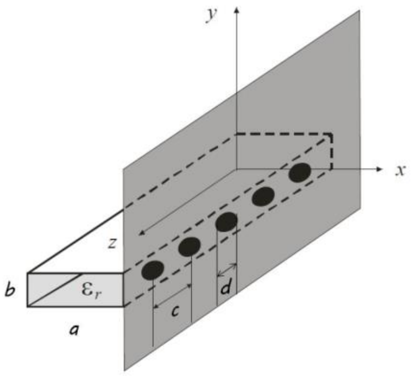

Figure 2: Holey Waveguide [11].

In 1957, Karas and Rotman presented another structure, which they called "Sandwich Wire Antenna", as shown in Figure 3 [13] . Its working rule was excessively confounded and not down to earth. Later, Rotman and Oliner in 1959 proposed another hypothesis called "Unbalanced Trough Waveguide Antenna" [14]. This hypothesis claims that the asymmetric trough open waveguide structure does not transmit without anyone else's input. However, the presentation of the asymmetry allows it to act like a leaky waves antenna, as presented in Figure 4. The purpose of the sandwich-wire antenna is to make a conversion of energy from the wave guided by the wire into a TEM mode between the parallel planes, which is then radiated into space from the aperture.

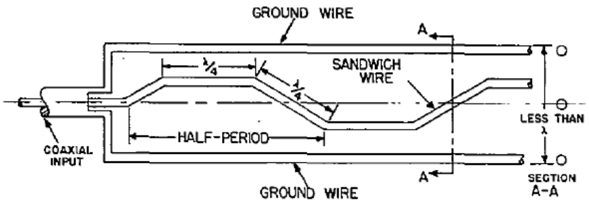

Figure 3: Sandwich Wire Antenna [13].

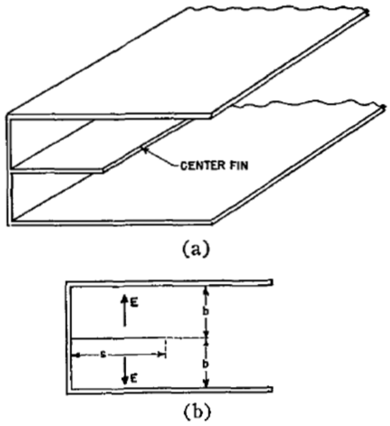

Figure 4: Symmetrical Trough Waveguide, (a) Full Figure View, (b) Cross-Section Of View For Zero-Thickness Center [14]

In 1982, Adelseck and Itoh showed the LWAs that utilize a dielectric waveguide [15] considering the grinding sort cracked wave reception apparatus is made of millimeter wave incorporated circuit, as illustrated in Figure 5. The qualities of the waveguide have been adjusted by changing the cross-sectional zone of the material dielectric.

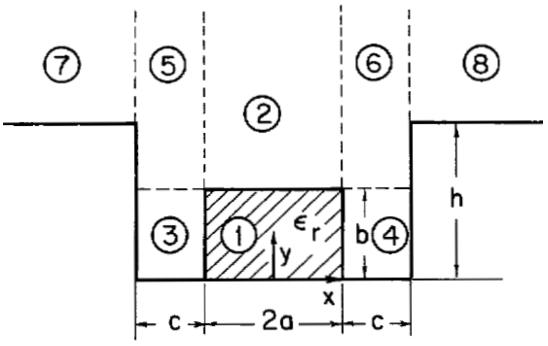

Figure 5: Cross Section Of The Dielectric Waveguide Used [15].

In 1985, Alexopoulos and Jackson demonstrated that the utilization of materials either with permittivity, ε, or porousness, μ more prominent than 1 helps in expanding the power pick up and contract the shaft width [16]. The power increase shifted relatively to either ε or μ depending on the configuration. An observation of the bandwidth varied inversely to the gain is illustrated in Figure 6.

Figure 7 shows the result of utilizing two materials with various electric and attractive properties. For example, in material No. (2), the steady dielectric ε_2 was put on top of material no. (1) ,which had a dielectric constant of ε_1. The materials were chosen to the point that $\varepsilon_2 > \varepsilon_1$. From the graph tabulated in Figure 8, it can be observed that the pickup was corresponding to the contrast between the dielectric constants of both materials. The increase becomes more severe as the distinction expanded. The beam width has to be distinctly limited when the contrast between the dielectric constants expanded, as illustrated in Figure 9. Jackson and Oliver concocted that a multi-layered dielectric structure created contract shafts [17]. They exchanged two dielectric materials with various thickness and electrical attributes, as as shown in Figure 9. The cause of the limited beam width was due to the flawed waves, which were weakened feebly. Additionally, the variety of beam width in relation to several layers and material properties has been observed.

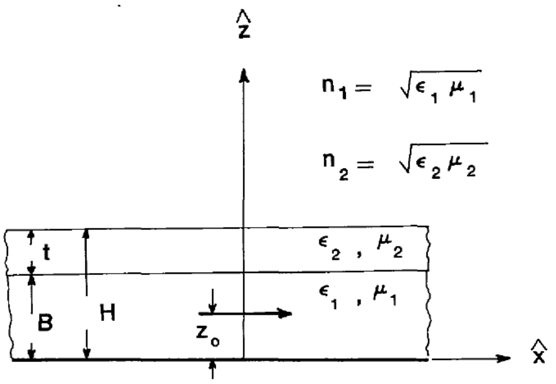

Figure 6: Superstrate-Substrate Geometry [16].

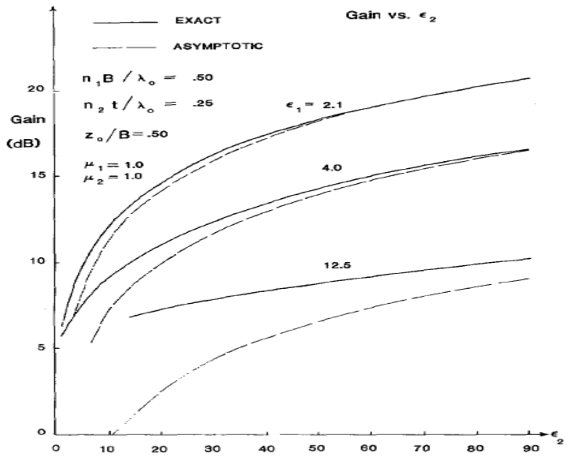

Figure 7: Gain against ε_2 [17].

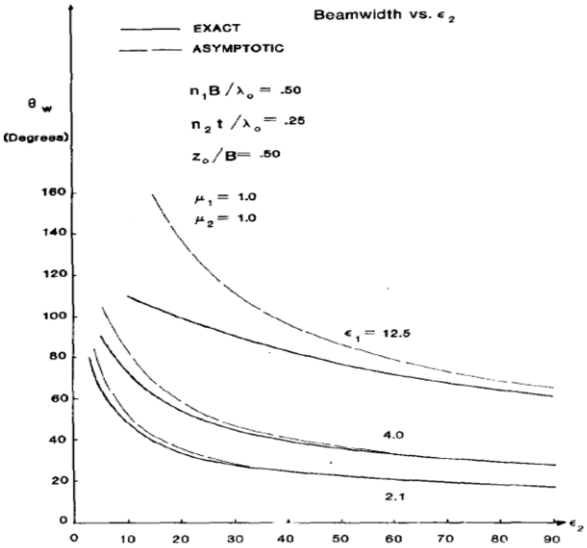

Figure 8: Beam Width Against ε_2 [17].

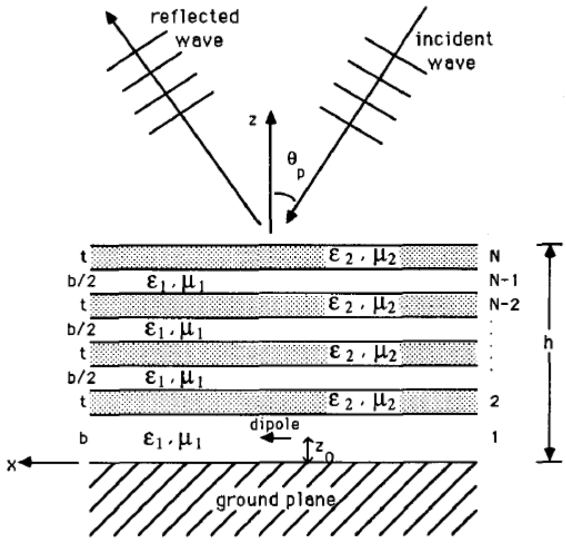

Figure 9: Narrow Beam Structure Consisting Of Electrical Properties And The Dielectric Layers Of Alternate Thickness[17]

In 1991, Guglielmi and Boccalone came up with another idea of putting metal strips occasionally over a dielectric waveguide, as shown in Figure 10 [18]. Through their review, they showed that the electrical attributes of this reception apparatus are adaptable.

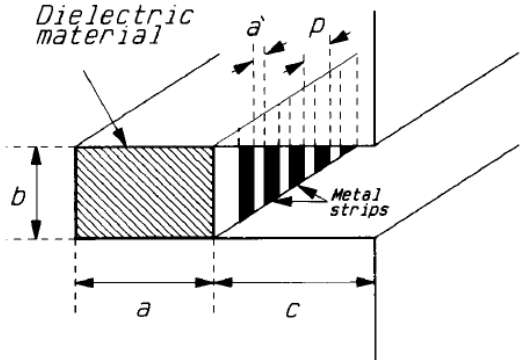

Figure 10: Metal Strip Loaded Dielectric Waveguide [18].

Itoh and Caloz, in 2003 demonstrated the utilization of metamaterials in LWA [19]. They called this as a Backfire-to-End fire LWA – an immediate utilization of Composite Right/Left Handed (CRLH) Transmission Line, as demonstrated in Figure 11. The reception apparatus is at its movement recurrence in its crucial method of operation could filter both in the reverse and forward wave. They exhibited a filtering range in the vicinity of 3.1GHz and 6.0 GHz respectively.

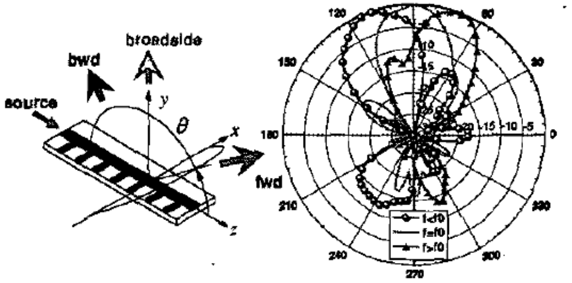

Figure 11: Backfire-to-End fire LWA and Radiation Pattern. by Itoh and Caloz [19].

III. THEORY OF LEAKY WAVE ANTENNA

LWAs have a place with the classification of Traveling Wave Antennas together with the opening clusters and surface wave that receives wires. Nevertheless, the radiation specialists change radically starting with one sub-class and followed by the next. The longitudinal spread is consistent with any mode propagation along any waveguide, as in [20][21]:

$$k_z = \beta y - j\alpha y \tag{2}$$

Where α is the weakening consistent in nip/m, β is the stage steady in rad/m, and that records the radiation and material spill. LWAs is demonstrated as a traveling wave antenna, where the current propagates along a guiding structure, as shown in Figure 12. If the perturbations are introduced along the structure, for example slits or apertures for waveguides, patches, or stubs for microstrip lines etc., the traveling wave leaves the structure and radiates into free space. Thus, in the ideal case, no energy reaches the end of the structure. In a practical scenario, any energy that reaches the end is absorbed by a matching load. Typically, LWAs are designed, in which at the least 90% of the power at the structures leaks away before the traveling waves reach the end of the antenna.

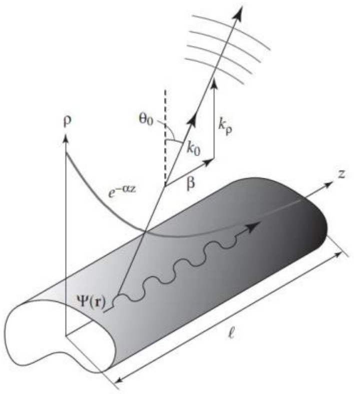

Figure 12: Generic Representation Of a Leaky-Wave Antenna And Its Radiation Principle [22]

Leaky-wave phenomenon is exhibited with fast propagating waves only. From Figure 12, the propagating wave number k_p is given by [23]:

$$k_p = \sqrt{k_0^2 - k_z^2} \tag{3}$$

In this case, $k_z = -j\alpha$ is for surface-wave or slow-wave *or* $kz = \beta$ is for leaky-wave or fast-wave, where k_z is the longitudinal wavenumber and k_0 refers to free space propagating wavenumber. The complexity of radiation k_z is given by

$$k_z = \beta - j\alpha \tag{4}$$

Where α and β are the attenuation and phase constants respectively. Assuming that there is a standard free space wave equation for the above wave, the waves outside the leaking structure that describes in Figure 12 are given by:

$$\psi(r) = \psi o\, e^{-j(k_p p + \beta z)} e^{\alpha z} \tag{5}$$

If $\beta < k_p$ i.e. if the phase velocity $_p$=/ is smaller than the free space velocity of light, C; then it is a slow wave and k_p is imaginary. The wave decays exponentially in amplitude along the length of the structure and it is a bounded wave. If however, $\beta > kp$ i.e. if the phase velocity >, it is a fast wave and k_p is purely real; therefore, the real power at an angle is radiated with respect to the normal given by [24]:

$$\sin(\theta) = \sin^{-1}\left(\frac{\beta}{ko}\right) = \sin^{-1}\left(\frac{c\beta}{\omega}\right) \tag{6}$$

Since the above terms are all functions of angular frequency, the angle varies with frequency; thus exhibits a frequency scanning behavior. The main beam-width is [24]:

$$\Delta\theta_o = \frac{0.91}{(l/\lambda)\cos\theta_o} \tag{7}$$

If the the above equation is applied for large antenna lengths, high directivity can be achieved as *(D=4πAe/λo)*. However, the effect of increasing directivity is negligible if there is no power left near the end of the structures, as shown in Figure 13 and 14. To characterize this parameter, the attenuation/leakage constant is formulated as [24]:

$$\alpha(z) = \frac{e_r^{\frac{A^2(z)}{2}}}{\int_0^l A^2(z)dz - e_r \int_0^z A^2(z)dz} \tag{8}$$

Where (=*1*−$^{-2}$) is the radiation efficiency. Therefore, if α is small enough so that $(1-e^{-2\alpha l} > 0)$, the improvement of directivity is appreciable as length *l* increases.

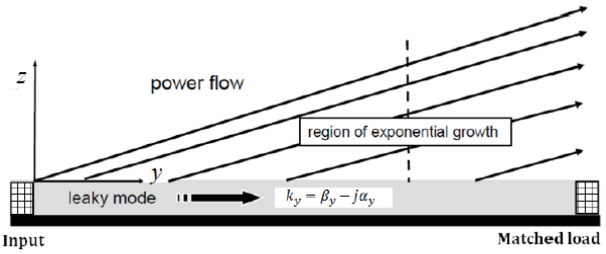

Figure 13: Scheme of The Near Field Created By a Forward Radiating Lw In a Quasi-Uniform One Dimensional LWAs [24][25]

LWAs can be classified under Uniform, Periodic and Quasi-Uniform structures based on the mode of propagation. Uniform leaky-wave antennas have invariant transverse cross-section along a longitudinal axis. These antennas use a higher-order fast-wave mode for leaking. Their phase constant is always positive and non-zero β > 0 for all frequencies. Due to phase reversal, the wave can sometimes be a backward leaky-wave, as in Figure 14.

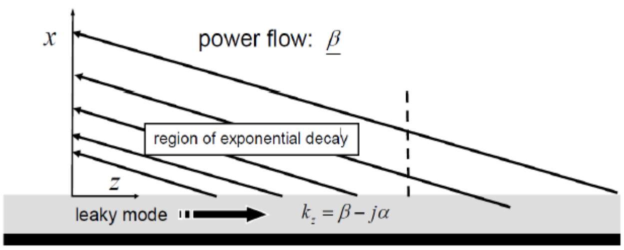

Figure 14: Scheme of The Near Field Created By A Backward Radiating *Lw* in A Quasi-Uniform One Dimensional LWAs [24]

The crucial mode for microstrip is the moderate wave quasi of TEM mode, as demonstrated in Figure 15. It is commonly argued that EH_0 does not emanate i.e. the fields created by the key EH_0 mode do not decouple from the structure. It is just when the key mode is blocked or confined inside the antenna that the microstrip transmission line can work in a higher-arrange mode (particularly odd-numbered modes). Periodic leaky wave antenna has a structure with a periodic modulation along the axis propagation. Because of their periodicity, as indicated by Bloch-Floquet hypothesis, they can bolster an infinite number of space music, as shown in Figure 16. The key space symphonious, however is moderate and bound. Promptly higher request spatial music or modes, for example, when n = - 1 mode are utilized for radiation, it raises the mode to the higher-arrange places in the quick wave area of the scattering graph. The odd numbered of the higher request modes at which the fields can decouple from the surface enable the transmition from the structure.

A higher-arrange mode for microstrip is not absolutely *TE* or TM, but rather a mixture blend of these two. As illustrated in Figure 17, EH_1 mode refers to the main higher arrangeable mode, which is scattered everywhere. It has a stage inversion or invalid along with the center line permitting the fields to be decoupled and emanated. EH_1 is a fast wave and has the potential to produce far-field radiation.

The dominant mode in microstrip transmission lines is perturbed by a variety of methods, including separating the strip by a uniform gap/slot/pins etc. or periodically placed slots or patches. The EH_1 mode on the microstrip transmission line is not a leaky wave mode. Rather, the EH_1 mode makes it feasible for the microstrip structure to bolster an LW. LWs are not modes in the standard sense and the broken waves are non-modular. Defective waves existing everywhere are called inappropriate or non-unearthly because the forwarded LW increments in the y-bearing are vertically far from the managing structure. Hence, apparently they infringe upon the condition that the radiation vanishes at unendingness [27].

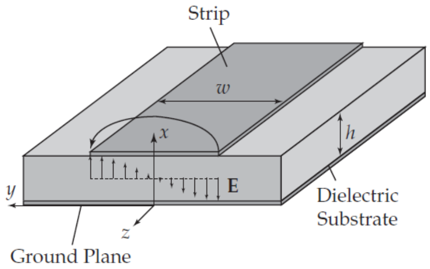

Figure 15: Quasi-TEM (Quasi Transverse Electromagnetic) Dominant Mode in Planar Microstrip Line On a Dielectric Substrate And Metallic Ground Plane [24]

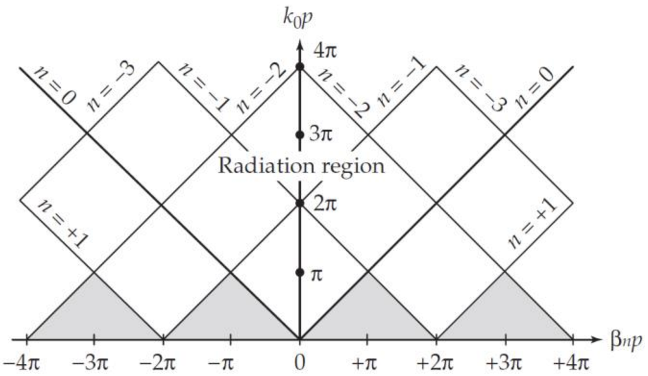

Figure 16: Brillouin Dispersion Diagram for a periodic Structure Showing Radiation (Fast-Wave) Region And Bound Modes (Shaded Regions) For Slow Wave Space Harmonics [23][26].

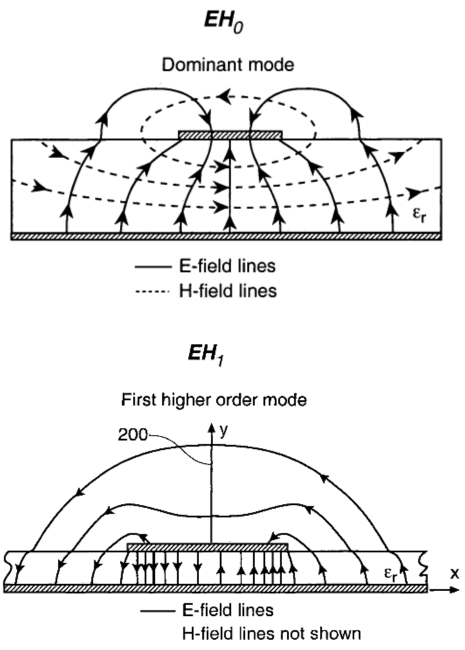

Figure 17: TransversE Field Profile Of A Microstrip Line In Its Dominant Eh0 Guiding Mode And Higher Order EH1 Leaky Mode [27].

The quality of the spilling field built exponentially to a separation y_{max} over the antenna is given by [27]:

$$y_{\max} = y\tan(\theta) \tag{9}$$

and then they quickly decay, i.e. the fields do not continue to increase indefinitely, as demonstrated in Figure 18.

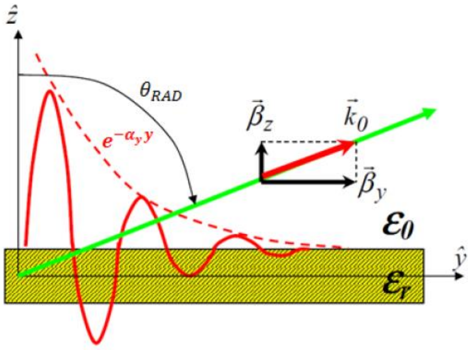

Figure 18: Scheme of a Generic Guiding Of The One-Dimensional Quasi-Uniform Or Uniform Structure Which Supports a Propagating a Leaky Wave [27]

The surface-wave modes propagation energy along the longitudinal bearing in the dielectric waveguide, including tthe misfortunes and identified with the materials are considered as none for simplicity. Thus, the longitudinal propagation constant is $k_y = \beta_y$ and $k_z = - j\alpha$, meaning the fields encompassing the guide are responding, debasing of exponentially in a transversal bearing and making no radiation. This is shown in Figure 19.

An exclusive way a surface-wave may emanate is at the twists or resistance discontinuities, which can exist in an open waveguide. For instance, at its extreme end, either capacitive or inductive discontinuity can exist in the shut waveguide. This property was connected to the waveguide dielectric. Keeping in mind that the end goal is to get the surface-wave reception apparatuses, which are essentially end-fire receiving wires. An overview these types of structures can be found in [17] and [28], both written by F.J. Zucker.

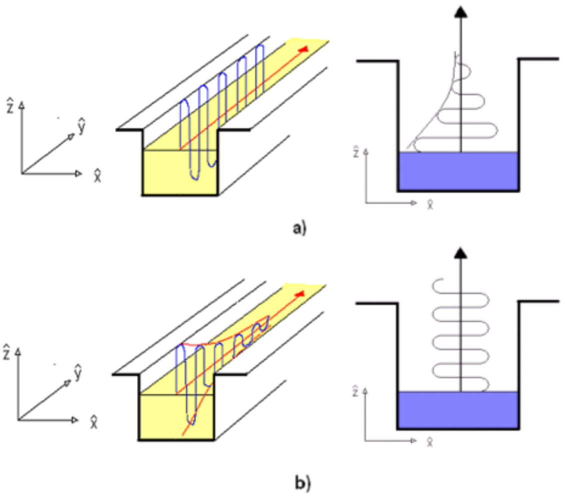

Figure 19: Transversal and longitudinal fields: a) Surface wave and b) Leaky Wave [26].

IV. OVERVIEW OF LEAKY-WAVE ANTENNAS

The surface wave is the waves that are bound to a surface, propagating the length of the surface and exponentially decaying in the amplitude (the perpendicular direction) [29]. The wave is formed at the interface between two materials (free space, metal, dielectric, etc.) as shown in Figure 20. Surface-wave antennas are a kind of traveling wave antennas, where the phase velocity V_P of a wave propagating electromagnetic along the antenna is less than the velocity of the plane wave propagating in the free space. Additionally, the strength of the field in the direction normal to the antenna are exponentially decreased.

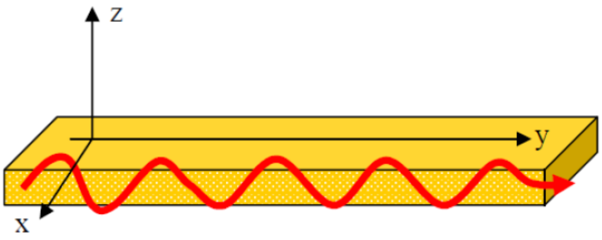

Figure 20: Surface Wave Antenna [29]

The delay-causing structure of the antenna is made in the form of metallic perturbing features (bumpy, ribbed, plane or corrugated) to make suitable to be placed onto a layer dielectric. The most advantages of such an antenna are that it can be constructed in the form of an insert that projects barely (low profile) from the support surface. This feature is very important for installations on aircraft that is usually restricted by the size of the fuselage and the constraints of the shape to improve the flight.

Surface-waves antenna is usually designed to radiate in the direction of the end-fire and the designs in accordance to the Hansen-Woodyard condition. For the high gains antenna, the surface guided wave becomes bound loosely to the guiding surface wave and the performance of the antenna becomes sensitivite to the irregularities in the structure. Modulating the surface along the impedance length of the antenna confines the guided wave and a variety of the modulations including sinusoidal modulations, steps, and tapers etc., which ll have to be tested to produce surface wave as a tightly-bound [29].

Oliner and Hessel observed that a modulation sinusoidal of a reaction surface that is periodicity along the modulation direction of the wave, which has a small propagation affects the propagation wave number of the surface wave and introduces one or more bands stop. If the spacing of the modulation is bigger than some critical values, the surface wave modulated gives rise to one or more leaky wave which will radiate away from the surface at an angle. It is also based on the level of modulation which may introduce some bands stop. The solution has been put forward to the phenomenon using a mathematical model, which focus on viewing the geometry in terms of the associated modes with the perpendicular propagation of the surface. This mode is discrete or quantized in nature and can be almost totally influenced by controlling the periodicity of the modulation [29]. For impedance conditions, the boundary dictates that from itself apart, each of these mode couples only to the next lower or higher modes. As mentioned in the definition of surface waves, the key is that, the controlling mode and its spatial harmonics which produce the slow waves have to be in the bound mode. This condition is effective, if the protected modulation period is small. When it is increased, one or most of the higher spatial harmonic modes may be unbound from the surfaces and give rise to a fast wave propagating [30].

V. DESIGN PRINCIPLE OF ONE-DIMENSIONAL UNIFORM LWAS

A uniform LWAs is a uniform along the length of the structure with the exception of a small tape that controls and enhances the side projections [31]. On a basic level, uniform leaky wave antenna transmits into the forward quadrant and can be examined from broadside to end-fire. Generally, the manner in which the receiving antenna can sweep to broadside or end-fire relies on the structure of the antenna. Uniform LWA apparatus comprises of a leakage waveguide with a length, L. The spillage happens along the length of the receiving antenna. In the longitudinal bearing z, the engendering attributes of the leaky mode are given by the phase constant β and the leakage constant α, where α is a measure of the leaked power (radiated) per unit length. The length of the antenna, L, frames the gap of the line-source receiving the wire and the abundance. The period of the voyaging wave along the gap is controlled by the estimations of β and α as a component of z. For whatever length of time that the waveguide is uniform along its length with no decrease, the estimation of β and α do not change with *z*. These would likewise bring about the gap appropriation having an exponential plentifulness variety and a steady stage due to high side lobe levels. Additionally, the end goal is to deal with the side flap level, where α needs to have a variety of *z*. In this case, bar heading and beamwidth of a uniform LWA are characterized by equation 1 and 10 [32]:

$$\Delta\theta_m = \frac{1}{(L/\lambda)\cos\theta_m} \tag{10}$$

where (θ_m) is referred to the maximum beam angle, (β) is referred to the phase constant, (k_0) is referred to the free space wave number, (L) is refered to the length of the antenna and ($\Delta\theta$) is referred to the beamwidth of the LWA. As can be seen from equation (10), the beam width of the LWA is basically dictated by the length, L, of the antenna. It is somewhat impacted by the gap field plentifulness circulation. The beam width is the tightest for a steady gap field and more extensive for strongly crested circulations. For a given estimation of α, if the antenna length is picked to such an extent that 90 % of the power is emanated, it can be found that [32]:

$$\frac{L}{\lambda_o} \approx \frac{0.18}{(\frac{\alpha}{k_o})} \tag{11}$$

where L and an are picked autonomously of each other and the rate of radiated power can vary fundamentally from the target estimation of 90%. The proportion of force that dwells in the leaky mode at $z = L$ to the info power can then be composed as [33]:

$$\frac{P(z=L)}{P(z=0)} = \exp(-2\alpha L) = \exp(-4\pi(\alpha/k_o)(L/\lambda_o)) \tag{12}$$

Where $P(z)$ shows the power in the waveguide at a propagation, which is denoted by z along the length of the structure.

The radiated power marginally changes when the beam is examined with frequency, given that a progression with recurrence. Nevertheless, the rate of radiated power (showed essentially by $P\%$) can be acquired effectively by revamping Eq. (12), accepting an exponential gap appropriation. The outcome is shown in the equation [33]:

$$P\% = 100\{1 - \exp[-4\pi(\alpha/k_o)(L/\lambda_o)]\} \tag{13}$$

The aperture dissemination will unavoidably be changed with a specific end goal to control side lobes, yet in any case, Eq. (13) remains a sensible guess. As far as output point is concerned, uniform leaky wave antenna can go against up to two structures. While the standards stay comparatively, the sweep point conduct of air-filled and dielectric-filled waveguide is in contrast to some degrees. Air-filled structures normally experienced depression guides and rectangular waveguides, both of which bolster quick prevailing modes. Subsequently, dielectric-filled structures regularly utilized the non-radiative dielectric guide and dielectric-stacked rectangular guide. To work these as LWA, they ought to be energized with a quick wave ($b < k_0$) [33].

VI. DESIGN PRINCIPLE OF THE ONE-DIMENSIONAL PERIODIC LWA

The significant contrast between the periodic LWA and the uniform LWA is that the waveguide is modulated periodically along its length in a periodic LWA. The periodic modulation produces the leakage. Figure 21 demonstrates a flawed waveguide with a variety of metal strips, which is set periodically along its length. Prior to the variety of metal strips, which includes the measurements of the guide and the recurrence are picked with the end goal, which is the $\beta > k_o$. The occasional cluster of strays presents a space music in view of the periodicity. Each of the harmonics space is described by the phase constant β_n. The space music is identified with each other by [34]:

$$\beta_n d = \beta_o d + 2n\pi \tag{14}$$

Where d is the period; β_o is the fundamental harmonic space and the first β of the prevailing method of the uniform dielectric waveguide. β_n can go up against an expansive assortment of qualities so that space harmonic can be either forward or reverse in nature, and slow or fast.

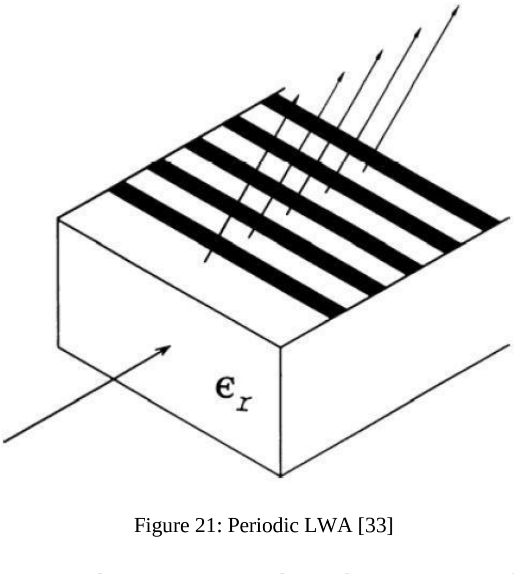

Figure 21: Periodic LWA [33]

Albeit two planar structures showed in Figure 22, the idea applies to numerous other periodic arrangements. For instance, a dielectric waveguide can be periodically bothered by holes or spaces and accomplish a comparable radiation attributes. The excitation of the waveguide, which is in the essential mode avoid the higher request mode engendering with narrower width. The spaces in Figure 22 could likewise be supplanted with a metal grinding (i.e., occasional metal strips on the dielectric) and comparable to a dielectric grinding. In the last case, the metal strip would rather be furrows in the dielectric surface, and the diffraction impact at this grinding would then change the excitation mode into LW [33].

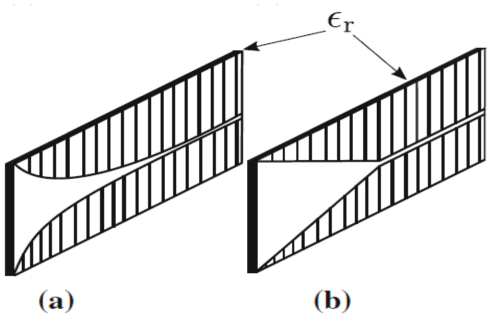

Figure. 22: Tapered Slot Leaky-Wave Antennas,
(a) Using An Exponential Taper and
(b) Using a Linear Taper [33]

VII. TWO-DIMENSIONAL PERIODIC LWAS

A leaky wave that starts from a two-dimensional directing structure propagates radially from the nourish point. This setup gives a simple strategy for acquiring a mandate shaft at the broadside, requiring just a straightforward source. The general type of such a structure has become a reflecting surface over a ground substrate. This is represented in Figure 23. The excitation source showed in Figure 23 is a straight horizontal dipole, which put inside the substrate and separated over the ground plane. The radio wire design, in any case, relies on the structure and not on the excitation. The substrate/superstrate structure could likewise be stretched out to incorporate different layers of the dielectric material, with the benefit of narrowing the beamwidth [35]. Expanding the permittivity of the superstrate layer brings about a smaller beamwidth. Another case of a reflecting surface is shown in Figure 24.

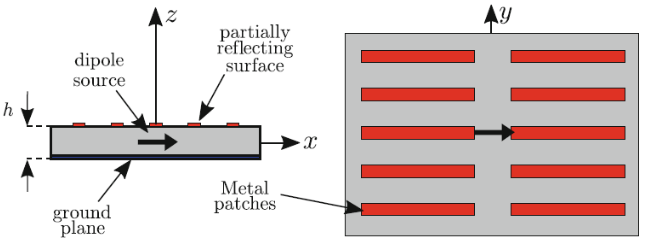

Figure 24: Construction of a Partially Reflecting Surface Using Metal Patches [35]

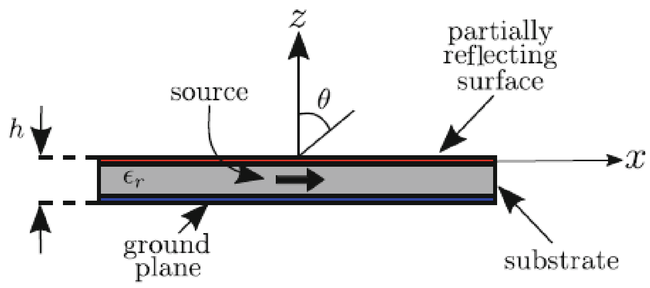

Figure 23: Substrate/superstrate structure of a two-dimensional leaky-wave antenna [35][36]

Bigger rectangular microstrip elements will bring about a smaller beamwidth. This structure is exceptionally appropriate for the photolithographic manufacture. A comparative arrangement to the one showed in Figure 24 is to supplant the patches with spaces. Similarly, smaller slots will cause a smaller beamwidth, and it ought to be noticed that the surface wave feeding the antenna is coordinated in the y-course (instead of in the x-heading as with the microstrip cluster). As the excitation recurrence is expanded, the pencil pillar starting from the reception apparatus will expect a tapered shape, successfully losing pick up in the broadside heading [37][38]. By and large, the directing structure of a two-dimensional leaky wave antenna is uniform (or if nothing else quasi-uniform) and the energized wave is a fast wave.

VIII. CONCLUSION

This paper has outlined the new advancement in the field of LWAs, particularly in the field of planar LWAs. Although leaky wave radio wires have been in existence since 1940s, the field has undergone noteworthy improvements in the latest researches, contributing to low profile and moderately simple to fabricate. A portion of the new improvements in the LWAs field has been identified, and the principle design of one-dimension uniform leaky wave antenna and the periodic one and two-dimension leaky wave antennas have been discovered.

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