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OPTIMIZATION OF LOG-PERIODIC ANTENNAS

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Previous work on standard log-periodic dipole antennas has shown that very sharply-defined, frequency-dependent anomalies are characteristic of non-optimal designs[1] and that the reduction of these anomalies is a useful optimization procedure[2] Anomalous responses are most clearly seen as sharp peaks in the swept-frequency measurement of the radiation pattern backlobe, but they are often evident as well in the front lobe and the input impedance. The anomalies occurring when the feeder impedance is too low (elements under-coupled to the feeder) are caused by an inefficient active region which permits a wave to proceed to the large end of the antenna and be reflected. When this results in a voltage null at the resonant element (the one approximately 5% shorter than a half-wavelength) an anomaly occurs and is accompanied by a large-amplitude standing wave between the resonant element and the large end of the antenna.

Recent work on standard log-periodic dipole antennas suggests that for under-coupled elements the region close to the resonant element is a stop region which behaves as a near short-circuit, as seen from the large end of the antenna. Thus when the distance between the resonant element and a short-circuit termination is a multiple of a half-wavelength, this part of the antenna behaves as a resonator and an anomaly occurs. This point of view makes it seem reasonable (and calculations and measurements have shown) not only that a terminating resistor should eliminate the anomalies but also that the size of the terminating resistor is not at all critical. The resonator concept also sheds light on the optimum reactive termination because it suggests the notion of avoiding an anomaly near the lowest operating frequency where, say, the second-longest element is resonant; obviously the worst termination would be a short circuit a half-wavelength behind this point and therefore a reasonable termination would be a short circuit a quarter wavelength behind it.

Optimization of antenna parameters by anomaly reduction is a useful procedure which can be carried out at any frequency using artificially induced anomalies created by attaching temporarily a short circuit along the antenna feeder or a variable length of balanced line at the large end of the antenna. Far-field anomalies can also be observed very easily within a wavelength of the antenna, making possible optimization of HF antennas in the field. An additional procedure involves attaching a matched detector to the large end of the antenna; a transmission loss through the antenna of 25 dB or more is usually enough to ensure the absence of anomalies when the detector is replaced by a reactive load.

Anomalies are also evident in the loop-coupled log-periodic antenna[3] a design in which unbroken dipole elements are inductively coupled to the transpose sections of a transposed parallel-wire transmission line; the elements are placed between the two halves of the line and spaced a distance t from them. Figs. 1(a) and 2(a) are for an antenna of this type and show well-defined reflection anomalies for the case where the elements are undercoupled to the line. At about 0.8 GHz the anomalies disappear and are replaced by increasing side radiation, phenomena characteristic of a feeder stop region developing between the active region and the large end of the antenna. Figs. 1(b) and 2 (b) illustrate optimum coupling while

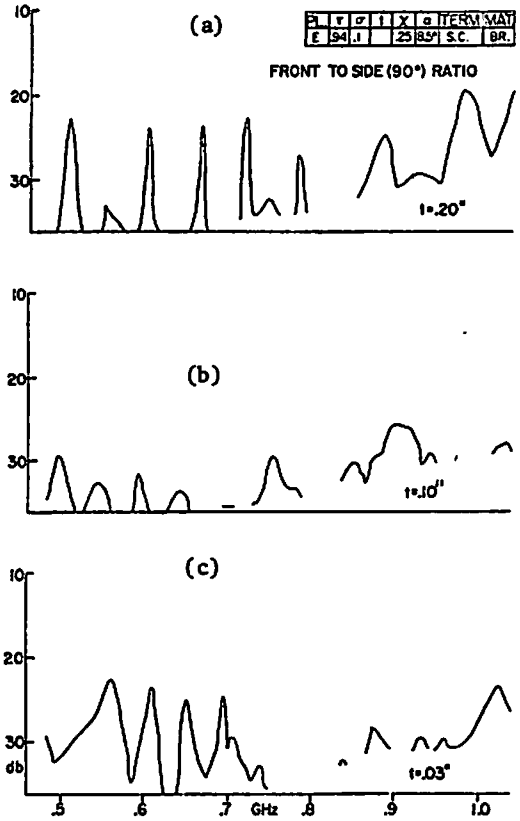

Fig. 1: Front-to-side ratio.

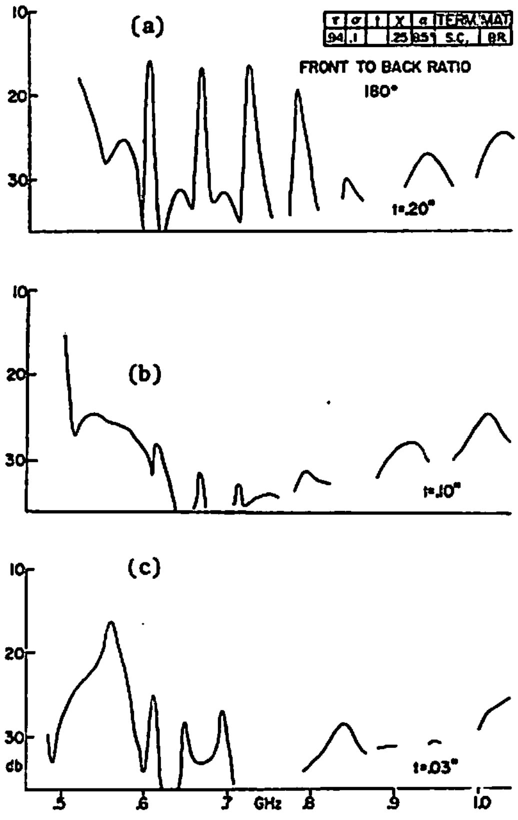

Fig. 2: Front-to-back ratio.

Note: The above figures are for a loop-coupled log-periodic antenna with three different values of element-to-feeder spacing t.

Figs. 1(c) and 2(c) show overcoupling anomalies with log-periodic spacing, characteristic of a feeder stop region which has merged with the active region. It should be noted that in the loop-coupled design the anomalies of Figs. 1 (a) and 2(a) occur when the large end of the antenna is effectively a resonator with an open-circuit at the resonant element and length measured along the feeder conductor; if this is taken into account, all the remarks made with regard to the standard log-periodic antenna apply equally well to the loop-coupled design.

References

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