Sensor and Simulation Notes

Note 146

General Principles for the Design of ATLAS I and II

Part IV: Additional considerations for the Design of Pulser Arrays

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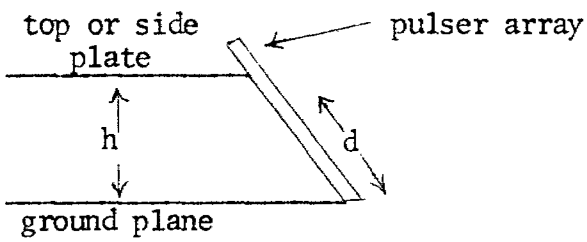
1. Reduction of average electrical stress on pulser arrays by sloping



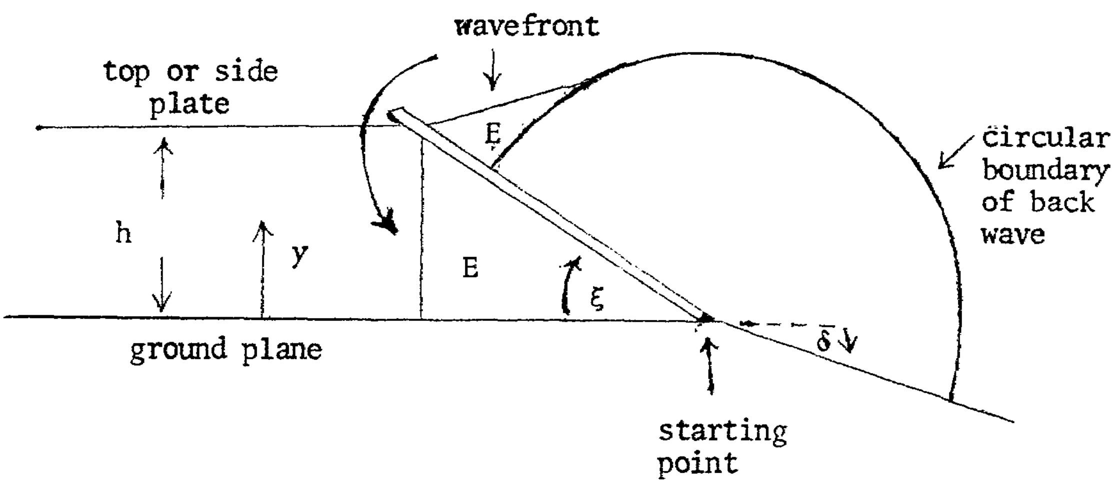
Given a certain number of megavolts being launched on a transmission line of spacing h the average field on the array can be reduced by sloping the array to have a distance d along the array between the ground plane and top or side plate of the simulator. Needless to say $d > h$.

Of course this is also a technique which perhaps allows h to be made smaller so that the frequency at which h is about a radian wavelength becomes higher. This may reduce problems with the high frequency characteristics of the array.

2. Array triggering sequence

The array is not triggered all at once but in a progressive manner so as to launch a plane wave down the cylindrical transmission line, or better launch a spherical wave down a conical transmission line. The distribution of pulsers with their turn-on times is to match the tangential component of desired TEM electric field at the array in a local averaged sense. Numerous notes discuss the theory such kinds of distributed sources though not specifically for this case. SSN 108 discusses arbitrarily shaped distributed source surfaces but not with a view toward any advantages inherent in sloping the array.

3. Array loading associated with the back wave



SSN 95, which is on terminations, can also be applied to the sloped source problem showing some of the advantages.

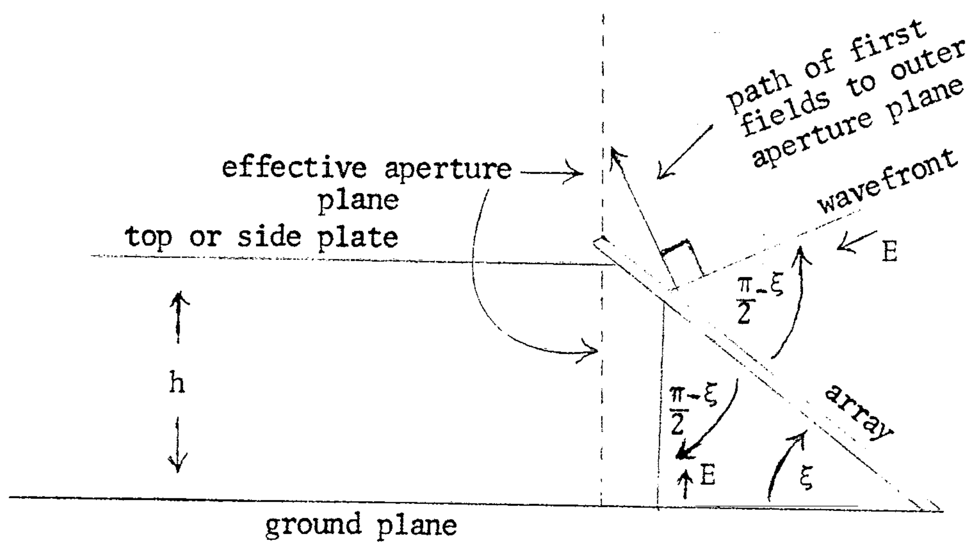
Consider the wave begun at the starting point. Behind the array there is an angle of $\pi+\delta-\xi$ between the array and the ground plane. In front the array has an angle ξ with respect to the ground plane. δ is the angle that the ground plane is bent. The first pulser near the starting point launches into an angle ξ in the forward direction but into $\pi+\delta-\xi$ behind. The back impedance is then larger than the forward impedance if $\pi+\delta >> 2\xi$. This reduces the amount of high frequency energy sent backwards.

Note how the influence of the starting point is felt at other points on the array sooner after those elements are turned on as ξ is made smaller. Thus the effective back impedance is increased from its simple plane wave value sooner in time for essentially all array elements as $\xi \to 0$ keeping h constant and the array elements each stationary with respect to y.

Note that there is some benefit to increasing δ.

4. Use of sloping to help fill an effective aperture plane with fields more rapidly

Refer to the question of filling the source plane as discussed in Part I, section 15. Change this to an effective aperture plane perpendicular to the direction of TEM propagation.



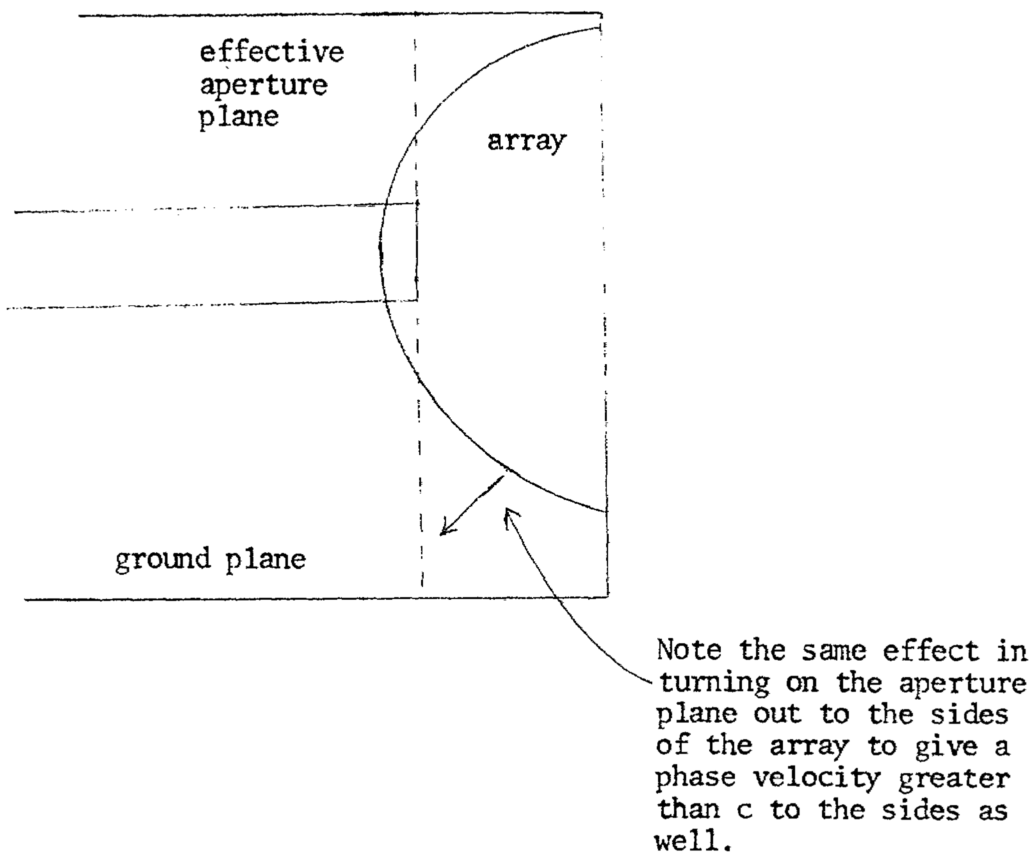
If $\xi < \pi/4$ then some of the fields launched behind the array reach positions on the "effective aperture plane" beyond the top or side plate before fields from the array near the top or side plate can reach there. Basically the phase velocity of fields reaching this outer aperture plane is faster than c. Note that the tangential components of E first reaching this portion of the outer aperture plane also have approximately the desired polarization.

If we make a modal decomposition of the fields on the "effective aperture plane" as appropriate to a two dimensional cross section then we are trying to make the TEM mode "turn on" as fast as possible. The coupling coefficient for the TEM mode has a general form like

$$\int_S \vec{E} \cdot \vec{E}_{TEM} \, dS$$

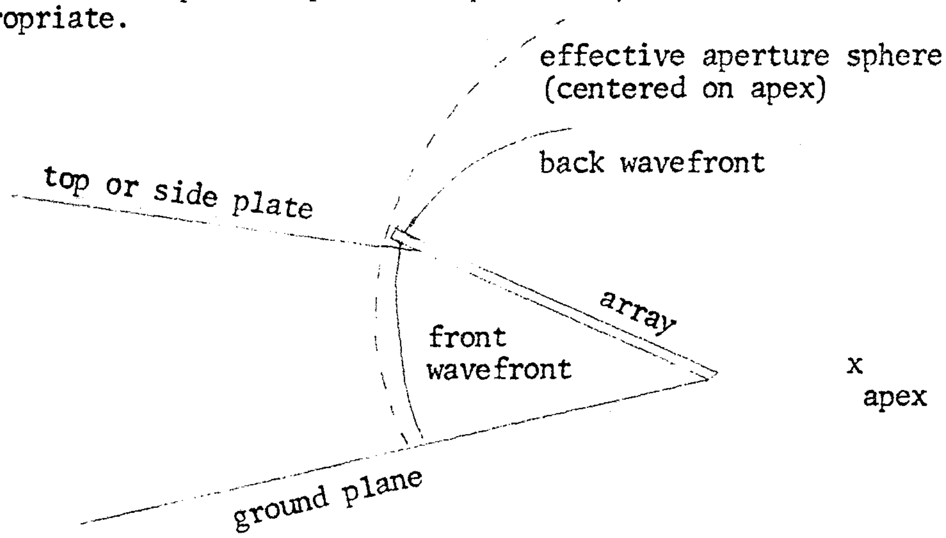
where $\vec{E}_{TEM}$ is the distribution as in SSNs 21 and 52. This coupling coefficient can be considered in both frequency and time domains.

view perpendicular to top or side plate



5. Turning on an aperture sphere

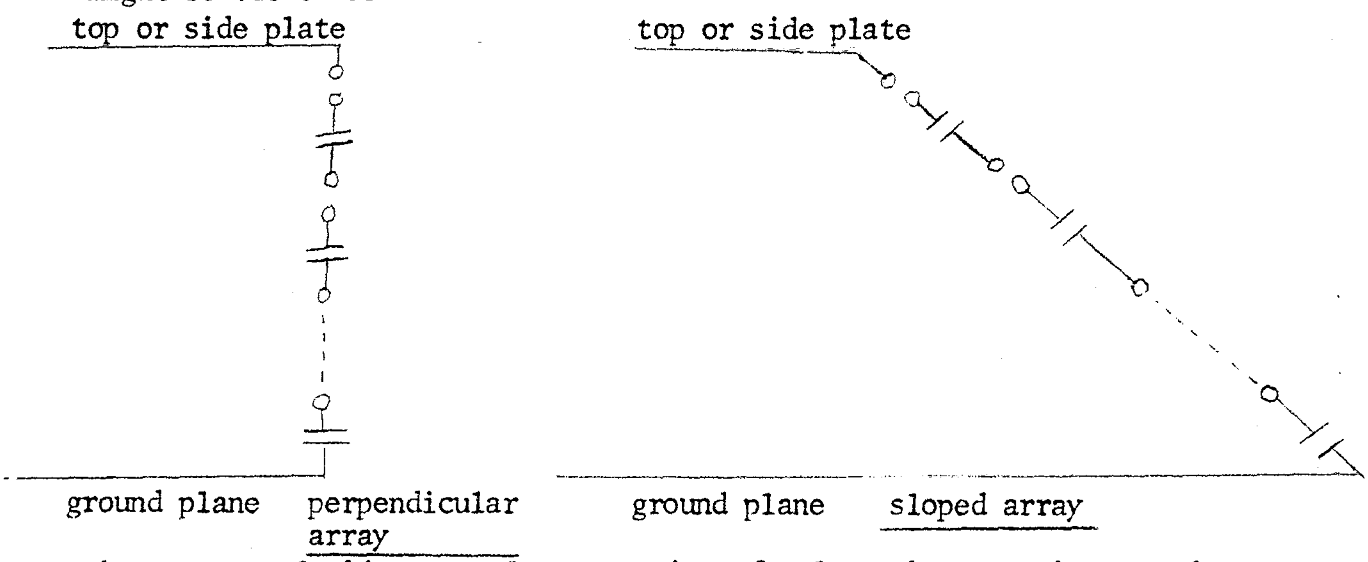
Actually the array drives a conical transmission line. Thus instead of an aperture plane an aperture sphere is somewhat more appropriate.



Notice that due to the curvature of the aperture sphere the back wavefront arrives at the "outside" portions of the aperture sphere a little faster than in the case of a planar aperture.

6. Staggering of module interconnections to form sloped array.

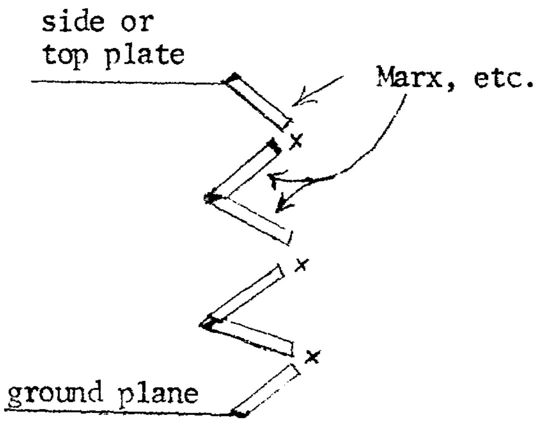
In its simplest form an array driving a transmission line might be viewed as



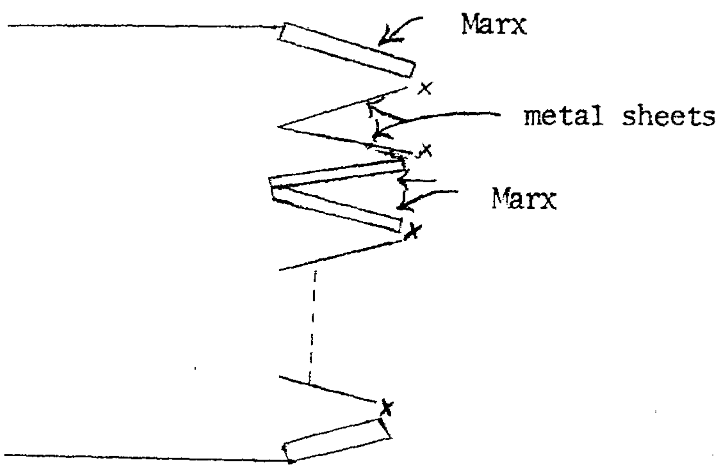
where we are looking at only one string of pulsers between the ground plane and the top or side plate.

Now each pulser may be driving a small conical transmission line or be configured so that various of its elements (such as peaking capacitors) form a high frequency waveguide such as a small conical transmission line which attempts to increase the efficiency of launching the highest frequencies in the forward direction down the main transmission line.

For a perpendicular array we might have something like

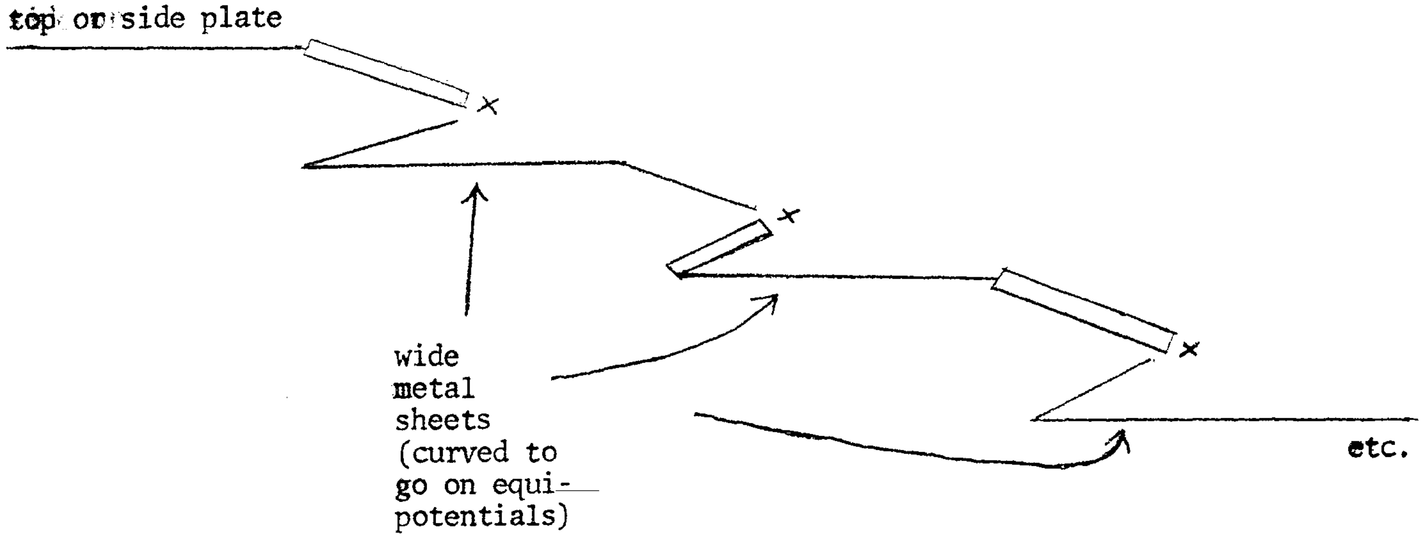


with X indicating the position of final output switches. As a first option such output switches might be split in half without basically altering the Marxs.



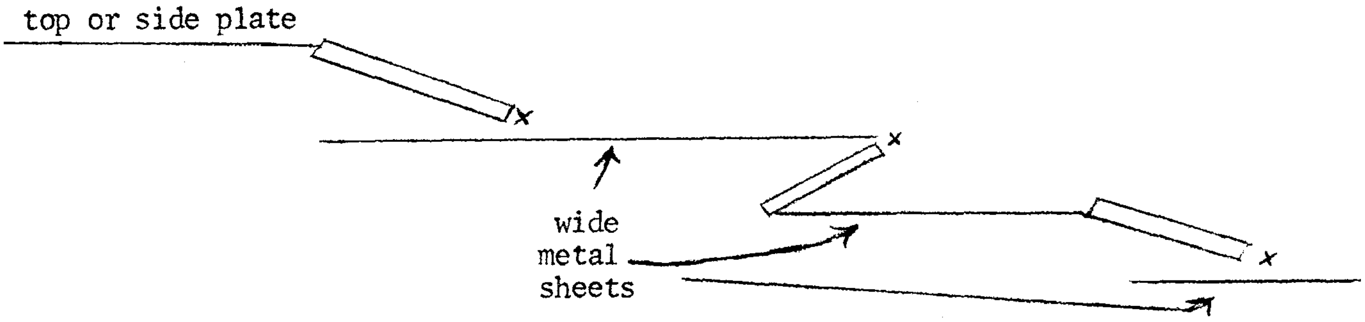
Now we have twice as many launch points (final output switches) on the array as before to make a less "lumpy" array turn on.

Now stagger this last array something like



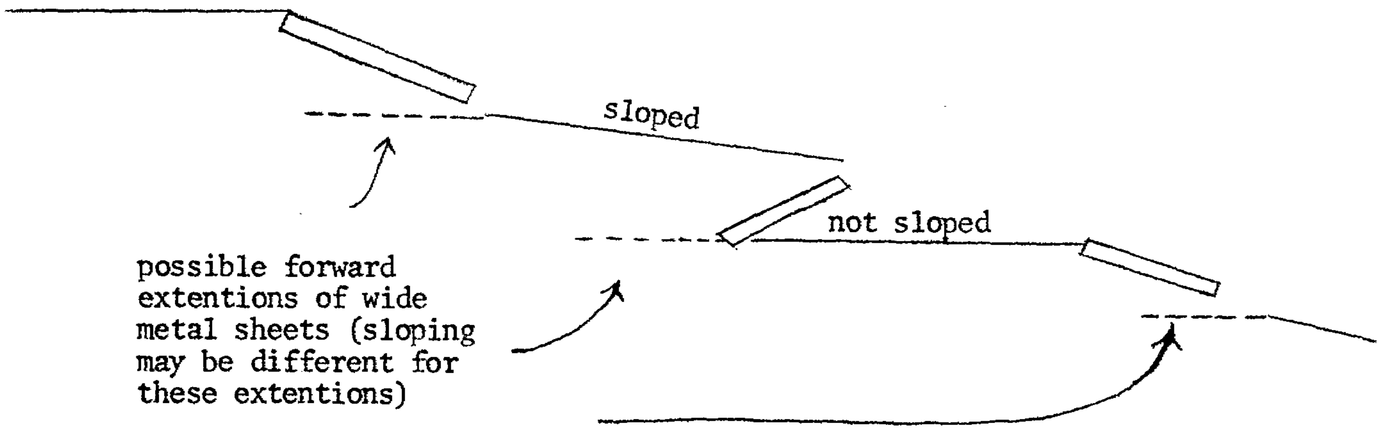
This merely involves adding conductors on the main TEM mode equipotentials so as to stretch the array back from the aperture plane.

An alternate arrangement might use halves of small biconics (or the Marxes, peaking capacitors, etc.) directly against the wide metal sheets.



However, this may reduce the effective number of launch points somewhat.

This last problem can be altered somewhat by alternately sloping the wide metal sheets.



Note that the "wide metal sheets" can be used to transport trigger signals on cables along rows of the array so this feature of parallel (not series) hardwire connections is maintained in sloped arrays to about the same extent as in perpendicular pulser arrays.

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Acknowledgement:

Floyd Graham of Maxwell Labs also independently proposed a few of the ideas contained in this paper, including the idea of sloping to reduce average electrical stress along the array and the possibility of staggering the array elements.