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Efficient Radar System Using a Ferroelectric Reflect Array Antenna

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Abstract:

The ferroelectric reflect array radar in space communication is a part consisting of a better reliability, cost reduction and high efficiency antenna. This antenna based radar consists of a phase shifter based upon coupled micro strip patterned on BaxSr1–xTiO3 films, which were laser ablated onto LaAlO3 sustrates.it is a concept of scanning a phased array based on a thin film of ferroelectric phase shifter, for an Band precipitation monocratic radar.

Introduction:

Reflective array antennas usually have a number of identical elements, present in a phase, as flat, electrically a unidirectional beam with large reflection, increasing gain, and deduced radiation in unwanted directions. The unique elements are mostly half wave dipoles, although they sometimes behaves as parasitic elements as well as driven ones. The reflector may be a wire screen or more commonly a metal sheet. A metal screen reflects radio waves as well as a solid metal sheet as well as the holes in the screen are smaller than or equal to about one-tenth of its wavelength, so these screens are often used to reduce air loads and weight on the antenna. They consists of a grill of parallel wires or rods, these rods are oriented parallel to the axis of the dipole elements. These driven elements are fed by a network of transmission lines, these network divide the power from the RF source equally between the elements. These usually have a circuit geometry of a tree structure.

Beam streaming

The main lobe of the billboard antenna can be steered electronically within a limited angle by phase shifting the drive signals applied to the individual elements. Every antenna element is fed through a phase shifter which is to controlled digitally, delaying each signal by a successive amount. This causes the wave fronts created by the superposition of the individual elements to be at an angle to the plane of the antenna. Antennas they use this technique are called phased arrays and are being intensively developed, especially for its use in radar systems. Second option for steering the beam is to mount the entire array structure on a rotating bearing and rotating it mechanically.

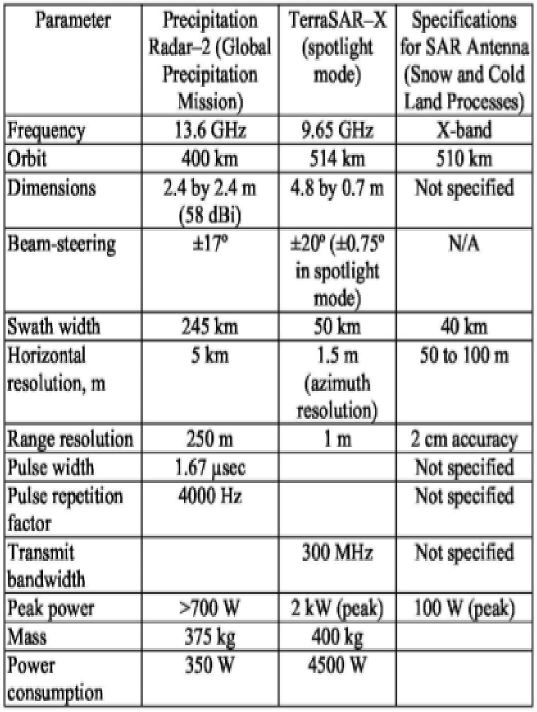
Ferroelectric Phase Shifters

A novel hybrid phase shifter combining an analogy ferroelectric section and a “digital” switch was devised. A photograph of the hybrid ferroelectric/semiconductor phase. Four coupled micro strip sections are attached to a virtual short circuit (radial stub) via a Gas beam lead diode. When the diode is forward biased, a short circuit terminates the analogy phase shifters and provides an additional approx. - irately 180° of phase shift. When the diode is off, the term- nation is essentially an open circuit with a near unity amplitude reflection coefficient and approximately 0° of phase shift. Average loss was 3.5 db. A loss of 1.2 dB is assigned to the diode since replacing it with a true open (off) and wire bond (on) reduces the loss to 2.3 db. Maximum phase shift was ,z320° (Fig. 5). Bandwidth and true time delay are important considerations. shows that the insertion phase shift is essen- tially proportional to frequency, and bandwidths in excess of 5 percent are achievable.

Phased Array Radar

Three specific NASA Earth Science applications illustrate the potential benefits of power-efficient, beam-steerable phased array X-band antennas (Table I). Precipitation radar is used to measure the amount and type of precipitation (water and/or ice) in selected three-dimensional columns from the earth’s surface up to a height of about 20 km. This data is crucial for climate modelling and weather forecasting. The purpose of Snow and Cold Land Processes Mission (SCLP) is to measure the quantity and distribution of water stored in the form of snow, on land and on ice sheets (Ref. 14). An objective of this mission is to correlate terrain variations with microclimate-related snow processes, and understand how these interactions impact macroclimate conditions. Hence high spatial resolution is important to the success of this mission, and a goal of around 50 to 100m resolution has been set. Since the space craft orbit is nominally 510 km, this resolution can only be achieved using synthetic aperture radar (SAR). Prior measurements have shown that the optimal frequency range to measure volumetric snowpack properties n X-band FRA. In order to provide a meaningful demonstration of a proto- type, a preliminary design for an X-band Reflect array Precipice- station Radar System would use a target beam width of about 2°. This specification represents a compromise between the resolution offered by state-of-the-art instrumentation such as that aboard the Tropical Rainfall Measuring Mission and pro- posed for the Global Precipitation Measurement System and realistic costs. This beam width relates to around 2560 element, 'z1 m diameter FRA, an achievable goal.

TABLE I.—SUMMARY OF ANTENNA PARAMETERS FOR SPACE-BASED PHASED ARRAY ANTENNAS



Parameter	Precipitation Radar–2 (Global Precipitation Mission)	TerraSAR–X (spotlight mode)	Specifications for SAR Antenna (Snow and Cold Land Processes)
Frequency	13.6 GHz	9.65 GHz	X-band
Orbit	400 km	514 km	510 km
Dimensions	2.4 by 2.4 m (58 dBi)	4.8 by 0.7 m	Not specified
Beam-steering	±17°	±20° (±0.75° in spotlight mode)	N/A
Swath width	245 km	50 km	40 km
Horizontal resolution, m	5 km	1.5 m (azimuth resolution)	50 to 100 m
Range resolution	250 m	1 m	2 cm accuracy
Pulse width	1.67 µsec		Not specified
Pulse repetition factor	4000 Hz		Not specified
Transmit bandwidth		300 MHz	Not specified
Peak power	>700 W	2 kW (peak)	100 W (peak)
Mass	375 kg	400 kg	
Power consumption	350 W	4500 W	

n X-band FRA. In order to provide a meaningful demonstration of a proto- type, a preliminary design for an X-band Reflect array Precipice- station Radar System would use a target beam width of about 2°. This specification represents a compromise between the resolution offered by state-of-the-art instrumentation such as that aboard the Tropical Rainfall Measuring Mission and pro- posed for the Global Precipitation Measurement System and realistic costs. This beam width corresponds to a 2560 element, 'z1 m diameter FRA, an achievable goal.

Gain limits

The more driven elements that are used, the larger the length of antenna is compared to a wavelength, and the higher is its gain, and the narrower the beam width of main lobe of the antenna. However, the number of driven elements increases, the complexity of the related feed network increases. Therefore, the rising inherent losses in the feed network become much more than the additional gain achieved with more elements, limiting the maximum gain achieved. The gain of practical array antennas is present across 25 to 30 db. "Active" array antennas, in which groups of elements are driven by individual RF amplifiers, can have a good gain, but are prohibitively costly.

Since the 1980s, versions for use at microwave frequencies have been made with patch antenna elements mounted in front of a metal surface.

Conclusion:

A key challenge is constructing the active array economically for radar applications—a cornerstone of this work. The ferroelectric phase shifters require only two bias lines and can be fabricated using a simple three-step (selective etch, metallization, and encapsulation) lithography process. The smallest feature size is the 8.5 µm electrode separation as opposed to submicron lithography that would be required for Gas MMIC technology. The reflect array structure requires only a multilayer DC bias distribution board, a support platen which also serves as the DC and RF ground plane, and the RF layer populated with M×N devices (patch antennas and phase shifters) that can be automatically placed and wire bonded. These qualities lead to comparatively low cost. A corrugated or dual-mode feed horn plus supporting struts, an amplifier, and a controller complete the system front end. The gradual increase in power for the reflect array curve is associated with the increase in the number of controller channels. A 616 channel controller that consumed only 25 W has been built to operate the FRA. We expect that a 1 m X –band FRA would comprise 2560 individual radiating elements and phase shifters and produce about a 2^{o} beam width and offer better than 1 m range resolution

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