Elefant Radar System

Statements of Arthur and Hugh concerning the ELEFANT antennas:

The ELEFANT and RÜSSEL antennas were superficially similar to those of KH, but the ELEFANT antenna had 18 (three sets of six) simple half-wave dipole elements as did the KH antenna, while the RÜSSEL antenna had 32 elements, described in [10] as „an array of broad band dipoles arranged in four bays stacked eight high with dipole reflectors behind, and supported on a single mast 220 feet high". The photograph of the RÜSSEL array in Figure 25 shows that the elements were broadband cage-type dipoles16. The ELEFANT receive antenna was mounted on a WASSERMANN-M4 tower, which had an open lattice construction; the KH antenna was on a WASSERMANN-S whose tower was a single tubular structure. So the misidentification of ELEFANT and SEE-ELEFANT/ RÜSSEL as KH is understandable, especially if made on the basis of aerial reconnaissance photographs which may not have been perfectly clear, and with the benefit of hindsight the identification was not in fact very wide of the mark.
Our conclusion is that the ELEFANT and SEE-ELEFANT radars

Some reflections on ELEFANT Radar System

Antennas

It seems for me that the ELEFANT transmit and receive antennas were linear multi - element arrays with numerous equally spaced horizontal polarized half - wave dipoles fed with equal currents in phase to obtain maximum directivity in the forward direction.

Remark

However, with a linear array of N radiators, excited with equal amplitudes and phase, the first sidelobe is only 13.3 dB down from the peak of the main beam.

Well, most radar antennas are either reciprocal or separable into distinct transmitting and receiving paths. It is more understandable to consider the antenna as a transmitter with signals spreading out to the various radiating surfaces and recombining at points in space.

A half - wave dipole in free space has a theoretical gain of 1.64 (2.15 dB) above an isotropic radiator. If that antenna is oriented horizontally in front of a conducting mesh wire screen, its maximum gain will be increased by a factor of 4, or 6 dB, to 8.15 dB at 0° elevation angle.
Arranging a set of $\lambda/2$ dipoles in a regular array with centres uniformly spaced at intervals of $\lambda/2$ each carries current of same magnitude and all currents are in phase. The net result is that the gain of the array is larger than that of an individual $\lambda/2$ dipole by a factor of order:

$$\frac{2\pi\, N(\lambda/2)}{\lambda}$$

An array of 16 horizontal polarized half - wave dipole radiators, excited with equal amplitudes and phase, installed in front of a perfectly conducting backplane has therefore a gain in the order of 18 dB.

Receiver Noise Figure

On the WWII epoch it was possible already to design receivers for radar operating in the HF band with low enough noise figures that environmental noise was dominant.

A major source of noise at the high end (30 – 40 MHz) of the HF band is beside of man made noise extraterrestrial or galactic noise. For that frequency range is the typical external noise power per Hertz in the order of -175 dBW.
For a receiver bandwidth of 100 kHz we can expect a detection threshold in the order of -95 dBm plus a S/N ratio required for a well discernible CRT indication.

Transmit Power

The ELEFANT transmitter is a non coherent self exited oscillator, modulated with 10 µs pulses on a pulse repetition rate of 25 Hz. The transmitter generates a HF peak power of 330 kW, by a duty cycle of 2.5×10^{-4} therefore the average power is only 82.5 watts.

Propagation - Path Factor, Transmit Loss, Receive Loss

Unknown !

Clutter Situation

HF Radars are generally look – down type that have earth or sea backscatter at the same rage as targets. The usable radar range may be occupied either by sidelobe clutter (ELEFANT antenna side lobes are only 13.3 db down from the peak of the main beam) or ground/sea clutter illuminated over the ionosphere.

Radar Range Examination

Although important system parameter (e.g. propagation - path factor, transmit loss, receive loss etc) of the ELEFANT radar are unknown a rough examination of the radar range calculation could be of interest:

$$R_{max}^4 = \frac{P_t\, G_t\, G_r\, \lambda^2\, \sigma t}{(4\pi)^3 \quad MDS} \qquad \frac{85\text{ dBm} \quad 20\text{ dB} \quad 18\text{ dB} \quad 18\text{ dB} \quad \underset{(1\text{ m}^2)}{0\text{ dB}}}{33\text{ dB} \qquad\qquad -92\text{ dBm}}$$

R	Maximum Detection Range in meters
Pt	Transmit Peak Power (330 kW = +85 dBm)
Gt	Transmit Antenna Gain +18 dB (Antenna Arraiy of 16 $\lambda/2$ dipoles)
Gr	Receive Antenna Gain +18 dB (Antenna Arraiy of 16 $\lambda/2$ dipoles)
λ	Wavelength 10 meter (10 x Log 10^2 = +20 dB
σt	Radar Target Cross Section in Square Meters
$(4\pi)^3$	Sphere Surface (twice) (= 33 dB)
MDS	System Noise + 3 dB S/N for discernible CRT indication

R_{max} for σt 1 m^2 (ME109 small fighter) = 100 km

R_{max} for σt 10 m^2 (HE111/HE177) = 178 km

R_{max} for σt 40 m^2 (B24 or Lancaster bombers) = 251 km