

## A Long Range Retro-Reflector

### I. INTRODUCTION

Passive retro-reflectors that modulate a scattered RF signal but do not transmit in their own right are well known. They are widely used in RFID tags, and keyless entry systems with a number of standardised solutions defined within the industry.

The main advantage of these systems is that the mobile unit (the tag) can either avoid completely the use of a battery by powering itself from the incident RF 'interrogating' signal or only require a very small battery with a long life. This enables a 'disposable' tag to be engineered at very low cost, size and weight. However, there are many potential applications that require a somewhat longer transmission range than can sensibly be achieved with this method. The conventional paradigm requires a higher power 'interrogating' signal in order to increase range and there are obvious limits to how far this can be taken. The combination of regulatory restrictions and the steep range vs power slope that results from the fundamental mode of operation generally restrict the range to a few metres at most.

Plextek have been taking a fresh look at the possible ways of circumventing this obstacle to produce a long range device that is nevertheless RF passive (does not transmit but only scatters). This paper describes in outline some ideas in this space, some initial experiments that have been done and some potential applications of the techniques.

### II. REFLECTION GAIN

One way to increase range substantially is to arrange the passive tag so that the scattered signal is in fact larger than the incident one. It is well known among RF specialists that circuits can be built which have reflection coefficients of greater than unity. What is not generally understood is that these circuits can be stabilised and used to achieve both reflection gain and modulation of the scattered signal. A recent programme sponsored by DSTL used this technique to substantially increase the perceived radar cross section of a foil antenna at VHF and impart modulation that would make the reflector appear to have a Doppler signature.

Whilst the focus of this work was not primarily communication, subsequent experiments with the devices

that were made (Figure 1, Figure 2) have shown that a 50m range to a passive tag using only modest (10mW) interrogator power is feasible at VHF. Clearly similar devices can be made at other frequencies.

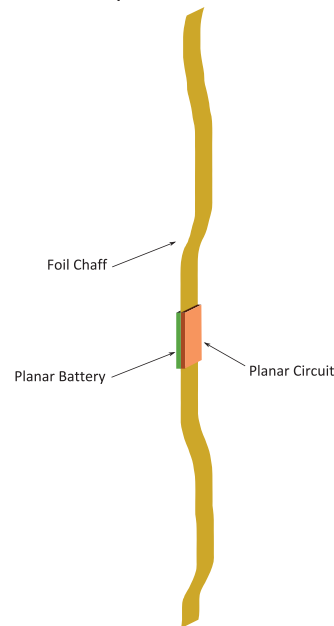


Figure1 Retroreflectorconcept



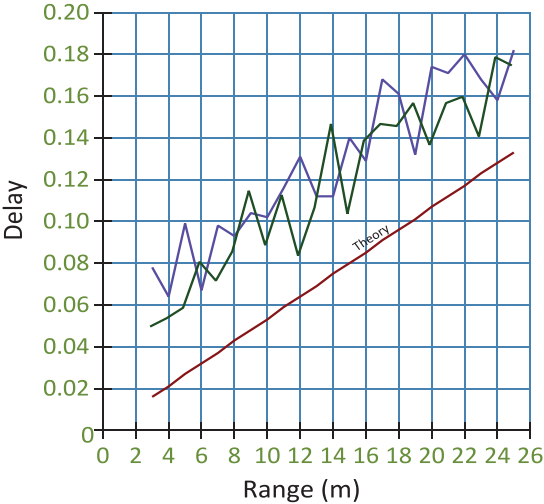
Figure2 Prototype device with reflection gain

### III. PHASE COHERENCE

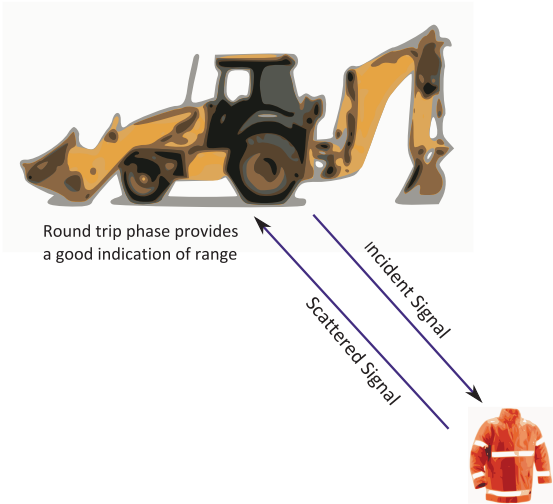
The modulation that is imparted to the scattered signal allows it to be separated from the incident, interrogating signal. If one sets about this in the right way, it is also possible to maintain phase coherence between the interrogating signal (which we know the phase of at the transmitter) and the scattered signal. This is illustrated in Figure 3 which shows

measurements made in an experiment where the tag was moved away from the interrogator whilst the round trip phase was recorded. The good correlation with the theoretical straight line can be observed apart from the fixed offset due to cable lengths in the equipment.

This phase coherence opens up a range of interesting possible applications. Firstly, as is clear from the figure, we can use this to determine the location of the tag. This measurement is considerably more resilient and accurate than those using amplitude alone. Potential applications of this kind include preventing accidents by alerting the drivers of large vehicles (for example on building sites) to the proximity of personnel. This concept is illustrated in Figure 4.



**Figure3 Relationship between range and delay (phase) in field tests of the active reflector**



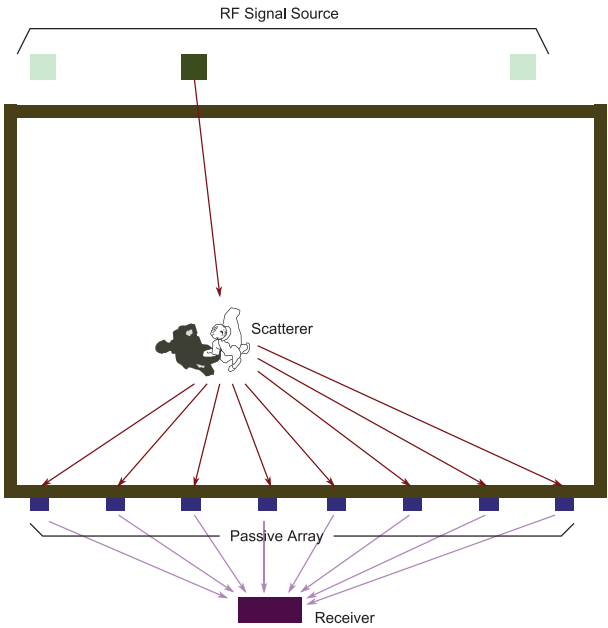
**Figure4 Safety Application of Coherence**

#### IV. THROUGH BUILDING RADAR

Those who wish to ‘see’ inside buildings using radar usually employ a relatively high RF frequency so that the radar aperture necessary to create the desired resolution is a feasible size. However, other than that, there is a lot to be said for using a much lower frequency for this purpose, in particular the building penetration loss is likely to be much lower and the fields are likely to be more stable, less complex and more straightforward to resolve into potential targets.

It occurs to us that the passive tags described with their coherence could be used to deploy a very large antenna aperture in a feasible and flexible manner. The concept (Figure 5) is to attach a series of passive tags to the building; each is easily carried and essentially disposable. The building is then illuminated from a stand-off position and the signals from the passive array of tags gathered; again from a stand-off position.

Because each element of the array (tag) has a known phase relationship with the source signal, the phase as well as the amplitude of the scattered rays can be determined; hence it is possible to use the elements to create an electronic aperture to locate and track objects in the building. An initial study (sponsored by MOD) concluded that, while there are many technical challenges in achieving this, there appeared to be no insurmountable obstacles.



**Figure5 In-Building radar concept**