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THE NEWCASTLE METEOR RADAR

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At the time of the First GLOBMET Conference (August 1985) the Newcastle Meteor Radar system was being gradually brought into operation after a period of development extending over more than ten year. The geographical coordinates of the radar installation are 32° 36' 42" S, 151° 50' 50" E and its elevation is 130 m. The radar transmitter, receiver and common antenna are located at the field site on a hilltop 34 km from the University of Newcastle campus and a VHF data link is employed to convey the video data from the station to the University of Newcastle, New South Wales, where it is processes in real-time by a multiple microprocessor system which is the most innovative feature of the project.

The nominal parameters of the radar system are:

Frequency	25.2 MHz
Pulse repetition rate	100 Hz
Transmitted pulse width	66 microseconds
Peak pulse power	25 kW
Antenna gain (twin yagis)	14 db (over isotropic)
Antenna azimuth	78°

The antenna polarisation is horizontal. The receiver has a logarithmic IF amplifier. The link transmitter is frequency modulated and operates at 471.5 MHz.

A block diagram of the system is shown in Figure 1.

Most of the block diagram is self-explanatory, except for the multiple-microprocessor meteor signal analyser which is shown in more detail in a further block diagram, Figure 2.

The initial objective when the project was commenced was to develop an entirely digital analyser capable of recognizing meteor echo signals and recording as many of their parameters as possible. It was desired that the smallest possible meteor echoes should be registered while maintaining the false-alarm rate (the number of spurious echoes) close to zero. A meteor echo simulator was built (Graham, 1969) which generated artificial echoes having a wide range of characteristics in the presence of both Gaussian noise and Poissonian impulse noise. This permitted realistic tests of the digital meteor signal analyser during its development (KEAY and KENNEWELL, 1979). In particular, the essential role of the impulse suppressor stage was demonstrated. A rigorous theoretical treatment of the analyser was published later (KEAY, BUTLER and KENNEWELL, 1976) when theory and test results each showed that the analyser improved the detection of small meteors to an

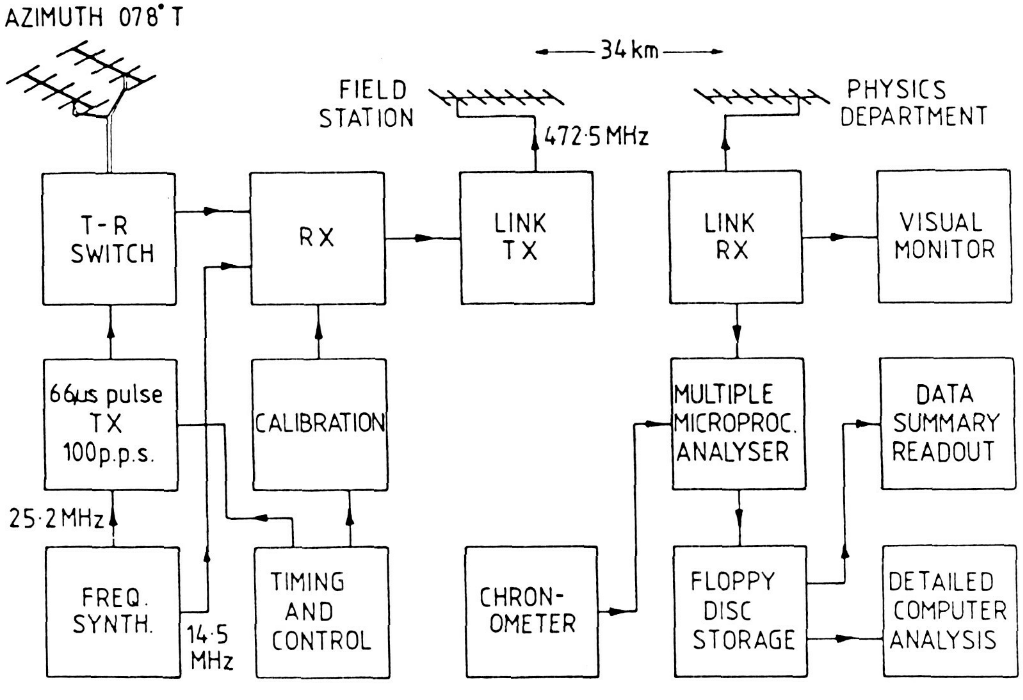

Fig. 1 Block diagram of the Newcastle Meteor Radar.

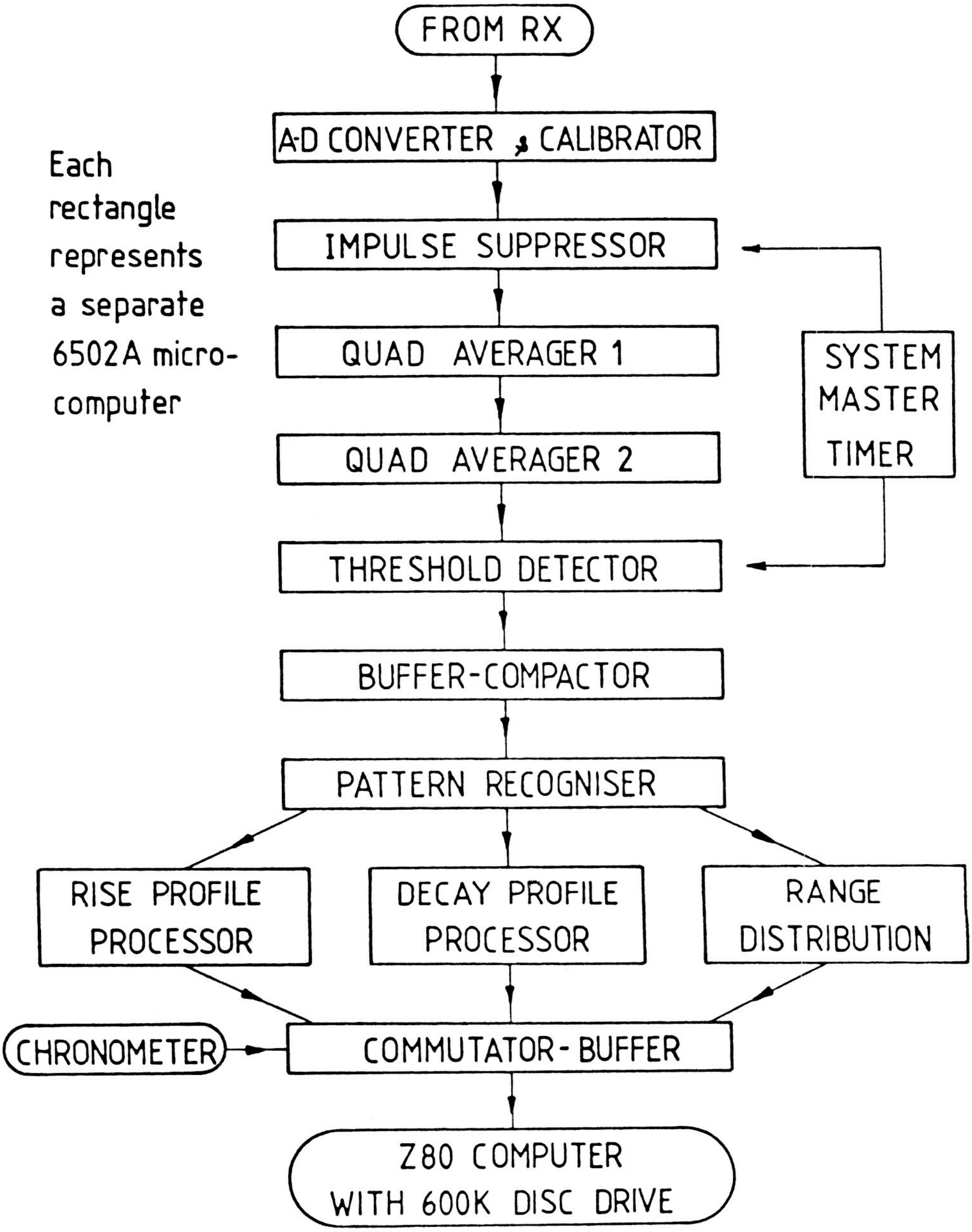

Fig. 2 Multiple microprocessor meteor signal analyser.

extent equivalent to a factor of four or five increase in transmitter power by comparison with a system without the analyser.

When the performance/cost ratio of microprocessors fell to the point where it became desirable to replace the hard-wired digital logic of the meteor signal analyser, a detailed comparison of all readily available microprocessor chips was undertaken (KEAY 1980). It was found that 16-bit types were no better than 8-bit types for the task. The most suitable microprocessor at the time proved to be the fast (2 MHz clock) version of the 6502 (the 6809 would now be a better choice) and it was chosen. Its powerful memory-oriented instruction set, including its fast zero-page instruction mode, enabled it to complete a useful processing loop within the 33 microseconds available in a system achieving 5 km range resolution. All programming is in machine code generated by a cross-assembler on a different microcomputer and loaded directly into type 2716 eproms which control the 6502s.

The use of microprocessors made it possible to extend the analyser to include some echo parameter extraction in real-time before the data is written to disk, rather than perform all analysis of the raw meteor data later on a separate computer.

Details of the design of the microprocessor circuit board, memory map and interfacing have been published (ROGERS, KENNEWELL and KEAY, 1982).

The first microprocessor stage controls the analog-digital converter driven from the link receiver. It locks onto a negative-going pulse coincident with the transmitter pulse to synchronise the systems. Then it registers the level of the calibration pulse, which follows the synchonisation pulse, to set the reference level of the converter which then samples and digitises the analog signal every 33 microseconds for transfer to the subsequent analysis stages.

The impulse suppressor state is quite vital in preventing the averager stage(s) from generating false echoes from high amplitude noise spikes. The suppressor truncates all signals at any given range to no more than twice the amplitude of the preceding signal at that range. Thus the high energy Poisson distributed noise is reduced to a low energy pseudo-Gaussian component which is further reduced by the averager algorithm.

In the early stages of the development of the system, an exponentially weighted average algorithm was employed in order to reduce the memory storage requirements of the system. Upon changing to microprocessor techniques the availability of ample memory allowed the use of better averaging algorithms within the time constraints of the system. It was shown (ROGERS 1982) that two identical consecutive microprocessor stages, even averaging four equally weighted samples in successive sweeps, produced an overall 1,2,3,4,3,2,1 weighting which was optimal for small meteors and yielded a noise variance reduction of 5.8. Much more complicated algorithms are required to gain further reduction in the noise variance.

The next stage is the threshold detector which not only rejects signals below a set level, but also rejects any signal which lasts for less than six successive sweeps. This further reduces the acceptance of false echoes by the system. This is very evident when local thunderstorms and other sources of noise intrude, but the system cannot cope with strong coherent interference from either back-scattered clutter or another transmitter.

Figure 3 shows the improvement in meteor echo detectability due to action of successive states of the signal analyser.

Following the threshold detector it is no longer necessary to process every range interval. Thereafter only the identified echoes are dealt with, allowing much more time for processing the individual echoes. The microprocessor stage referred to as the buffer-compactor acts as a buffer which stores only those echo amplitude values above the threshold level. Each group of values representing a single meteor is prefixed by the range value and is separated from the next by a single zero-byte delimiter instead of the many zeroes between successive echoes. In this way each scan is compressed in time to allow it to be passed on to the next stage as a compact packet. This removes the need for subsequent processing to strictly synchronised with the sweep rate. It is effectively a desynchronising stage.

The next stage carries the packet technique a step further by applying a pattern recognition approach to ensure that meteor echoes which drift in range, or fade and reappear, are associated with just a single meteor which is given an identification number. Only when a given echo has been absent for a period of time equal to its total echo duration is it deemed to be finished and passed on to the next stages, which may now operate in parallel.

At present the only two parallel stages are one which produces a cumulative echo count histogram as a function of range and another which derives the slope of decay of each echo. The histogram provides a check every six minutes on the range distribution of all echoes. This has value as a warning of the occurrence of false echoes and acts as a diagnostic of problems with the system. The decay-slope is, hopefully, the first of several which will examine various parameters of the meteor echoes. Figure 4 demonstrates how the information obtained from the meteor echoes will be treated to yield useful data on the meteor flux detected by the system.

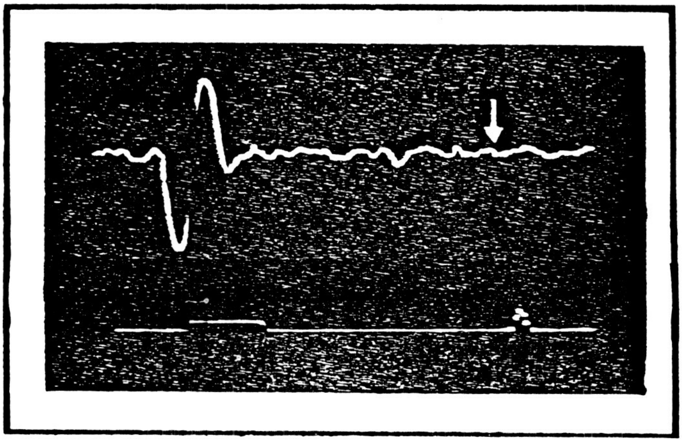

Fig. 3 The upper trace is the output signal from the link receiver, showing the negative transmitter synchronism pulse, the positive calibration pulse and noise with a meteor echo hidden within it. The lower trace is the processed output from the threshold detector, revealing a distance meteor echo. The sideways offset is due to the processing delay in the five microprocessor stages producing this result.

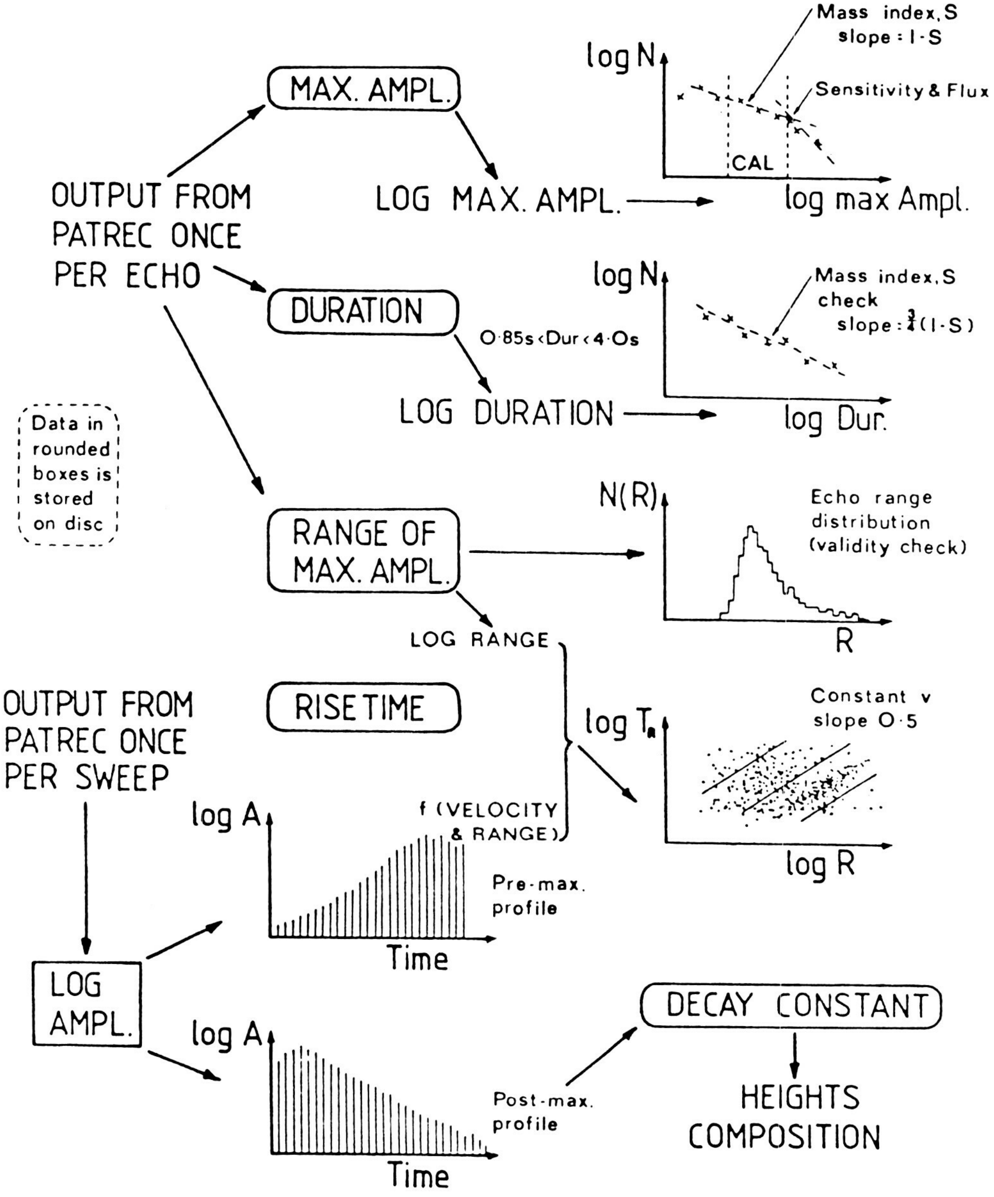

Fig. 4 Overview of the data reduction and analysis scheme.

Finally, the outputs from the parallel stages are brought together in an output stage which assembles the data for transfer out of the analyser to a Z80-based microcomputer which runs under the CP/M operating system and has a 1.2 megabyte floppy-disk drive for data storage.

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