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# Investigation of Printed Wiring Board Testing By Using Planar Coil Type ECT Probe

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**Abstract** - A new application of eddy current testing techniques for investigating trace defects on printed circuit boards is proposed. A test probe consisting of a meander type exciting coil is used to induce eddy currents. The following three experiments are conducted: measuring the induced signal when a circuit trace is cut; measuring the induced signal for a number of traces placed in parallel and with a cut in the centre trace; measuring the induced signal for two back to back right angle traces. The experimental results reveal that it is possible to clearly detect defects and that the signal response obtained is strongly associated with a particular defect pattern. The signals obtained from a high density patterned board have a complicated signal signature and are therefore difficult to interpret. This complexity can be avoided by comparing the signal signature of a known good board with a defective board. The difference signal gives a clear indication of a trace defect.

## I. INTRODUCTION

Eddy current testing techniques (ECT) are a non-destructive, non contact means of detecting surface defects in conducting materials. A new ECT probe consisting of planar meander and mesh coils has been proposed recently and can be used to detect the shape and size of cracks in a metallic plate [1], [2]. The planar coils are constructed using an etching technique and can have very small feature sizes limited only by the etching process. The meander coil is used to generate the eddy currents and the mesh coil is used to detect the resultant induced voltage signal. The eddy currents induced in the conducting medium are parallel to the meander coil. In this paper we explore the possibility of using an ECT probe to detect trace defects on printed circuit boards. Printed circuit boards differ from continuous conducting medium in that the eddy currents are constrained to specific paths. If the orientation of the meander coil is parallel to a trace, then significant eddy currents are induced in the trace. In contrast, a meander coil orientation perpendicular to the trace will result in a eddy current which is small. Therefore detection sensitivity depends strongly on the orientation of the meander coil and therefore cracks in horizontal traces can be easily discriminated from cracks in vertical traces.

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## II. EDDY-CURRENT TESTING FOR PRINTED WIRING BOARD

### A. Structure of a planar type ECT probe

The configuration of the proposed ECT probe is shown in Fig.1[1]. It consists of a planar-meander type exciting coil and a planar-mesh type detecting coil. The two coils have the same pitch. The mesh sensing coil is placed above and tightly against the meander coil. The measurement principle of the ECT probe is based on the variation of mutual inductance between the two coils. The magnetic flux alternates in polarity at each pitch of the meander coil as shown in Fig. 2(a). For a uniform conducting plate, eddy currents are induced in a pattern which is similar to the shape of the meander coil. The mesh coil detects the flux in the shaded mosaic area as shown in Fig. 2(b). The output voltage at the terminal of the mesh coil becomes zero if the underlying surface is uniform.

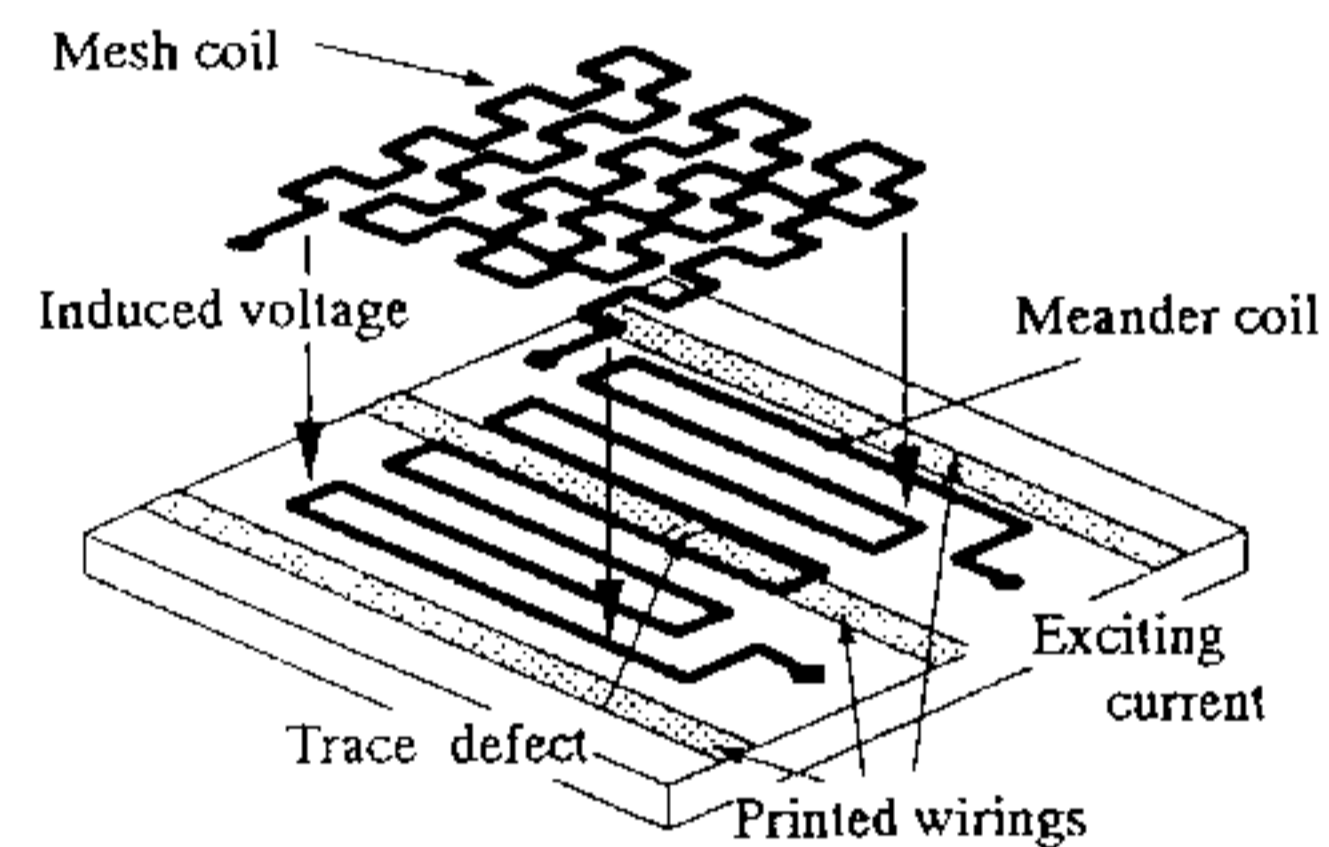


Fig.1 Probe structure.

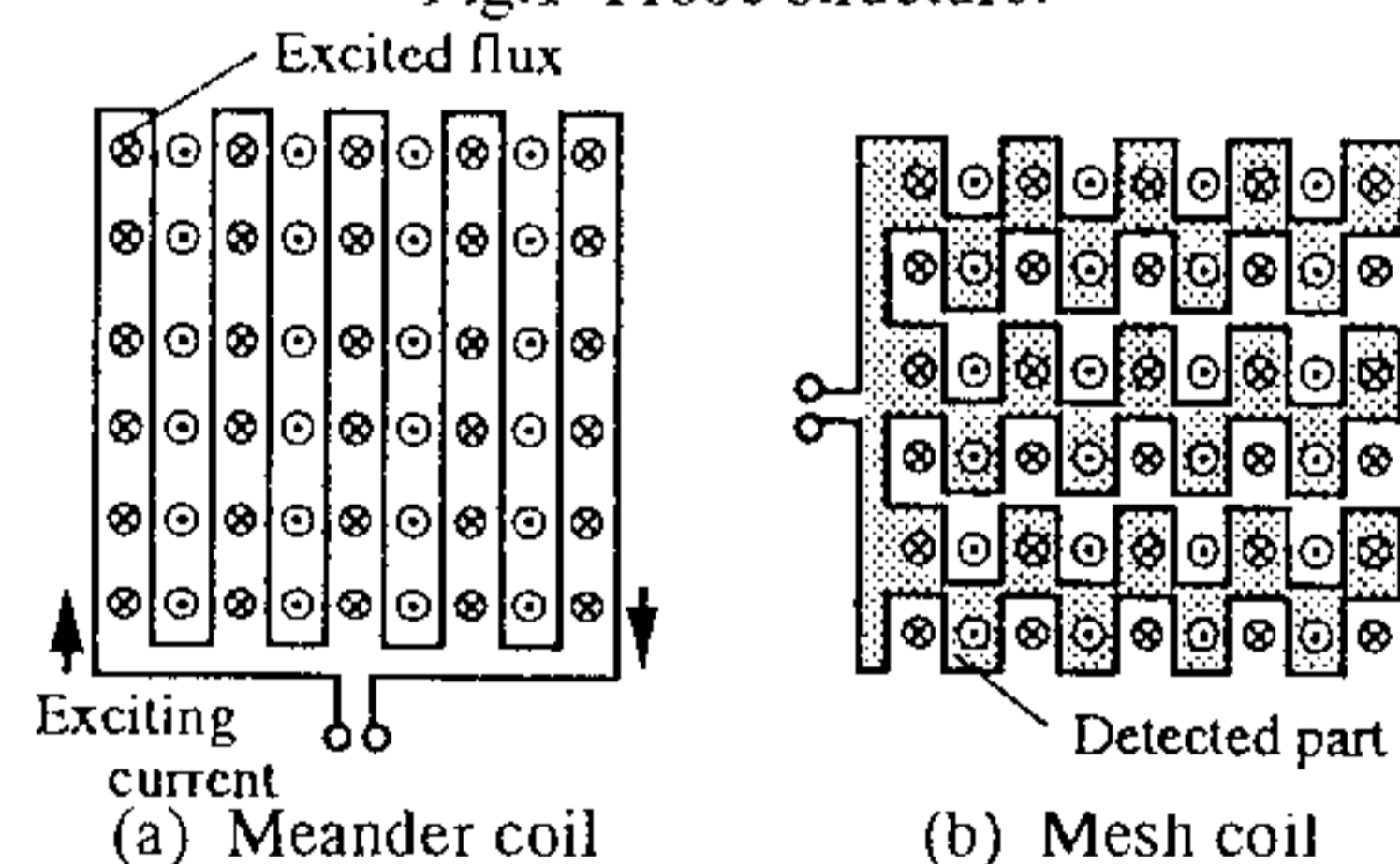
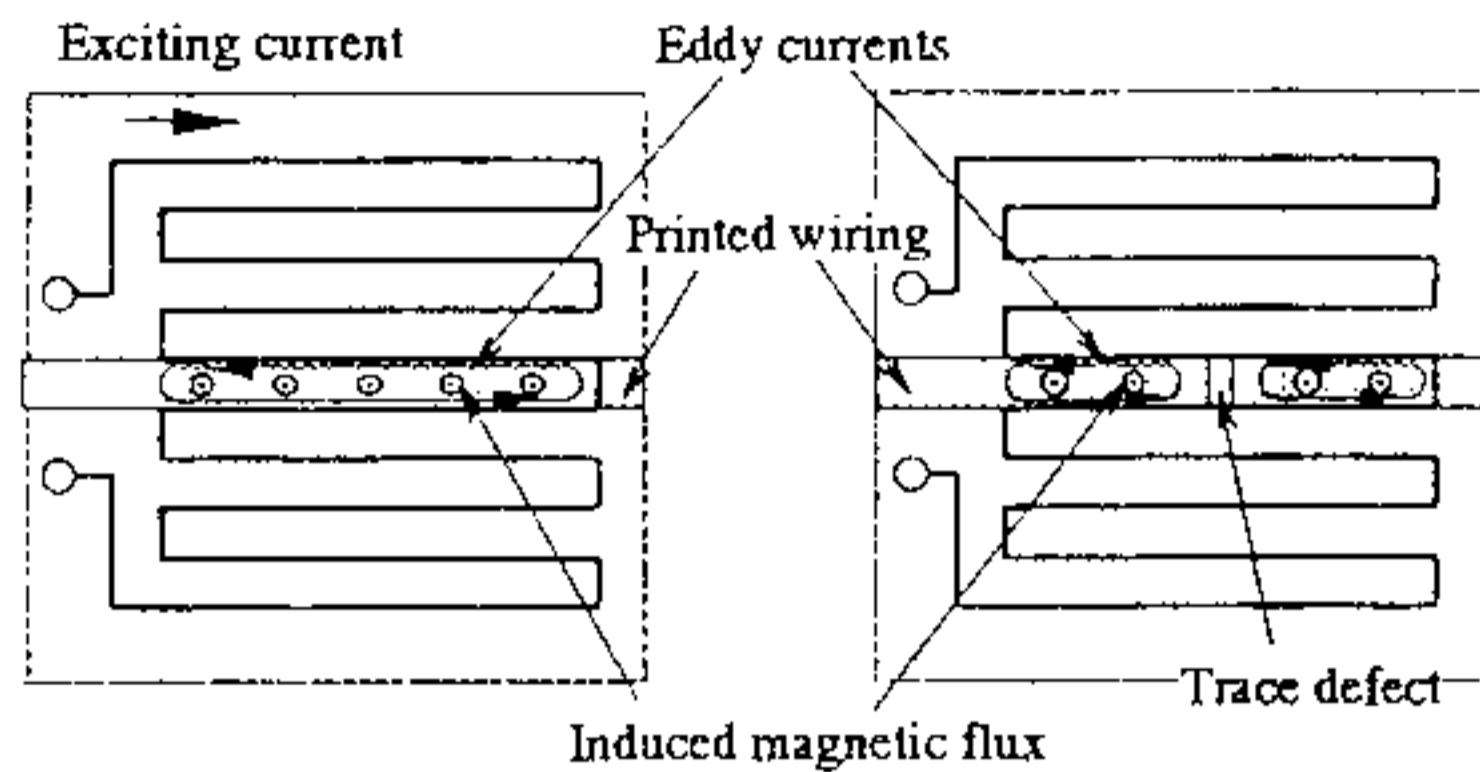


Fig.2 Excitation and detected flux.

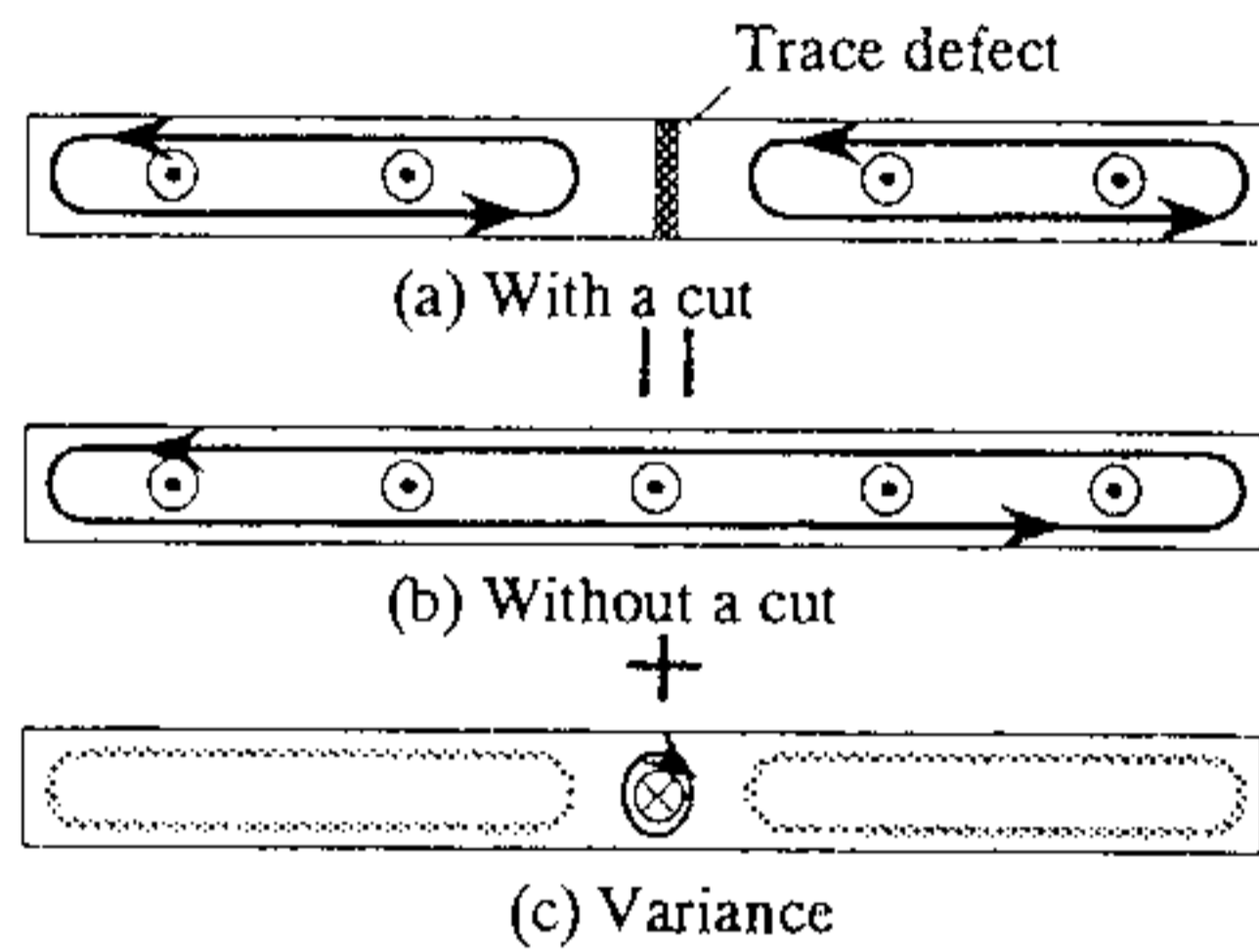
### B. Principle for detecting defects on printed circuit boards

Consider the output signal from the sensing coil when the probe is scanned along the length of a trace and the frequency is high enough to generate a significant eddy current. The signal obtained with and without a cut in the trace is shown in Fig. 3(a) and 3(b) respectively. By comparing the two eddy current patterns one obtains a signal corresponding to the variance or difference between the two signals as shown in Fig. 4. The mesh coil senses the voltage induced by the magnetic

flux within the gray area as shown in Fig 1. The output signal obtained for the case shown in Fig. 4(b) is a constant RMS voltage. In contrast the output signal for the case shown in Fig. 4(a) consists of a variance signal added to the same constant voltage. The output signals magnitude varies along the pitch of the mesh coil.



(a) Without a cut (b) With a cut  
Fig.3 Eddy current pattern.



(a) With a cut (b) Without a cut (c) Variance  
Fig.4 Induced current when a trace is cut.

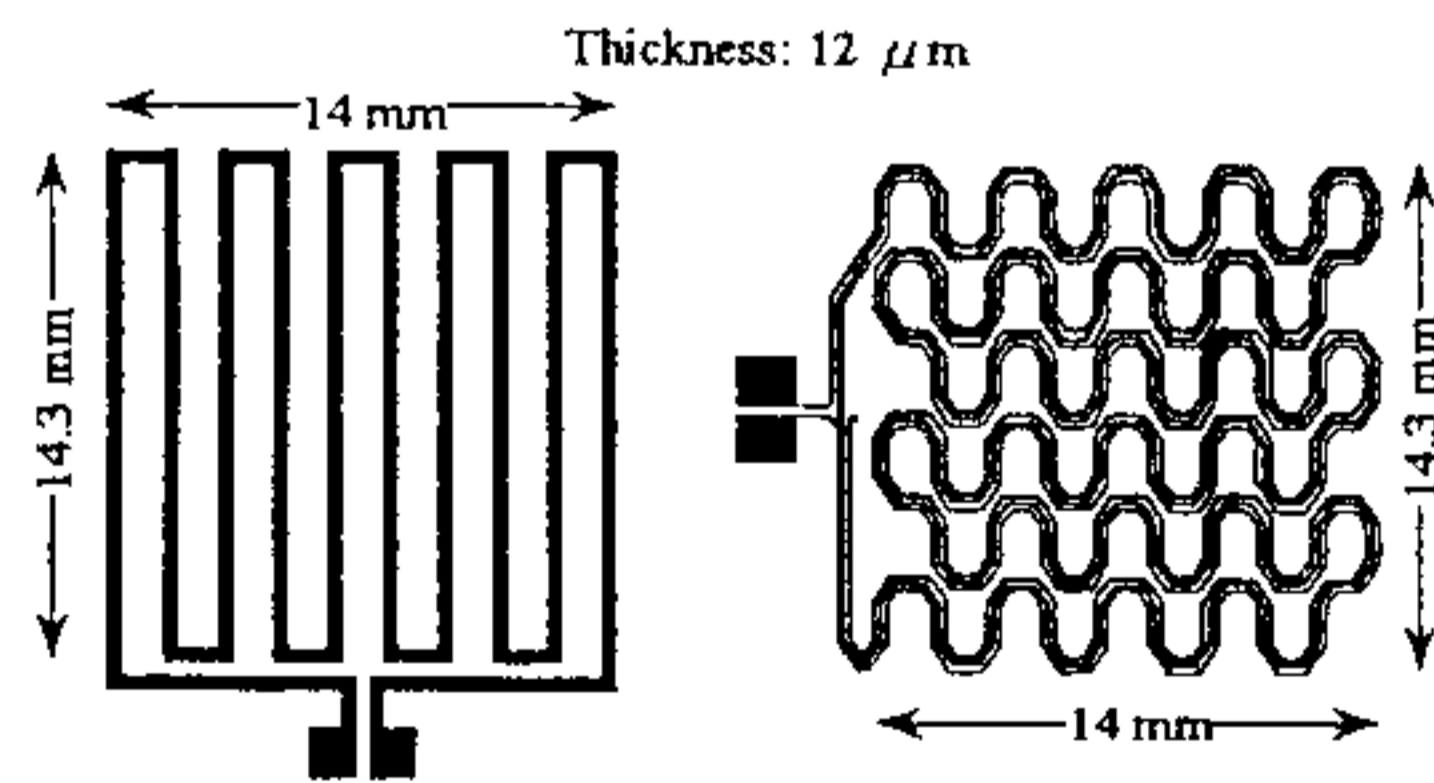
### III. EDDY-CURRENT TESTING MODEL PRINTED BOARD

#### A. ECT probe and measuring system

The coil pattern of the ECT probe is shown in Fig. 5. The area of each mesh coil fits within the area occupied by a strip of the meander coil. The mesh coil consists of three turns so as to achieve a higher measuring sensitivity. The measurement setup is shown in Fig. 6. The exciting source is a 5 MHz sinusoidal waveform with a peak voltage of 0.25Vp. The output signal is measured using a lock in amplifier.

#### B. ECT signals obtained from a printed circuit board having a single cut trace

A printed circuit board with a single cut trace has been fabricated as shown in Fig.7. The width and thickness of the trace are



(a) Meander coil (b) Mesh coil  
Fig.5 Coil patterns for a planar-type ECT probe.

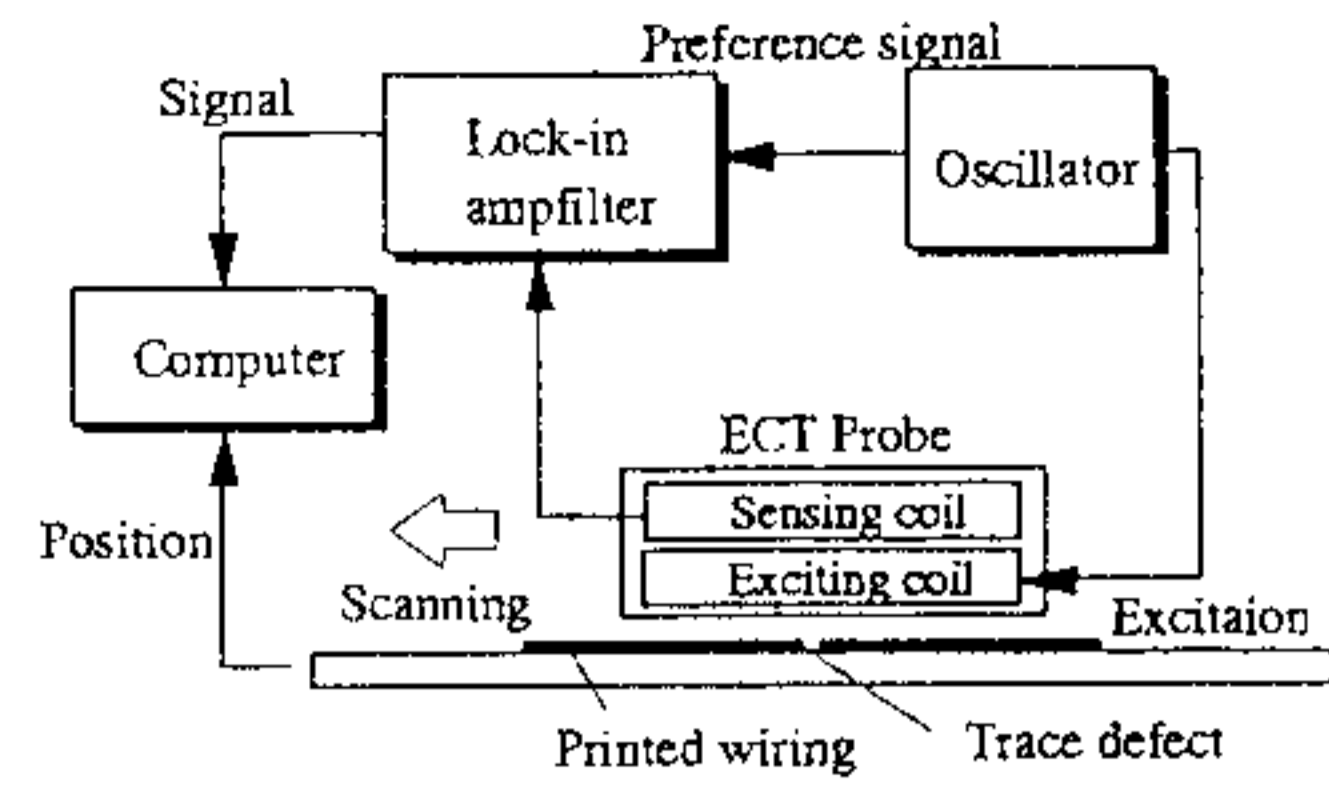


Fig.6 Measurement system.

1.0 mm and 35  $\mu\text{m}$  respectively.

The width of the cut is less than 10  $\mu\text{m}$ . The probe is scanned along the trace as shown in Fig. 8. The long side of the meander coil is parallel to the trace. The sensed signal for this case is shown in Fig. 9 where the coil position indicates the distance between the cut and the centre of the ECT probe. A small fluctuation of the signal is observed while the probe is scanned at some distance away from the cut. Three cycles are observed in the output signal as the coil is scanned over the cut. The number of cycles depends on the pitch of the mesh coil. Notice that this simple example clearly demonstrates the ability of the sensor to detect a cut.

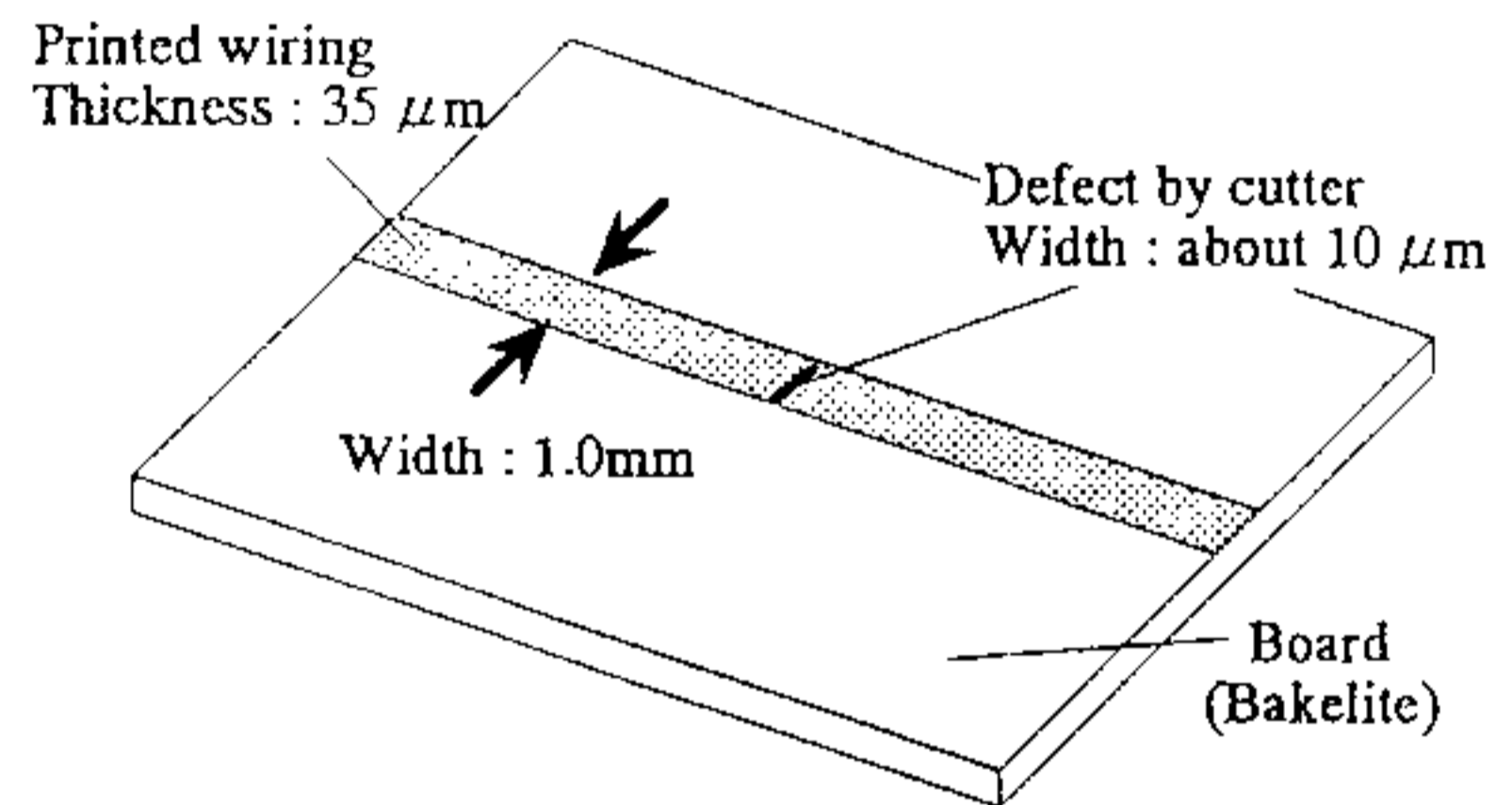


Fig.7 Single trace with a cut .

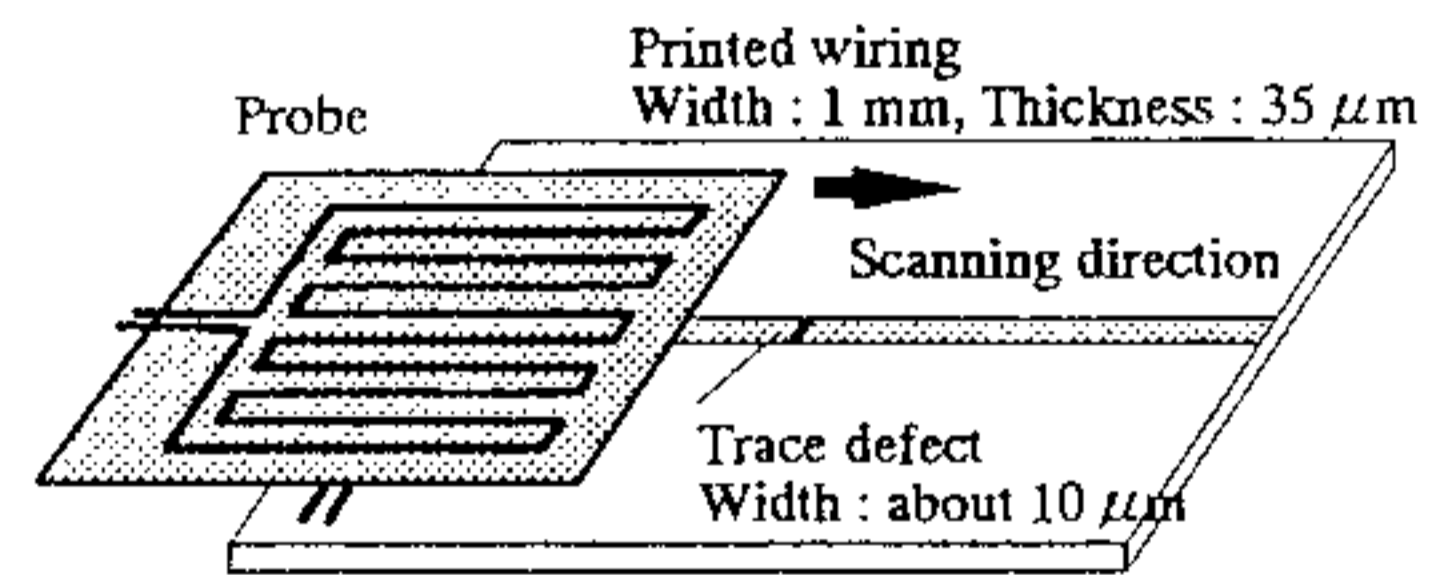


Fig.8 Scanning motion.

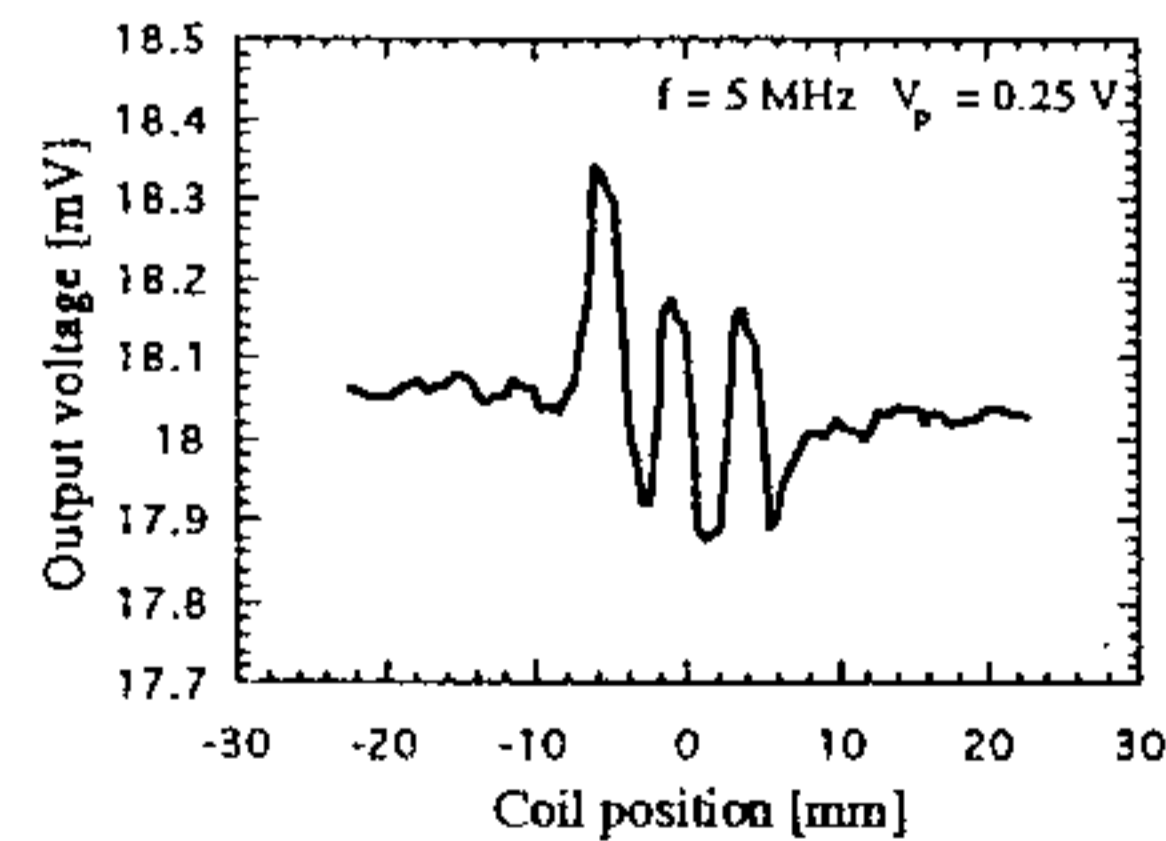


Fig.9 Output signal detected with the trace configuration shown in Fig.7.

C. ECT signals obtained from a printed circuit board having back to back right angle traces

Back to back right angle traces are used as a test pattern and are shown in Fig.10. This is a common pattern on actual printed circuit boards. Fig. 11 shows the ECT signal when the probe is scanned as shown in Fig. 10. The signal pattern is clearly different from the signal pattern observed with a single cut trace as shown in Fig. 9.

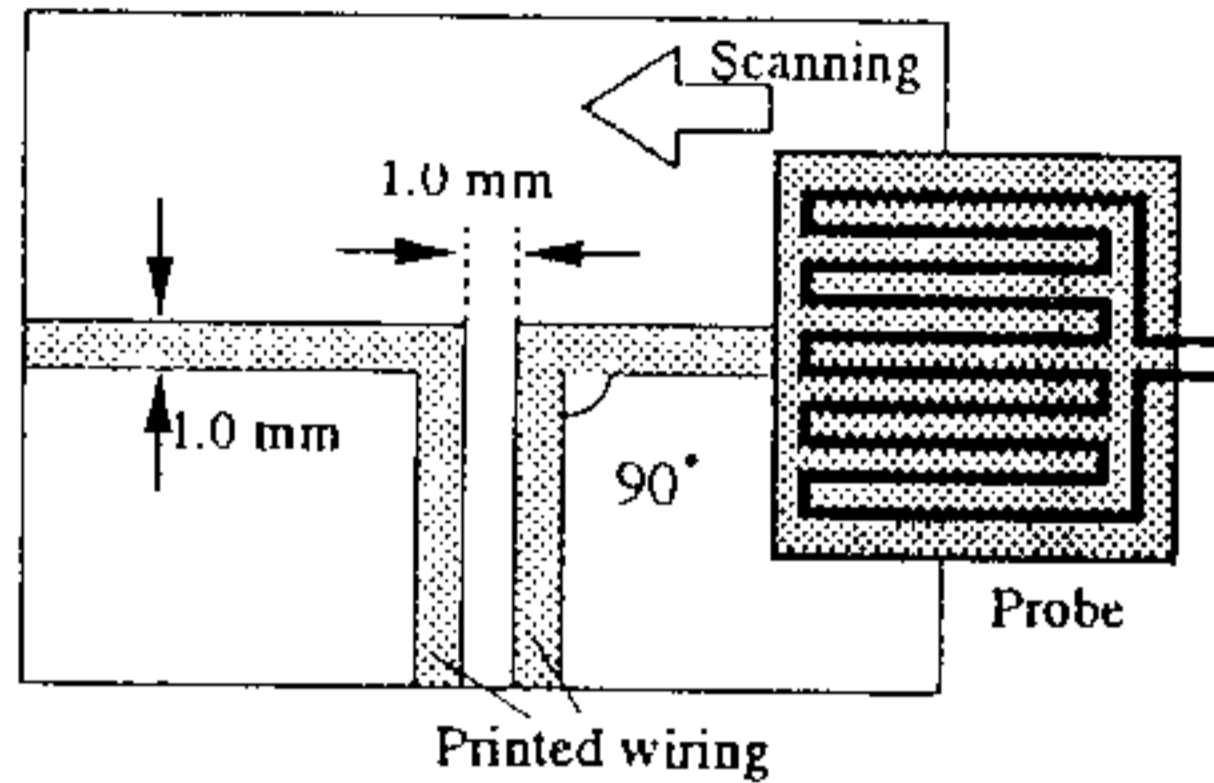


Fig.10 Back to back right angle traces.

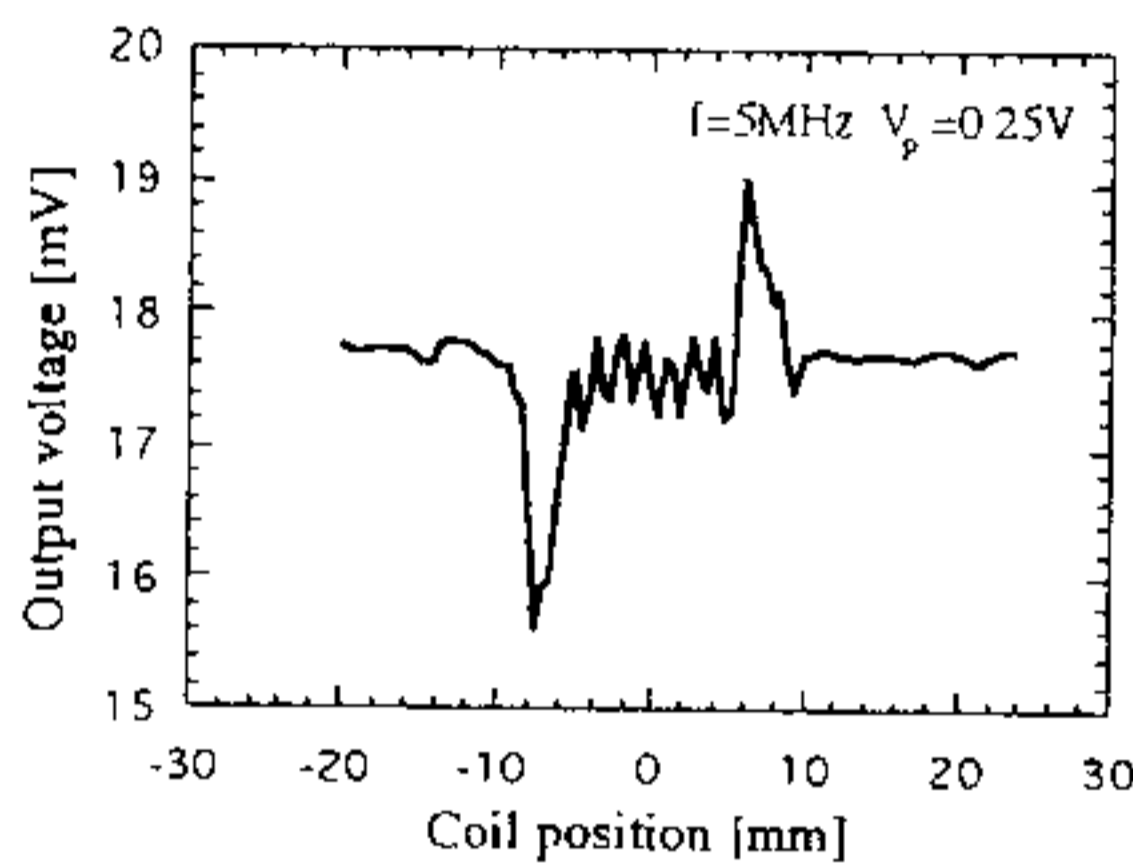


Fig.11 Output signal detected with the trace configuration shown in Fig.10.

D. ECT signals obtained from a printed circuit board having multiple traces and a single cut

Fig. 12 shows a printed circuit board with a number of traces and with the centre trace cut. The width of each trace is 1 mm and the separation between each trace is 0.5 mm. The probe is scanned along the length of the traces. The output signal from the mesh coil is shown in Fig. 13. The signal indicates the existence of a cut in the centre of the trace. With the added traces the the output signals differ from the the normal pattern as seen from Fig 13(b). The output voltage becomes irregular away from the crack therefore it is advisable to ignore signals obtained at some distance away from the cut. In order to check printed circuit boards with a high trace density it is necessary to decrease the mesh density.

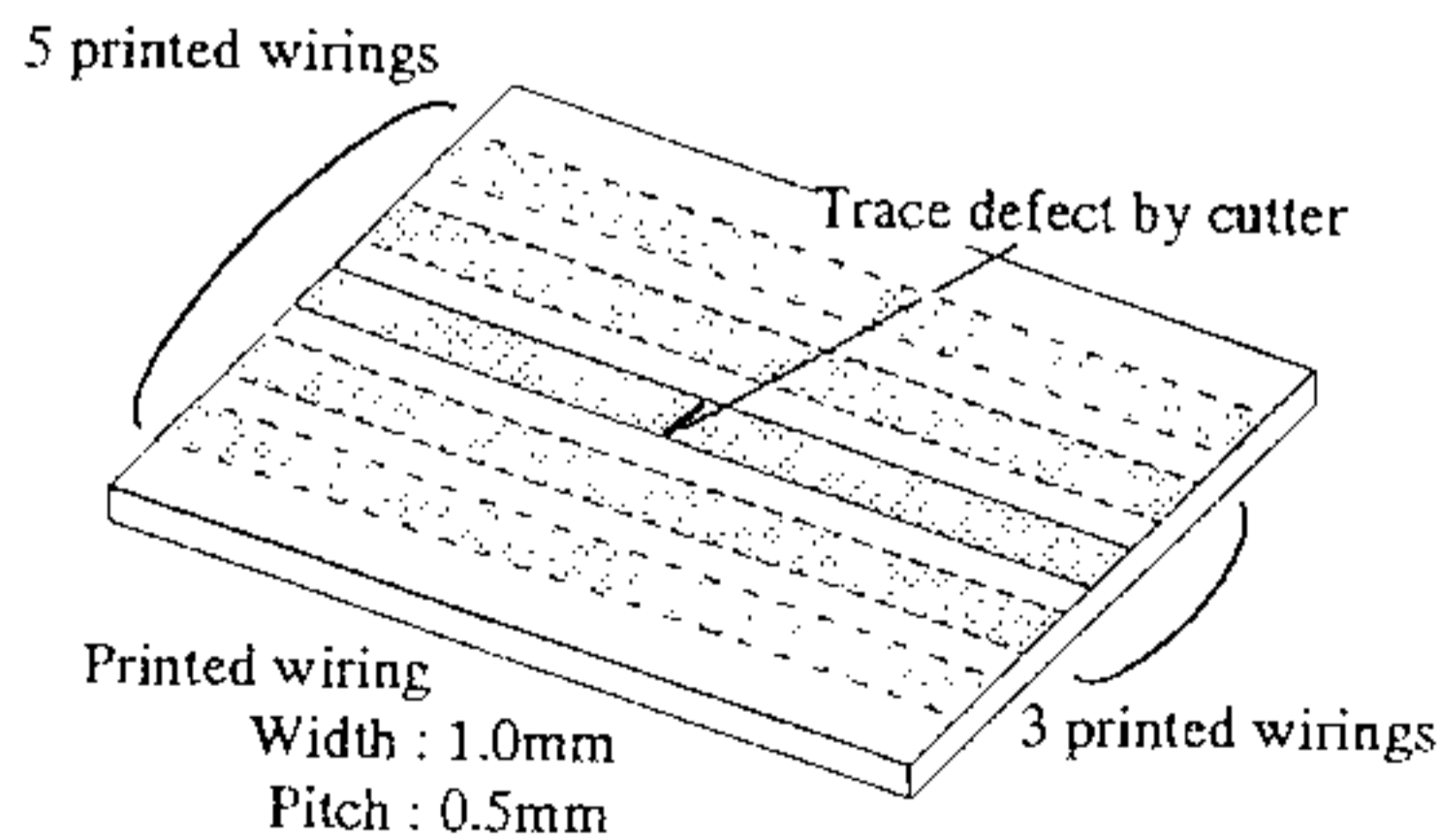
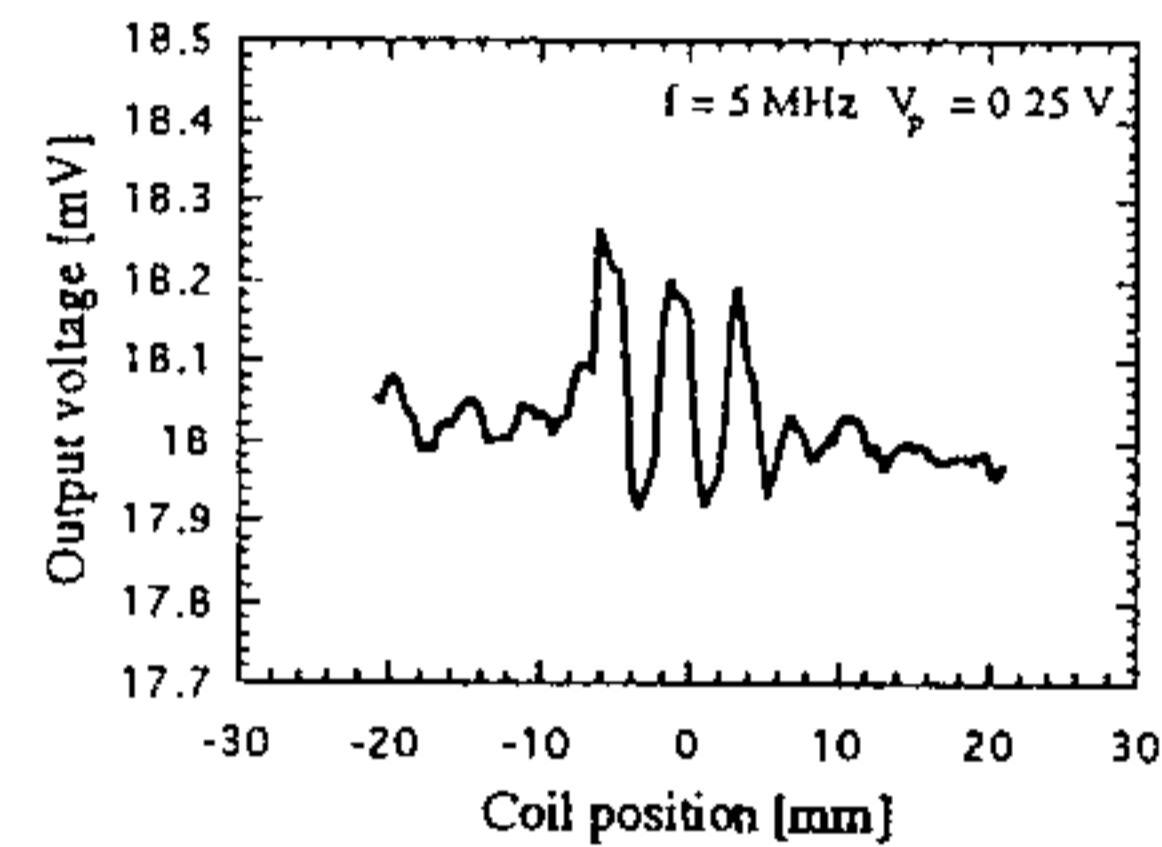


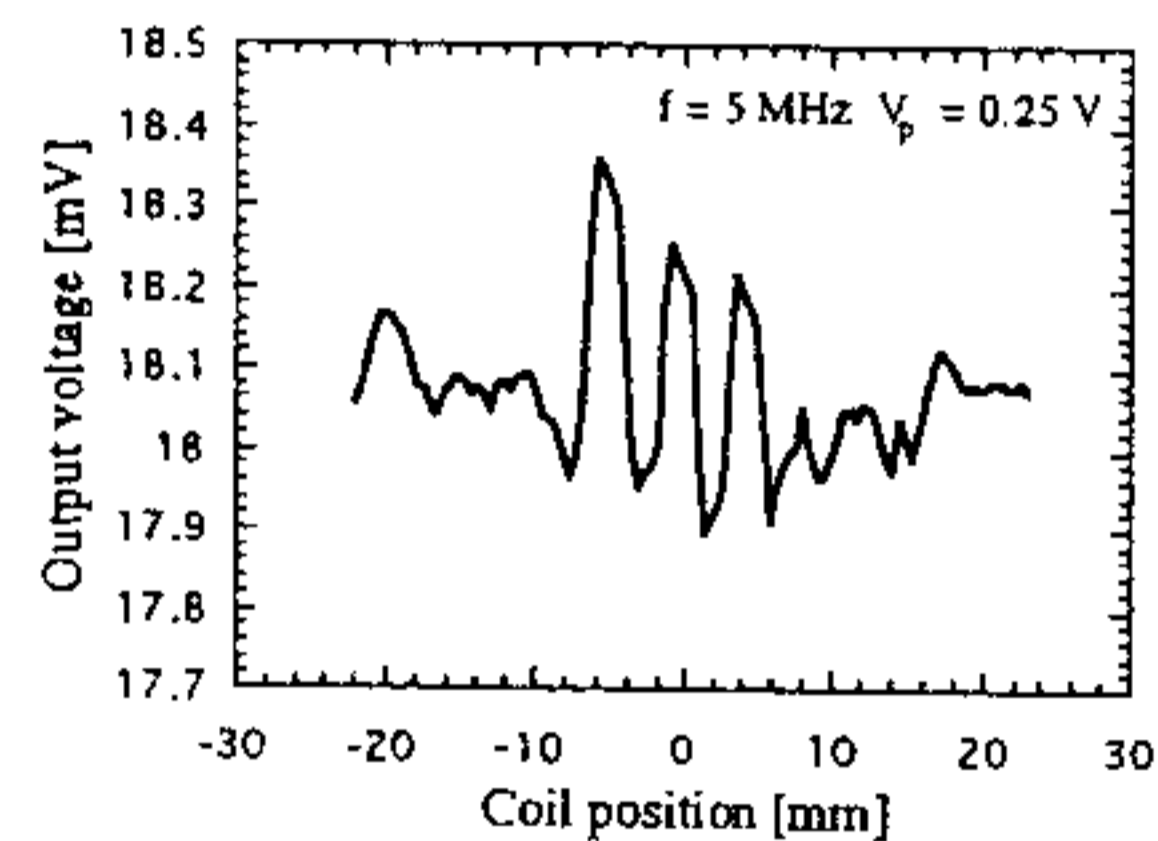
Fig.12 3 and 5 parallel traces with the central trace cut.

E. ECT inspection of printed circuit boards

The choice of ECT technique depends on the type of conducting material and the nature of the printed circuit board. By scanning a known good board one can employ a comparative testing approach to determine a defective board. The signals can be processed and the resultant resolution is sufficient. Printed circuit boards consist of traces with a small thickness and a narrow width. This type of geometry is ideally suited for use with a meander mesh probe sensor arrangement since the eddy current magnitude is very sensitive to the coils orientation. It is possible to fabricate a planar coil pattern which is tailored to suit each printed circuit board pattern.



(a) 3 printed wirings



(b) 5 printed wirings

Fig.13 Output signal detected with the trace configuration shown in Fig.12.

IV. CONCLUSION

The application of the ECT technique for printed circuit board inspection is a new approach. This technique may be useful for detecting defective traces on high density patterned printed circuit boards. The signals obtained from a high density patterned board have a complicated signal signature and are therefore difficult to interpret. This complexity can be avoided by comparing the signal signature of a known good board with a defective board. The difference signal gives a clear indication of a trace defect.

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