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ADAPTIVE EDDY CURRENT FLAW DETECTORS

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For reliable revealing of defects it is necessary to correct adjustment eddy current flaw detector at transition from one controllable object to another or change of conditions of the control. In existing flaw detectors there is an opportunity of creation of the appropriate library of adjustments. However conditions of the control and parameters of controllable object on its various sites can differ. The variant is possible, at which these parameters, for example, type of metal or thickness of a sheeting, beforehand are unknown. Application adaptive eddy current flaw detectors, varying the adjustment automatically in this case is expedient, depending on electromagnetic properties of metal, its thickness, thickness of a sheeting etc.

Two are considered new adaptive eddy current flaw detectors «ZOND AVD-96» and «GALS VD-103» below.

Flaw detector «GALS VD-103» is designed as a tester with parametrical superimposed eddy current probe. The device is intended only for revealing superficial cracks in any metal objects and works on the fixed frequency. It does not require manual installation of sensitivity of the control and offsetting the interfering factors like a change of a working backlash and eddy current probe axle skew relatively an controllable surface. Depending on a type of metal, identifying by the defect eddy current probe itself, mathematical processing parameters are modified. It supports establishing the necessary sensitivity and suppression of influence of interfering factors .

Work of «GALS VD-103» based on fundamental ideas of eddy current testing. When scanning on surface of object, we have complex signal from probe. Real and Imagine components of signal depends on some reasons, such as electrical conductivity, magnetic permittivity, distance between metal surface and probe etc. A small variation of properties makes small variations of signal. In easy case, interesting for us, there are variations of GAP (blue vector) and (red vector) (fig. 1).

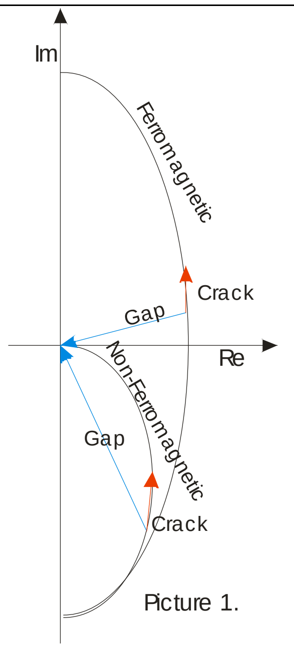

Fig. 1. Complex plane of eddy current probe

Fig. 2. Signals from surface cracks and variations of Gap (lift-off effect)

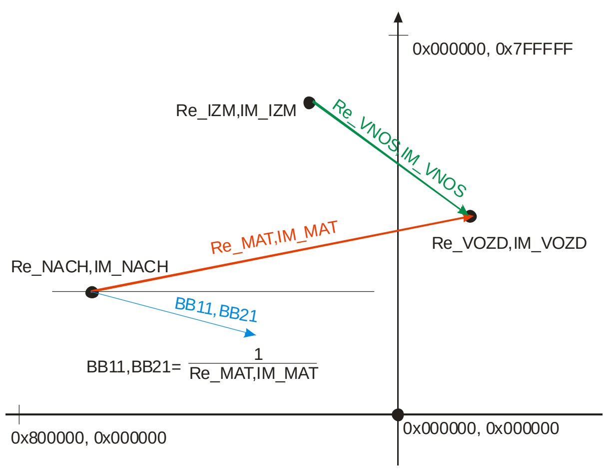

Fig. 3.

As we can see, both reasons (Gap and Crack) influence on both components (Real and Imagine). To separate the reasons we must rotate signal vector, so that signal from Gap was horizontally oriented (has only Real component), in such a manner Image component of signal – signal from Crack. (fig.2).

For a small depth of cracks (less than diameter of probe) Imagine part of signal approximately ratio to depth of crack.

Rotation of vector is simple mathematical operation – multiplying rotation matrix on vector.

Rotation matrix consist of trigonometrically functions (sinus and cosines) of ϕ – angle of rotation.

There is easy way to calculate components of rotation matrix. If we have vector A- difference signal between air and metal, we must calculate vector B=1/A. After that we multiply all new signals on vector B (equivalent multiplying on matrix). Signal from Gap automatically will be horizontal. More of that, this way allows make automatic gain change.

Another function for the fine tuning of components of rotation matrix –delta phi - allows change angle of rotation ϕ approximately ±7 degrees. It made by multiplying initial matrix on matix

1	Sin(delta)
-sin(delta)	1

Because delta angle is small (7°=0.125 rad), we use formula sin(f)=f. Using 1 instead cos(f) we make mistake less than 1% (1/128).

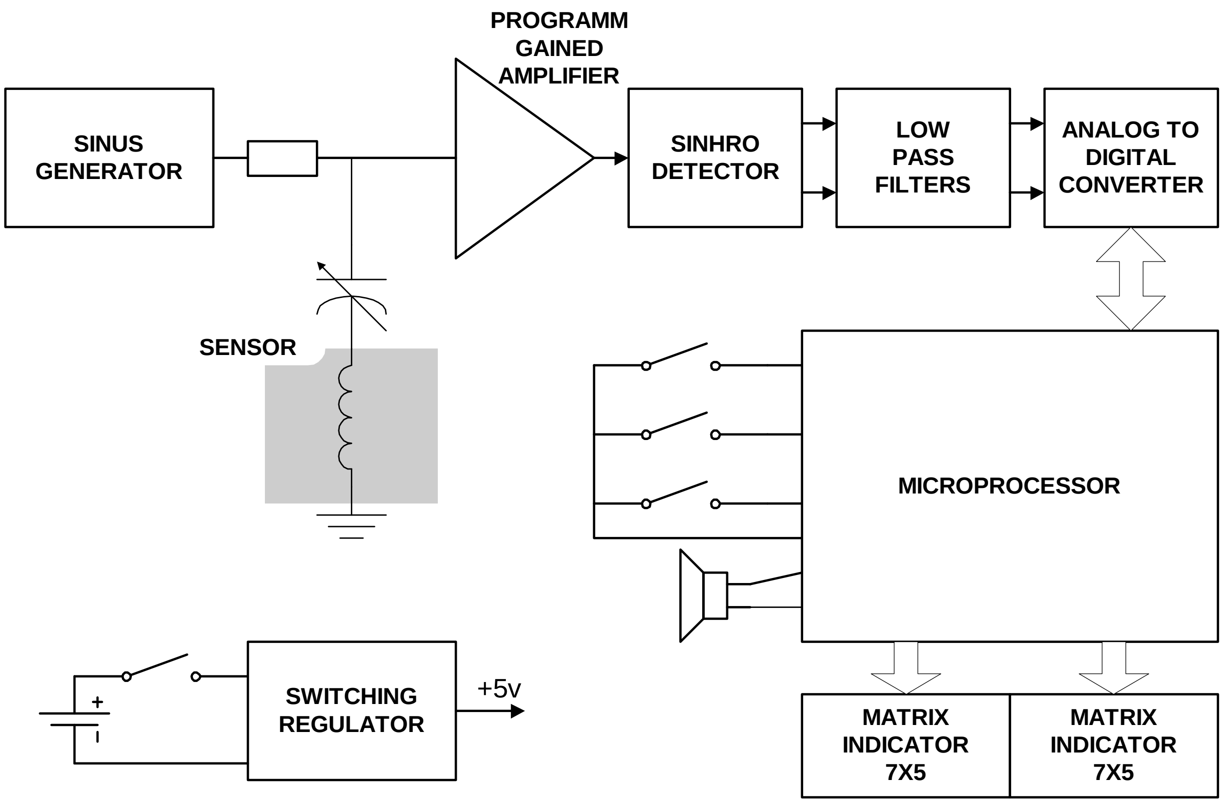

Fig. 4. Gals structural scheme.

Such, main calculating procedure:

Each time ADC sends to microprocessor 24-bit (3-byte) integer number. It stores in RE_IZM or IM_IZM address, depend on selected channel of ADC (CS0 , 12 pin of ADS, 11 pin of PIC).

Each Compensation procedure (push “Metal” key, or set REJIM,2 bit) – accumulates 256 signals RE_IZM and IM_IZM in RE_VOZD and IM_VOZD addresses conformably.

After first Compensation procedure RE_VOZD and IM_VOZD values loaded to RE_NACH and IM_NACH numbers. It is signals from probe on air.

Next Compensation procedures gives RE_VOZD and IM_VOSD – signal from probe on crackles metal, more of than difference signal on metal and signal on air is vector of metal properties.

RE_MAT=RE_VOZD-RE_NACH

IM_MAT=IM_VOSD-IM_NACH

If module of this vector quite big, we calculates inverted vector BB11, BB21 and after that rotation matrix AA.

The block diagram flaw detector «GALS VD-103» is given in a fig. 4. Due to the developed algorithm flaw detector provides effective отстройку from change of a working backlash (lift-off effect) and is automatically adjusted according to electromagnetic properties of metal of controllable object.

One of important for air engineering of tasks consists in detection of corrosion defeats in the plating glider. The similar defects successfully come to light eddy current flaw detector «ZOND VD-96» with eddy current by the converter such as UVTP. The given converter has a stimulating winding with the U-figurative core and measuring windings placed between end faces of the core. Optimum for revealing corrosion defeats the working frequency essentially depends on thickness of the plating, and sensitivity - from thickness of sheetings. It is illustrated a fig. 5. Dependences received on duraluminium plates of various thickness T (1 mm, 2 mm, 3 mm, 4 mm and 5 mm) with deaf apertures by a diameter of 5 mm and depth h=0,1T, 0,2T and 0,3T, located with the back party of plates here are given.

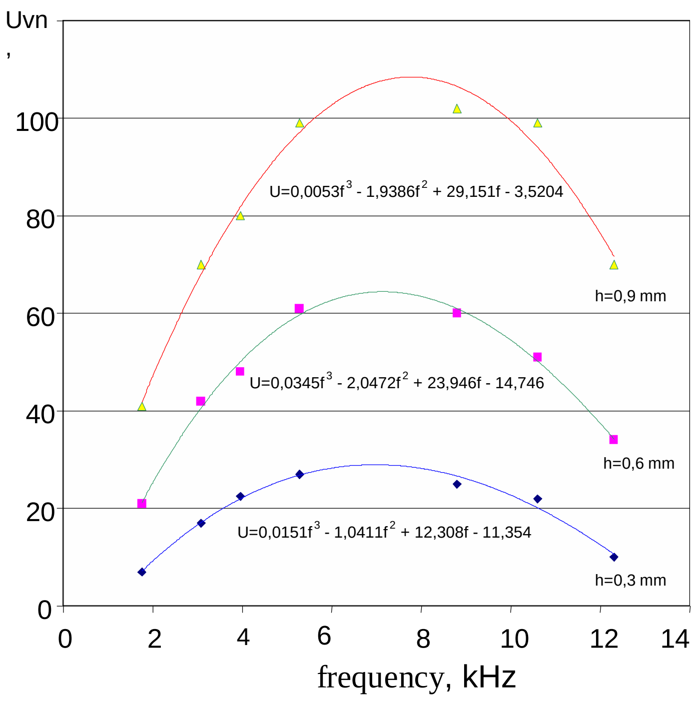

Fig. 5. Dependence U_{vn} from frequency *fa* T=3 mm, d=5 mm.

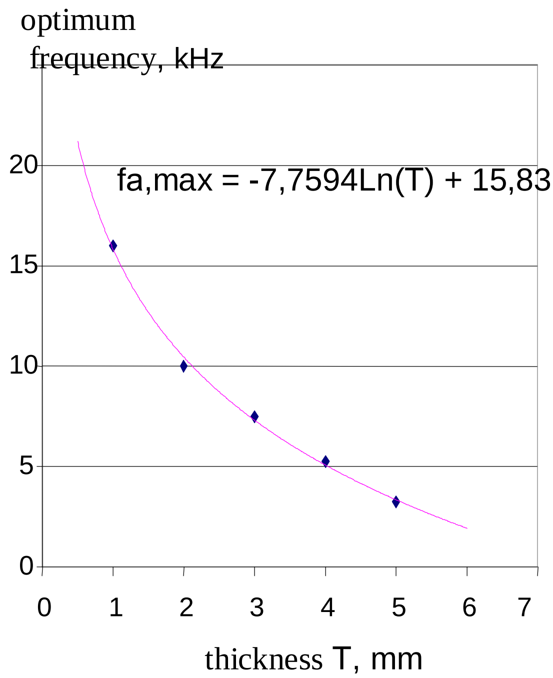

Fig. 6. Dependence of optimum frequency *fa,max* from thickness T.

With accuracy, acceptable to practice, the dependence of optimum frequency $f_{a,max}$ from thickness T can be submitted by expression

$$f_{a,max} = -7,76\, Ln(T) + 15,8 \quad (1)$$

The appropriate dependence is given in a fig. 6. At change of distance Z from eddy current of the converter up to a surface of metal the pressure brought in by defect, changes under the law close to an exhibitor. The appropriate dependences are given in a fig. 7, where To=T-h.

Thus, it is necessary to correct working frequency and sensitivity. At change of distance Z from eddy currentof the converter up to a surface of metal the pressure, brought in by defect, changes under the law close to an exhibitor. Thus, it is necessary to correct working frequency and sensitivity flaw detector depending on thickness T, backlash Z and depth of defect h.

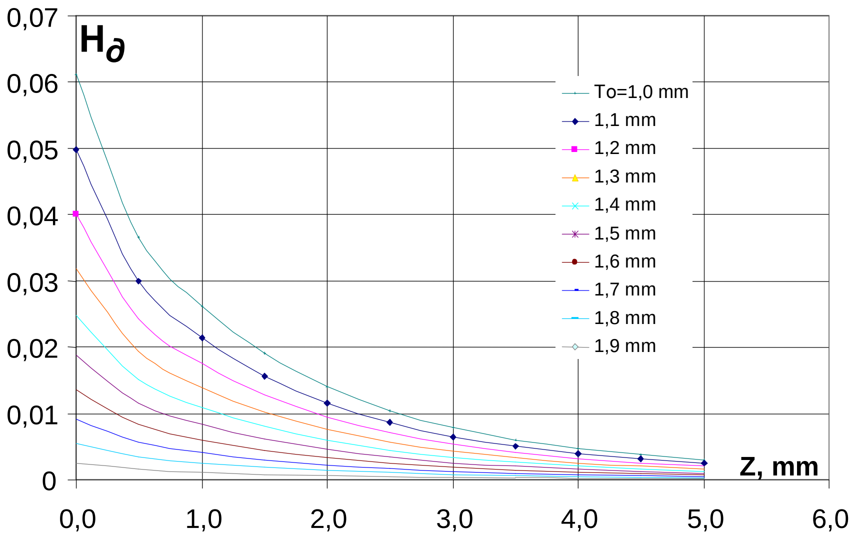

Fig. 7. Dependence $H_{\partial,max}$= $H_{\partial,max}(Z,T_0)$: *f=44 KHz, T=2 mm.*

On a basis analysis of researches «ZOND AVD-96» with modernized eddy current by the converter such as UVTP-M ensuring complete automation of process of measurements was developed adaptive eddy current flaw detector. The device has three channels: first - flaw detector, second - measurement of a backlash and third - measurement of thickness. The block diagram of the device is submitted in a fig. 8.

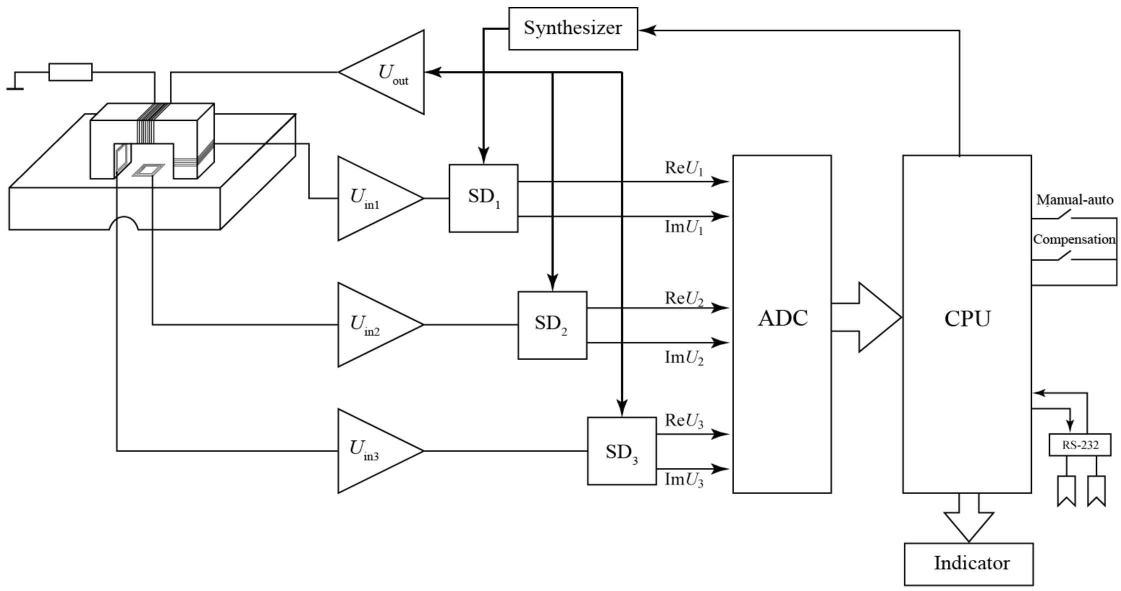

Fig. 8. The block diagram adaptive eddy current flaw detector «ZOND AVD-05»

Flaw detector contains modernized eddy current converter UVTP-M, generator, flaw detector channel, channel of measurement of a working backlash and channel of measurement of frequency, analog-digital converter, processor and indicator.

Each of measuring channels contains the synchronous detector SD, connected by an alarm input through the amplifier to the appropriate winding eddy current converter and basic input to an output of synthesization.

The modernized converter UVTP - M has two additional measuring windings. The measuring winding of the channel of measurement of a working backlash is placed on a lateral surface of the Π-figurative core, and channel of measurement of thickness - covers ferromagnetic core. The received information on size of a working backlash allows automatically to correct sensitivity on flaw detector to the channel and channel of measurement of thickness according to changes of a working backlash, for example, because of presence varnished of coverings or layer hermetic.

The choice of working frequency of the device is carried out by results of measurement of thickness according to the received expression (1).