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DEPARTMENT OF THE ENVIRONMENT – CANADA

Technical Memoranda

APPLICATION OF SYNCHRO TO SIN-COS RESOLVER IN COMPUTER RECORDING OF WIND DIRECTION FROM M.S.C. U2A ANEMOMETERS

by

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ENVIRONMENT CANADA - ATMOSPHERIC ENVIRONMENT SERVICE
4905 Dufferin Street
Downsview, Ontario

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ABSTRACT

Solid state SYNCHRO to SIN-COS RESOLVER is utilized to provide the interface between the M. S. C. U2A wind-vane-synchro and the computer analog-to-digital converter. The resolver accepts the five conductor synchro input and outputs two DC voltages (0-10V) proportional to the sine and cosine of the vane angle.

Based on the calibration tests of four SYNCHRO to SIN-COS RESOLVERS the maximum error between the actual vane angle and the angle calculated from the resolver outputs was found to be of the order of ±1 degree.

At present this method of digitization of wind direction is intended primarily for research applications, however, it also holds considerable promise to be used operationally at airports equipped with a digital computer.

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APPLICATION DU CONVERTISSEUR SELSYN À SINUS-COSINUS À L'ENREGISTREMENT PAR ORDINATEUR DE LA DIRECTION DU VENT À PARTIR DES ANÉMOMÈTRES M. S. C. U2A

par

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RÉSUMÉ

On utilise le CONVERTISSEUR transistorisé SELSYN à SINUS-COSINUS pour assurer la liaison entre le selsyn de la girouette du M.S.C. U2A et le convertisseur analogique-numérique. Le convertisseur selsyn à sinus-cosinus reçoit à l'entrée les signaux du selsyn sur cinq conducteurs et donne à la sortie deux tensions continues (de 0 à 10V) proportionnelles respectivement au sinus et au cosinus de l'angle de la girouette.

D'après les données fournies par les essais d'étalonnage de quatre CONVERTISSEURS SELSYN à SINUS-COSINUS, on a découvert que l'erreur maximale entre l'angle réel de la girouette et l'angle calculé à partir des tensions du convertisseur était de l'ordre de ±1 degré.

Actuellement, cette méthode de représentation en numérique de la direction du vent est destinée principalement à la recherche; toutefois, son avenir est très prometteur, car on prévoit des applications dans les aéroports dotés d'un ordinateur numérique.

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1. Introduction

This report describes a relatively simple method of sampling the wind direction from the M.S.C. U2A anemometers, using a computer. As explained elsewhere (Instrument Manual No. 50, 1969) the M.S.C. U2A wind direction sensor assembly comprises a precision positional motor (Muirhead 18M4J1, Synchro) controlled by the wind vane which in turn reacts to the ambient wind direction. The output from the synchro is in the form of three voltages varying sinusoidally from 0-90 volts and 120 degrees out-of-phase. This complex output is rather difficult to digitize without a special interface. In the operational U2A wind systems the output from the detecting synchro is connected to a receiving synchro which drives a pen mechanism of an analog recorder or is fitted with a pointer and housed in a remote dial indicator.

Recent emphasis on computer sampling and recording of meteorological variables, such as wind direction, at the major Canadian airports has resulted in a need for an interface which will transform the synchro output signals into a form acceptable to the computer input devices. Several techniques have been devised in the past. Most of them involved a mechanical shaft-to-shaft coupling between the receiving synchro and the interface device (such as a potentiometer or an optical encoder). These types of interfaces are relatively expensive - requiring the receiving synchro as well as the interface, and they are subject to errors due to shaft torque. Recently a new type of synchro-to-computer interface became available which is relatively inexpensive, does not require the receiving synchro, and has no moving parts. The application of this new device, (known as the SYNCHRO to SIN-COS RESOLVER), to wind direction sampling is described in the following pages.

2. Description of SYNCHRO to SIN-COS RESOLVER

The SYNCHRO to SIN-COS RESOLVER (Transmagnetics Model-665-60C-B) converts the five-wire synchro input (R1, R2, S1, S2, S3) to two DC outputs ($V\sin\Theta$, $V\cos\Theta$) proportionally to the sine and cosine of the vane angle. A typical application of the resolver to digital sampling of wind direction is shown in Figure 1.

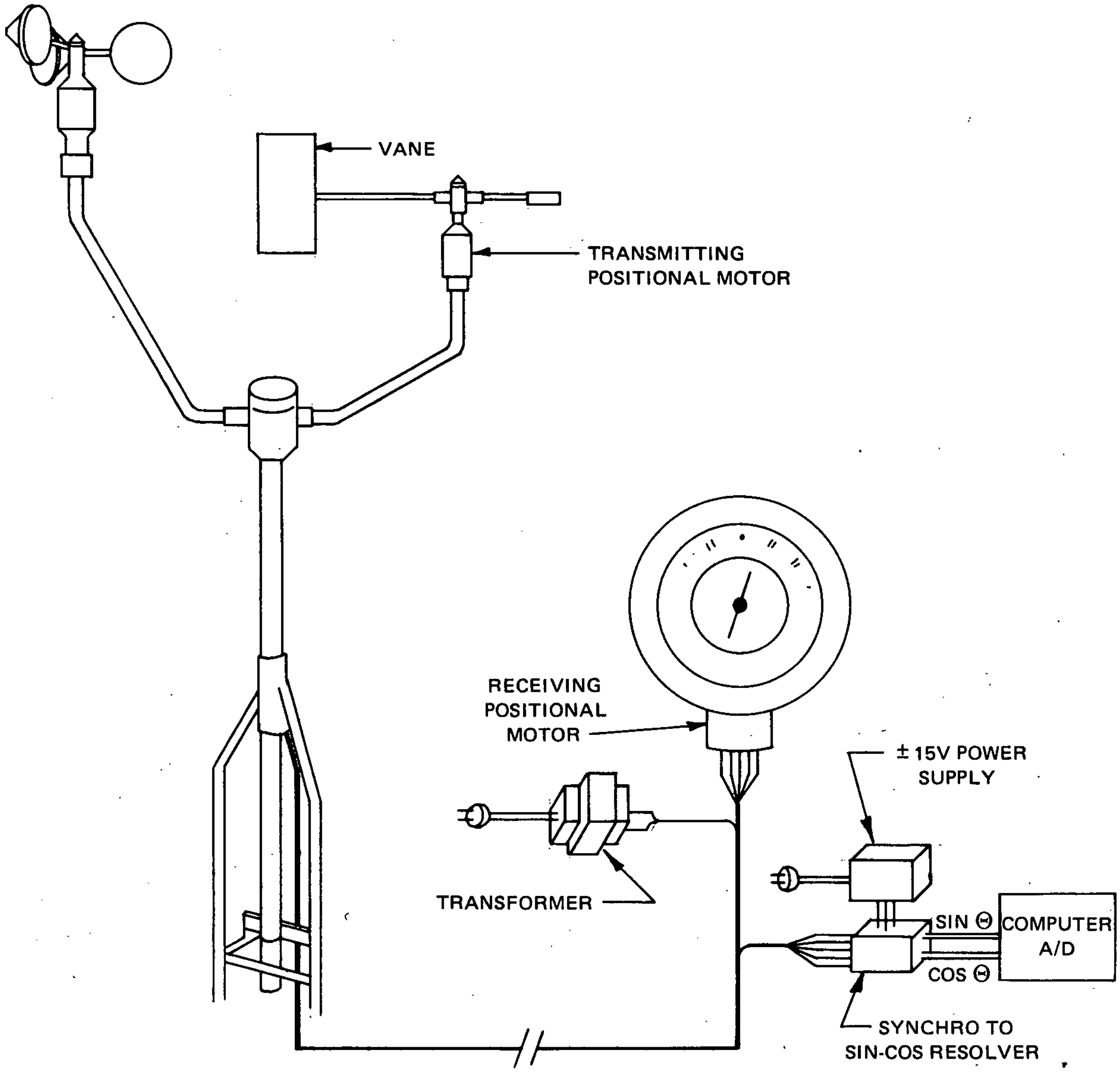

Figure 1.
A Typical Application of SYNCHRO to SIN-COS RESOLVER to Wind Direction Sampling

The output from the SYNCHRO to SIN-COS RESOLVER is in the form of sine and cosine signals varying from approximately 0 to 10 volts as shown in Figure 2. This output can be easily digitized at any desired rate to obtain instantaneous wind direction data.

2. Data Processing

For operational meteorological purposes, the wind direction is defined as the direction (in degrees) from which the wind is blowing with reference to true north (MANOBS, 1971). Therefore, operationally, the sine-cosine data need to be transformed into the angle the vane makes with respect to true north. This transformation is accomplished with the use of Equation 1.,

$$\Theta = \text{ARCTAN}\ \frac{V\sin\Theta - 5.0}{V\cos\Theta - 5.0} \qquad (1)$$

where Θ is the vane angle. The reason for subtracting 5 volts from each $V\sin\Theta$, $V\cos\Theta$ value is simply to shift the zero line to the origin.

Next, since the arctan function is not continuous, as shown in Figure 3, it is necessary to add to Θ, 180 degrees in quadrants 2 and 3 and 360 degrees in quadrant 4 to obtain continuous 0-359 degree readings.

A short computer program (Appendix 1) was written to transform the sine-cosine data into the angular form. This program was then used to process the calibration data obtained from four SYNCHRO to SIN-COS RESOLVERS as explained in the next section.

4. Calibration Tests

Four SYNCHRO to SIN-COS RESOLVERS were subjected to the calibration tests[1] to determine the accuracy with which the angular position of the vane could be recorded. The apparatus consisted of a complete U2A wind direction assembly, a precision rotary table, a SIN-COS RESOLVER, and a digital voltmeter.

As shown in Figure 4, the vane was effectively rotated using the rotary table, and readings of $V\sin\Theta$ and $V\cos\Theta$ were taken from the

[1]The calibartion tests were conducted by Mr. R.J. Grauman at the Calibration Laboratory of the Atmospheric Instruments Branch.

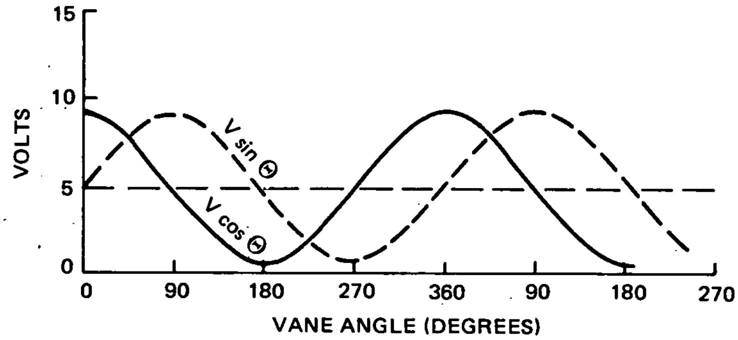

Figure 2.
Graphical Presentation of the SYNCHRO to SIN-COS RESOLVER Output

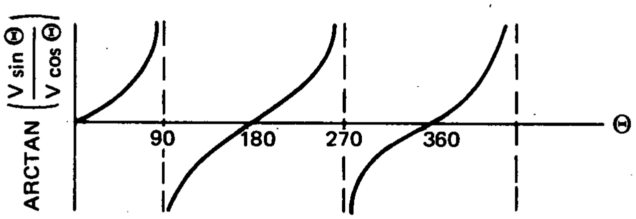

Figure 3.

Graph of Θ vs Arctan $\frac{V\sin\Theta}{V\cos\Theta}$

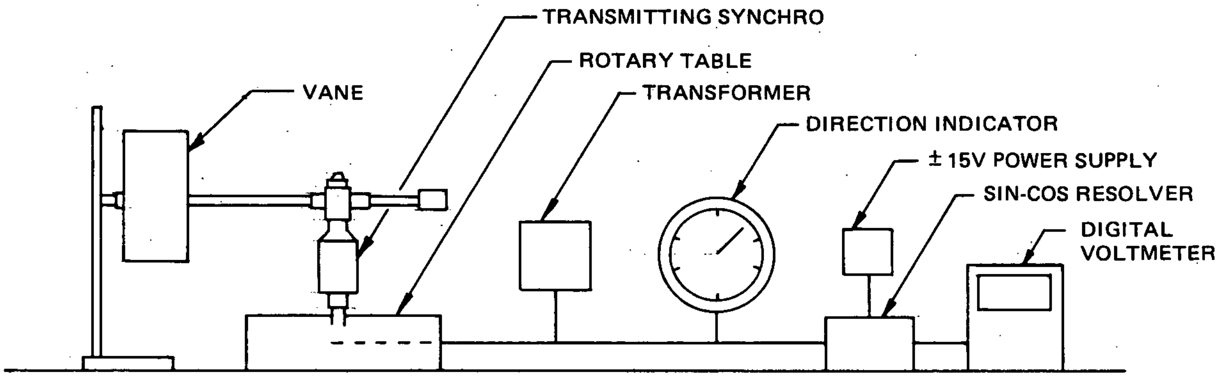

Figure 4.
Block Diagram Showing the Calibration Apparatus Setup

digital voltmeter at 20-degree intervals. The vernier on the rotary table was read with a precision of ±1 minute of arc and the digital voltmeter was read to four significant figures. Table 1 shows the calibration data for all four resolvers.

5. Conclusions

The calibration data presented in Table 1 show that by using the SYNCHRO to SIN-COS RESOLVER the angular position of the U2A vane can be recorded to an accuracy of ±1 degree.

The advantages of using SYNCHRO to SIN-COS resolvers in digital recording of wind direction from U2A anemometers are as follow:

1. Reasonably inexpensive (approx. $200.)

2. Continuous sinusoidal output (no discontinuity at 360 degrees)

3. Can be connected into any operational U2A anemometer circuit in addition to the existing indicators.

4. No moving parts i.e. does not require a receiving synchro with a shaft-to-shaft coupling.

5. The resolver outputs are suitable for generating orthogonal wind vector components which may be integrated over a fixed time or wind run period to provide the along- and cross-runway components of the surface wind.

Acknowledgements

The writer wishes to express his sincere appreciation to Mr. E.G. Morrissey for his guidance and support and for reviewing the report. He also wishes to thank Mr. R.J. Grauman for performing the calibration tests.

APPROVED,

J.R.H. Noble,
Assistant Deputy Minister,
Atmospheric Environment Service.

TABLE 1.

Calibration Data for SYNCHRO to SIN-COS Resolvers

Direction from rotary table (deg. ±1' of arc)	Resolver Output: Vsin θ (Volts)	Resolver Output: Vcos θ (Volts)	Direction given by Eg. 1 (deg.)	Error (deg.)
		Resolver 1		
0	4.123	9.475	359.2	-.8
20	5.706	9.502	19.2	-.8
40	7.206	8.992	39.2	-.8
60	8.443	7.991	59.3	-.7
80	9.256	6.609	79.5	-.5
100	9.544	5.000	100.3	+.3
120	9.267	3.415	120.6	+.6
140	8.471	2.040	140.7	+.7
160	7.255	1.034	160.6	+.6
180	5.784	0.513	180.3	+.3
200	4.204	0.518	200.3	+.3
220	2.720	1.058	220.3	+.3
240	1.523	2.078	240.3	+.3
260	0.727	3.468	260.5	+.5
280	0.461	5.030	280.6	+.6
300	0.734	6.579	300.6	+.6
320	1.504	7.929	320.2	+.2
340	2.669	8.921	339.5	-.5
		Resolver 2		
0	4.194	9.533	0.2	+.2
20	5.781	9.533	20.0	0
40	7.276	8.997	39.9	-.1
60	8.496	7.971	59.9	-.1
80	9.293	6.575	80.1	+.1
100	9.566	5.003	100.2	+.2
120	9.297	3.442	120.2	+.2
140	8.527	2.076	139.9	-.1
160	7.356	1.070	159.3	-.7
180	5.894	0.509	179.0	-1.0
200	4.305	0.477	199.0	-1.0
220	2.795	0.985	219.0	-1.0
240	1.548	1.990	239.2	-.8
260	0.721	3.380	259.5	-.5
280	0.426	4.997	280.2	+.2
300	0.701	6.595	300.6	+.6
320	1.497	7.985	320.7	+.7
340	2.719	9.005	340.6	+.6

TABLE 1. (Cont'd)

Direction from rotary table (deg. ±1' of arc)	Resolver Output Vsin Θ (Volts)	Resolver Output Vcos Θ (Volts)	Direction given by Eg. 1 (deg.)	Error (deg.)
		Resolver 3		
0	4.198	9.515	0.2	+.2
20	5.783	9.516	20.1	+.1
40	7.272	8.981	40.0	0
60	8.484	7.959	59.9	-.1
80	9.278	6.566	80.1	+.1
100	9.549	4.998	100.3	+.3
120	9.283	3.439	120.3	+.3
140	8.518	2.080	139.9	-.1
160	7.353	1.077	159.3	-.7
180	5.893	0.515	179.0	-1.0
200	4.311	0.483	198.9	-1.1
220	2.808	0.989	218.9	-1.1
240	1.564	1.993	239.0	-1.0
260	0.744	3.377	259.4	-.6
280	0.448	4.993	280.2	+.6
300	0.720	6.586	300.6	+.6
320	1.513	7.972	320.7	+.7
340	2.730	8.989	340.6	+.6
		Resolver 4		
0	4.243	9.532	0.8	+.8
20	5.830	9.518	20.7	+.7
40	7.320	8.964	40.6	+.6
60	8.530	7.933	60.5	+.5
80	9.314	6.532	80.7	+.7
100	9.572	4.956	100.8	+.8
120	9.289	3.398	120.7	+.7
140	8.506	2.044	140.4	+.4
160	7.327	1.051	159.7	-.3
180	5.857	0.507	179.5	-.5
200	4.269	0.486	199.5	-.5
220	2.761	1.011	219.6	-.4
240	1.525	2.027	239.7	-.3
260	0.707	3.430	260.2	+.2
280	0.430	5.039	280.7	+.7
300	0.724	6.631	301.1	+1.1
320	1.531	8.008	321.2	+1.2
340	2.763	9.020	341.2	+1.2

References

1. Instrument Manual No. 50, 1969: Wind Measuring Equipment, Type U2A. Department of Transport, Meteorological Branch, Toronto, Canada, 82 p.

2. MANOBS, 1971: Manual of Standard Procedures for Surface Weather Observing and Reporting. Sixth Edition, Environment Canada, Toronto, 63-67.

APPENDIX 1.

Computer Program to Calculate the Wind Vane Angle Using the Data from SYNCHRO to SIN-COS RESOLVER

```
      DIMENSION S(50), C(50)
      N=19
      CALL IFILE(20,'DAT1')
      READ(20,4) (C(I), S(I), I=1, N)
4     FORMAT(2G)
      DO 20 I=1, N
      TS=S(I) - 5.0
      TC=C(I) - 5.0
      ANGT=ATAN(TS/TC)
      ANGT=(ANGT*180.0)/3.14159
      IF (TS.LT.O.. AND.TC.GE.O.) ANGT=ANGT+360.
      IF (TS.LE.O.. AND.TC.LT.O.) ANGT=ANGT+180.
      IF (TS.GT.O.. AND.TC.LT.O.) ANGT=ANGT+180.
      ANGT=ANGT+10.25
      IF (ANGT.GT.360.) ANGT=ANGT - 360.
      WRITE(21,10)I, S(I), C(I), TS, TC, ANGT
20    CONTINUE
10    FORMAT(1X, 13,' S- C=',2F9.3,' TS- TC=', 2F8.4,' A=', F7.2)
      STOP
      END
```

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4 pps. 4 figs. 1 table 2 refs.

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