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A SOLID STATE COELOSTAT DRIVE SYSTEM FOR A TELESCOPE

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Abstract

This paper describes the design and fabrication of an all solid state drive system for 3- phase AC synchronous motors commonly used in telescopes. The novel feature of this drive system includes a digital approach to sine wave synthesis and a digitally programmable frequency setting. The amplitude stability is derived from a stable temperature compensated reference source and the frequency stability is obtained from a crystal source. A report of the system performance when used with the Solar Tunnel Telescope at Kodaikanal is also included.

1. Introduction

Three phase AC synchronous motors are commonly used in telescope drive systems.The speed of such motors is directly proportional to the frequency of the input supply. To achieve good tracking performance, it is important to maintain good stability of the frequency of the input AC voltage. This paper reports the implementation of an all solid state drive system for a three phase AC synchronous motor.

2. Principle of operation

The three phase sinusoidal waveform is obtained through the data stored in three EPROMs (Erasable Programmable Read Only Memory) driven by a programmable period generator. The digitally obtained sinusoidal output signal is amplified by solid state power amplifier. The power amplifier outputs are coupled to the three phase synchronous motor through suitable coupling network.

3. Description of the circuit

The major building blocks of the system include:

a. Programmable period generator
b. Three phase waveform generator
c. Power amplifier and coupling circuit

A brief description of the various sub-units follows:

3.a Programmable period generator

A block diagram of the programmable period generator is shown in Fig.1. The 10 MHZ clock advances a cascade of five decade counters (7490). The least significant setting is 0.1 micro sec. When the thumbwheel switch setting matches with that of the counter output, 'coincidence gate' (7486+invertor) output goes 'high'. For example, if the thumbwheel switch setting is set to 19,856 the coincidence gate output goes 'high' after an elapsed period of 1985.6 micro second. The coincidence gate output forms the programmable period pulses and also resets the decade counters, so that counting for the next period starts with zero reference time.

3.b Three phase waveform generator

A block diagram of the three phase waveform generator is shown in Fig.2. Since a cycle of the sine wave is generated in 64 steps, we need a 6 bit address counter, which can count cyclically from 0 to 63. The address counter simultaneously addresses the three EPROMs storing the digital data for the three phase waveform. Table.1 lists the hexadecimal values stored in the three EPROMs. The data bytes in the EPROMs are fed to the corresponding digital to analog converters (DAC). Since the DAC (NE 5009) gives an unipolar current output, a current to voltage converter with an offset voltage arrangement is employed to obtain an alternating voltage. The DAC is fed from an external reference voltage obtained from a 723 voltage regulator integrated circuit. A temperature compensated precision reference ensures stable amplitude of the output AC signal. Since the same reference is used in the offset circuit, the zero average value of the output is maintained stable. The output from the DAC is passed through an active low-pass filter to give a smooth sinusoidal wave.

3.c Power amplifier and coupling circuit

Power amplifiers (Type EM-1812-00B, manufactured by M/S Inland Motor) are used to boost the power from the signal level provided by the three phase waveform generator. These power amplifiers can be utilised as voltage or current amplifiers by appropriate terminal selection and their gain can be programmed by using external resistors. In our circuit the power amplifiers are configured for voltage mode operation with a gain of 20V/V. A current limit resistor senses and clamps the load current to 15A. The current drawn by the motor depends on the load and hence the power gain varies depending on the load. The power amplifiers operate from a single 24 V, 20 ampere power supply. Since the voltage at the power amplifier outputs are limited to the power

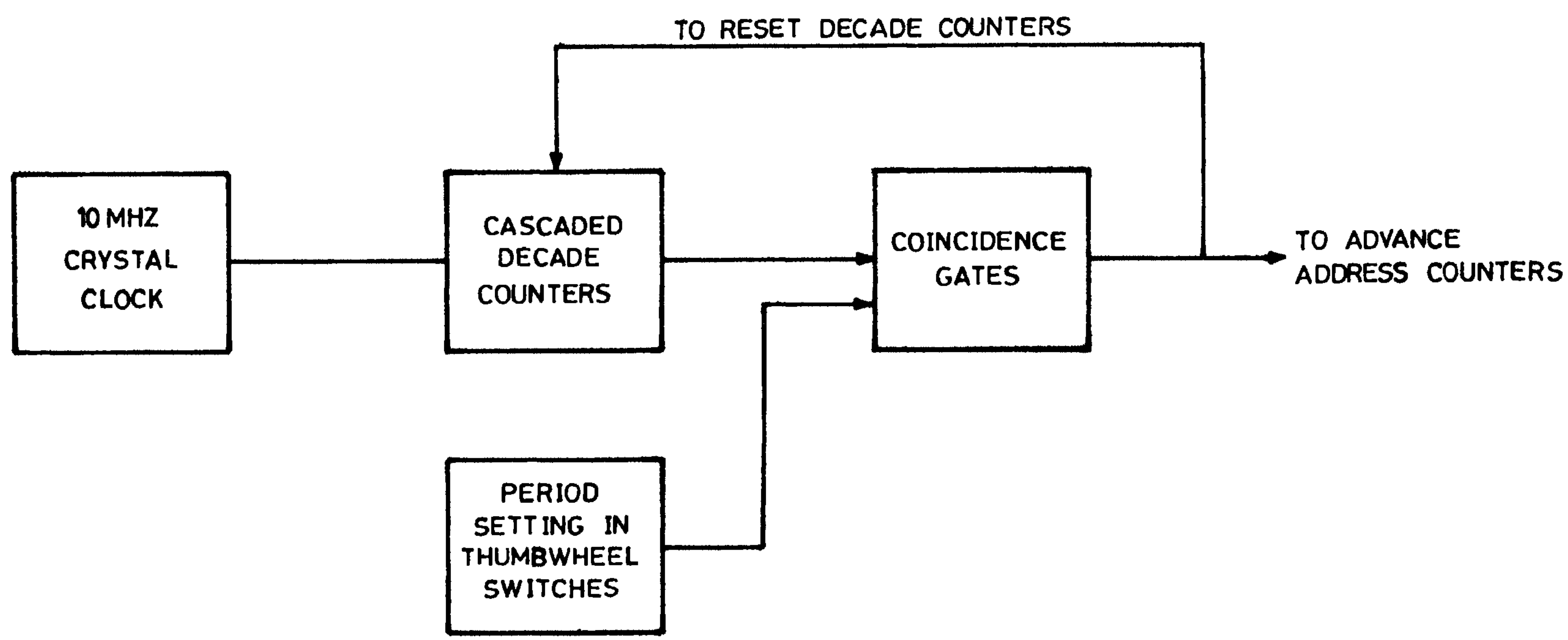

Fig. 1

BLOCK DIAGRAM OF THE PROGRAMABLE PERIOD GENERATOR

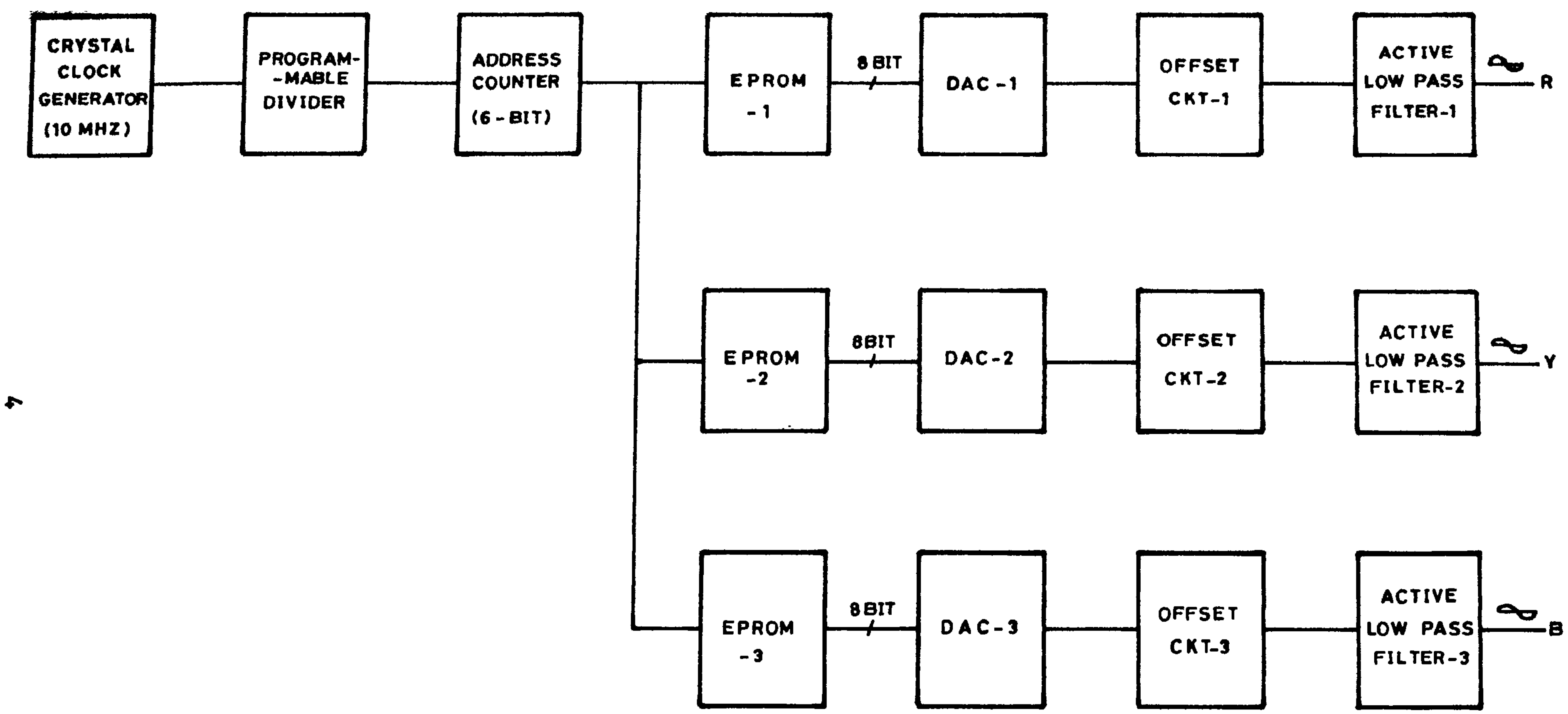

Fig. 2 BLOCK DIAGRAM OF THE 3 PHASE SINE-WAVE GENERATOR

PHASE - I			
0	80	33	73
1	8C	34	67
2	99	35	5A
3	A5	36	56
4	B1	37	43
5	BD	38	38
6	C7	39	2E
7	D1	40	25
8	DA	41	1D
9	E0	42	13
10	EA	43	0E
11	F0	44	0A
12	F5	45	05
13	FA	46	02
14	FD	47	01
15	FE	48	00
16	FF	49	01
17	FE	50	02
18	FD	51	05
19	FA	52	07
20	F5	53	0E
21	F0	54	13
22	EA	55	1D
23	E0	56	25
24	DA	57	2E
25	D1	58	38
26	C7	59	43
27	BD	60	56
28	B1	61	5A
29	A5	62	67
30	99	63	73
31	8C		
32	80		

PHASE - II			
0	11	33	F4
1	0B	34	F8
2	07	35	FB
3	03	36	FE
4	01	37	FF
5	00	38	FE
6	00	39	FD
7	02	40	FB
8	04	41	F7
9	08	42	F2
10	0D	43	EC
11	16	44	E5
12	1A	45	DD
13	23	46	D4
14	2C	47	CA
15	35	48	C0
16	40	49	B5
17	4A	50	AA
18	57	51	9D
19	63	52	91
20	6E	53	84
21	7C	54	78
22	88	55	6B
23	95	56	5E
24	A1	57	53
25	AE	58	47
26	B8	59	3C
27	C3	60	32
28	CD	61	29
29	D7	62	20
30	DF	63	18
31	E7		
32	EE		

PHASE - III			
0	EE	33	18
1	E7	34	20
2	DF	35	29
3	D7	36	32
4	CD	37	3C
5	C3	38	47
6	B8	39	53
7	AE	40	5E
8	A1	41	6B
9	95	42	78
10	88	43	84
11	7B	44	91
12	6E	45	9D
13	63	46	AA
14	57	47	B5
15	4A	48	C0
16	40	49	CA
17	35	50	D4
18	2C	51	DD
19	23	52	E5
20	1A	53	EC
21	16	54	F2
22	0D	55	F7
23	08	56	FB
24	04	57	FD
25	02	58	FF
26	00	59	FF
27	00	60	FE
28	01	61	FB
29	03	62	F8
30	07	63	F4
31	0B		
32	11		

Table. 1

HEXA DECIMAL VALUES STORED IN EPROMS

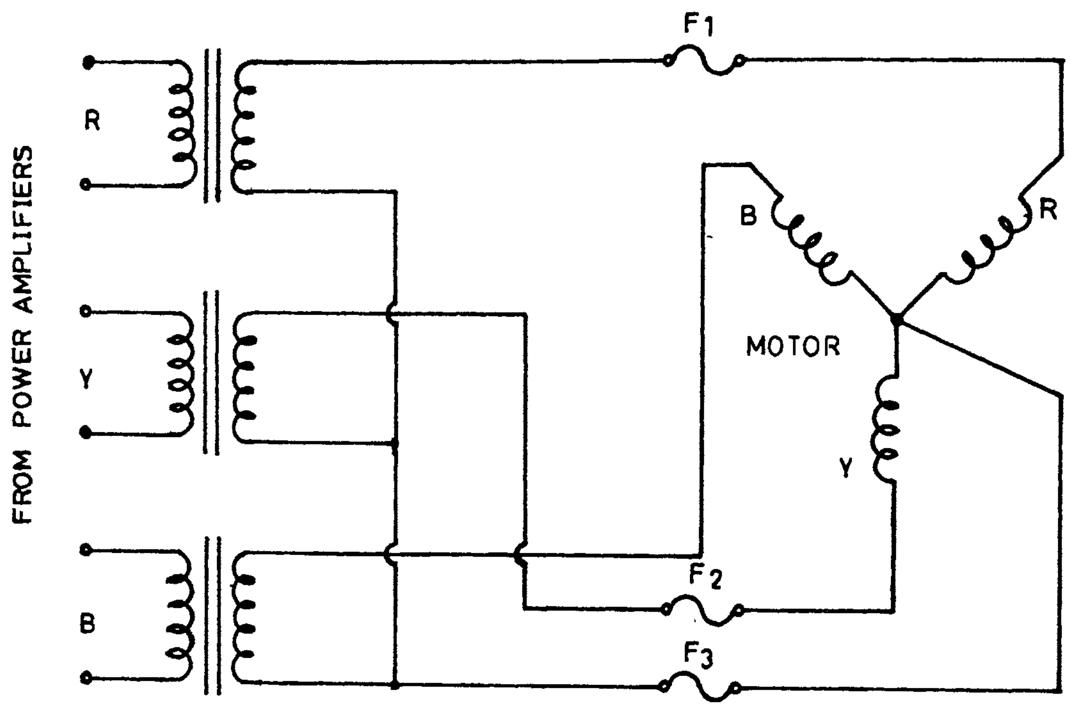

Fig. 3 OUTPUT COUPLING ARRANGEMENT

TABLE-2

Date	Starting time of observation (IST) H M	Duration of observation in min	T.W. setting for no drift in E-W for 10 min	Frequency Reading (HZ)
1988 Dec 21	10 00	20	307	47.16
	10 45	15	305	47.19
	11 20	15	304	47.20
	11 40	10	304	47.20
	12 20	10	302	47.23
	13 05	10	303	47.21
	16 00	10	302	47.23
1988 Dec 22	08 15	10	312	47.12
	08 30	10	311	47.13
	09 20	20	307	47.16
	10 00	16	305	47.20
	10 30	15	305	47.19
	10 45	30	305	47.19
	12 20	15	302	47.23
	14 20	15	302	47.23
	15 00	30	305	47.19
	15 30	35	305	47.19
	16 05	25	303	47.21
1988 Dec 23	07 30	20	316	47.06

Cont'd

	08 20	10	311	47.13
	08 50	10	310	47.14
	09 25	15	307	47.16
	09 40	60	306	47.18
	11 10	40	305	47.19
	12 10	20	302	47.23
	14 40	15	302	47.23
	14 55	15	304	47.20
	15 10	15	305	47.19
1988 Dec 24	08 15	10	308	47.16
	09 10	10	306	47.18
	10 40	20	305	47.19
	11 00	30	305	47.19
	11 30	30	305	47.19
	12 00	30	303	47.22
	12 30	15	302	47.23
	14 20	15	303	47.22
1988 Dec 25	09 45	30	305	47.18
	11 00	30	305	47.19
	11 30	20	304	47.20
1989 Jan 24	11 14	10	305	47.15
	11 30	20	305	47.15
	11 55	10	305	47.15
1989 Feb 06	08 10	60	306	47.10
	10 30	60	305	47.11
	11 50	10	304	47.13

supply value, an output coupling circuit is necessary to bring the voltage to the levels required by the motor (200V rms). The coupling circuit arrangement is shown in Fig.3 and utilises a step-up transformer of 12:230. The three phases are so mixed to give a phase difference of 120 degree between the successive phases.

4. Performance of the unit

This unit has been installed to drive the first stage motor of the coelostat system at our Tunnel Telescope at Kodaikanal, and is operational since Dec 20, 1988. The monitoring of the solar image was carried out for five days during different times of the day. The results of the monitoring are given in Table.2. The frequency was adjusted during the day, so that the solar image remains steady in the E-W direction for more than 10 min. The value of T W setting in colum 4 of Table.2 indicates that same frequency is required during the same part of the day to keep the image steady in E-W direction. For example, setting of 305 is needed at about 10h (IST) to keep the solar image steady in E-W direction. This value repeats on all the days of observations. While monitoring the solar image, the second mirror was not adjusted and the image was allowed to drift in the N-S direction, due to change in the dec of the Sun with time. This N-S drift is offset by a guiding system, which adjusts the second mirror, to keep the image steady in that direction.

Acknowledgement

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