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Sonic Buoy - Buoy Heading Sensor handbook

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ABSTRACT

The Buoy Heading Sensor was designed to provide a continuous measure of the orientation of the Sonic Buoy; this was required for referring the sonic and provane anemometer data to magnetic North.

This document describes in detail the design of the Buoy Heading Sensor; it is intended to serve the combined purposes of documenting the design and acting as a guide to operating and testing the sensor.

KEYWORDS

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SONIC BUOY COMPASS

1. Introduction

The compass unit is required to give a buoy heading reference for the ultrasonic and mechanical anemometers. The ultrasonic anemometer requires an analogue signal for input to its analogue input #1; the Multimet meteorological logging system, used to log the Young AQ anemometer, requires a digital heading reference input so that the standard software can be used, to give correct averaging of the wind direction.

2. Functional Description

The unit incorporates a Digicourse Model 225 digital 8 bit magnetic compass, with gray code output. This device has internal gimballing and the housing is, therefore, "strapped-down" to the buoy hull.

The electronics added by IOSDL performs the following functions:

a) strobes the compass LED source at intervals of, nominally, 1 second, sampling the heading at this rate

b) latches the (buffered) photo transistor outputs (gray code)

c) opto-isolates the latched gray code for use by the Multimet system

d) decodes the latched gray code to binary code and

e) converts the binary code (range 0 to 255) to an equivalent analogue output signal in the range +2.048V to +4.088V, for connection to the Sonic anemometer analogue input #1.

These functions are implemented by 3 circuit cards, connected by flexible strip wiring.

3. Hardware

3.1 General

The compass is mounted in a 100 mm diameter tube with end cap containing 3 Lemo connectors. The compass system is powered by a +12V supply, with the exception of the opto-isolator outputs, which are powered by the Multimet +5V supply

3.2 Circuit Descriptions

3.2.1 COMP1 Board

This board includes the LED drive circuit, the photo transistor buffers and latches. The sampling frequency (1 Hz) TRIGGER signal, from board COMP3, triggers a D-type flip-flop (part of IC2) which is connected to produce a 4.2 mS output pulse. This pulse drives the LED via the FET TR1 with a nominal current of 25 mA.

The other half of IC2 is used to generate a 3.8 mS pulse, whose complement is differentiated and inverted to give an ~ 10uS clock for the latches IC4 and IC5, occurring 0.4 mS before the end of the LED drive pulse.

The inverted LED drive pulse is differentiated and inverted to give an ~ 10uS WR/ signal (normally high). This is used to load the digital to analogue converter on COMP3 about 0.4 mS after the data have been latched into IC4 and 5.

A 220 μF capacitor, C8, trickle charged via R6, is used to supply the LED current pulse, smoothing the average consumption of the system. The charge taken from C8 during the LED pulse amounts to 105 μcoulombs, resulting in a droop of about 0.5V

Part of IC1 and all of IC3 (Schmitt trigger input inverting buffers) are used to buffer the photo transistor outputs. The buffered 8 bit gray code is then latched into IC4 and IC5 as described above.

3.2.2 COMP2 Board

This board includes an 8 bit Gray code to binary converter and opto-isolators for the 8 bit parallel binary output used by Multimet. The circuit is straightforward, using exclusive-OR gates to perform the gray to binary decoding. The opto-isolator inputs are driven at approximately 2 mA and have a Schmitt trigger output circuit supplied by the Multimet +5V supply (PLUSb and GRNDb).

3.2.3 COMP3 Board

This board includes an RC oscillator/divider, IC16, with selectable output frequency in the range 1 to 128 Hz (1 Hz is used in this application) and a digital to analogue converter circuit. The latter uses a 12 bit AD7545 converter, together with a REF-02 voltage reference and two 308 operational amplifiers for current to voltage conversion and level shifting. The D-A analogue ground is held at the +5V reference, whilst the D-A Vref is connected to 0V. The non-inverting input to IC19 is held at the +5V reference voltage, so that its output ranges from +5V to +9.98V over the full digital range of 0 to 4080 (16*255 since the 8 bit input is applied to the 8 most significant bits). IC20 is configured to give an output range of +2.048V to +4.088V over the full digital range of 0 to 4080.

4. Wiring

The wiring is simple, the boards being daisy-chained together using flexible jumper cable. Connections are made to the housing bulkhead connectors and to the compass DIL plug PL1 from Molex connectors SK6 and SK8 on the boards.

Jumper from PCB COMP1, PL3 to PCB COMP2, PL4

Pin	Function
1	+12V
2	0V
3	WR/
4	GRAY8
5	GRAY7
6	GRAY6
7	GRAY5
8	GRAY4
9	GRAY3
10	GRAY2
11	GRAY1
12	TRIGGER
13-15	N/C

Jumper from PCB COMP2, PL5 to PCB COMP3, PL7

Pin	Function
1	+12V
2	0V
3	WR/
4	BIN8
5	BIN7
6	BIN6
7	BIN5
8	BIN4
9	BIN3
10	BIN2
11	BIN1
12	TRIGGER
13-15	N/C

Connection from COMP1, SK2 to Compass, PL1

SK2 Pin	PL1 Pin	Function
1	1	0V
2	2	BIT8
3	3	N/C
4	4	LED
5	5	BIT3
6	6	BIT4
7	7	N/C
8	8	BIT7
9	9	+12V
10	10	BIT2
11	11	BIT6
12	12	BIT1
13	13	BIT5
14	14	ANODE

Note that, although the wiring is pin for pin, the nature of IDC DIL connectors requires interleaving of the ribbon cable connection wires 1-7 and 8-14, i.e. the order of the wires entering the DIL connector clamp is 14, 1, 13, 2, 12, 3, 11, 4, 10, 5, 9, 6, 8, 7.

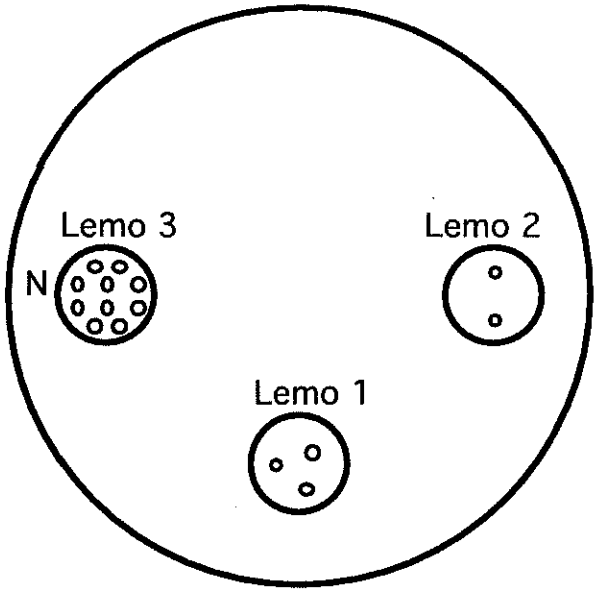


Figure 1. Lid Connectors, showing North index mark

Connections from COMP2, SK6 to Lemo 3

SK6 Pin	Lemo 3 Pin	Function
1	10	PLUSb (opto-isolator +ve supply I/P)
2	9	GRNDb (opto-isolator ground)
3	8	Isolated GRAY8
4	7	Isolated GRAY7
5	6	Isolated GRAY6
6	5	Isolated GRAY5
7	4	Isolated GRAY4
8	3	Isolated GRAY3
9	2	Isolated GRAY2
10	1	Isolated GRAY1

Connections from COMP3, SK8 to Lemos 1 and 2

SK8 Pin	Lemo 1 Pin	Lemo 2 Pin	Function
1	2		+12V
2	1		0V
3		2	AN-O/P
4		1	0V

5. Operational

The unit requires no special attention, other than in ensuring its correct alignment relative to the buoy.

6. Specification

6.1 Supplies

The compass uses a single +12V supply, with a consumption of approximately 4.5 mA.

6.2 Power Consumption

The power consumption is approximately 54 mW.

6.3 Analogue Output

The analogue output ranges from +2.048V to +4.088V as the compass is rotated 358.6° clockwise (looking down on its top) from an initial orientation with its N index mark pointing to magnetic North.

6.4 Digital Output

The digital output is an 8 bit gray code which, when decoded to binary, ranges from 0 to 255 as the compass is rotated as above.

7. Acknowledgements

The development of this equipment was part funded by DRA Portland. The writer also wishes to acknowledge the important contributions made by the OTDD Met Team, Design Office, Production Office and Workshop towards its development.

Appendix A Hardware

A.1 Parts Lists

Mechanical Details

1 off IOS/C5597 Detail 83	Compass Housing Body
1 off IOS/C5597 Detail 84	Compass Housing Cap
1 off IOS/C5597 Detail 85	Compass Housing Base
4 off IOS/C5597 Detail 87	Compass Bolt
8 off IOS/C5597 Detail 88	Compass Spacer

Assorted Fasteners

8 off 12 mm x M4 hex grub screws
4 off 15 mm x M4 C/H Screws

Lemo Connectors

1 off ERA 3E 303CNL	Lemo 1	Bulkhead Series 3, 3 way connector
1 off ERA 3E 302CNL	Lemo 2	Bulkhead Series 3, 2 way connector
1 off ERA 3E 310CNL	Lemo 3	Bulkhead Series 3, 10 way connector

(part numbers given below are for supplier FEC = Farnell Electronic Components Ltd.)

COMP1 PCB

1 off PCB		PC Board to artwork COMP1.ART	G&B Electronic Designs Ltd.
1 off 15LINK	PL3	Flexstrip Jumper, 15 way, 101.6 mm	FEC 151-961
1 off CCEA#220µF	C8	Capacitor Electrolytic, 16V	FEC 106-004
2 off CD40106	IC1, IC3	CMOS Schmitt I/P Invertor	FEC CD40106BCN
1 off CD4013	IC2	CMOS Dual D-Flip Flop	FEC CD4013BCN
2 off CD4042	IC4, IC5	CMOS Quad D-Latch	FEC CD4042BCN
2 off CFKC2#100PF	C6, C7	Capacitor FKC2	
1 off CFKC2#SOT	C2	Capacitor MKS2, nom 15n, 63V	FEC 143-675
1 off CFKC2#SOT	C4	Capacitor Ceramic X7R, nom 33n, 100V	FEC 108-948
1 off CMKS2#SOT	C3	Capacitor Ceramic X7R, nom 33n, 100V	FEC 108-948
2 off CMKS2#SOT	C5	Capacitor Ceramic X7R, nom 22n, 100V	FEC 108-947
1 off CTANT#10µF	C1	Capacitor Tantalum, 10µ, 16V	FEC .227-766
1 off IDC16	PL2	IDC Transition Connector 14 Way	FEC 469-221
Associated Parts		14way ribbon cable	FEC 297-318
		14 way DIL Plug	FEC 145-061
1 off PATCH	PATCH/1	Wire link	
4 off RMFW25#100K	R1, R2, R3, R4	Resistor 100k Metal Film	FEC MFR4 100K
1 off RMFW25#270R	R5	Resistor 100k Metal Film	FEC MFR4 270R
1 off RMFW25#4K7	R6	Resistor 100k Metal Film	FEC MFR4 4K7
1 off VN10KM	TR1	MOSFET	FEC VN10KM

COMP2 PCB

1 off PCB		Printed Circuit Board to artwork COMP2.ART	G&B Electronic Designs Ltd.
1 off 15LINK	PL5	Flexstrip Jumper Cable, 15 way, 101.6 mm	FEC 151-961
2 off CD4030	IC6, IC7	CMOS Quad 2 I/P Exclusive-OR	FEC
8 off H11L1B	IC10, IC11, IC12, IC13, IC14, IC15, IC8, IC9		
1 off MOLEX10	PL6	Molex Connector, 90°, 10 way	FEC 146-697
Associated Part		Crimp Connector 10 way	FEC 143-131
		Crimp terminals	FEC 143-116
1 off RP8C#4K7	R7A-H	SIL Resistor Array, Bourns 4609X-101 4K7	FEC 148-903

COMP3 PCB

1 off PCB		Printed Circuit Board to artwork COMP3.ART	G&B Electronic Designs Ltd.
1 off AD7545	IC17	D-A Convertor	FEC AD7545KN
1 off CD4060	IC16	CMOS Oscillator/Divider	FEC CD4060BCN
2 off CFKC2#1N5F	C12, C13	Capacitor FKC2 1n5	FEC 147-666
3 off CFKC2#33PF	C10, C11, C9	Capacitor Ceramic NPO	FEC 498-555
1 off CTANT#10µF	C14	Capacitor Tantalum, 10µ, 16V	FEC .227-766
1 off DIPSW8NO	SW1-8	DIL Switch 8 single Throw	FEC 422-666
2 off LM308N	IC19, IC20	Operational Amplifier	FEC LM308AN
1 off MOLEX4	PL8	Molex Connector, 90°, 4 way	FEC 146-693
Associated Parts		Crimp Connector 4 way	FEC 143-128
		Crimp terminals	FEC 143-116
1 off REF-02CP	IC18	Voltage Reference 5V	FEC .REF02CP
4 off RMFW25#10K	R11, R13, R14, R9	Resistor 100k Metal Film	FEC MFR4 10K
2 off RMFW25#5K0	R10, R12	Resistor 100k Metal Film	FEC MFR4 5K0
1 off RMFW25#68R	R8	Resistor 100k Metal Film	FEC MFR4 68R
1 off RPOTVTM#10K	RV1	Multi Turn Cermet Trimmer	FEC 237-516

A.2 Assembly Details

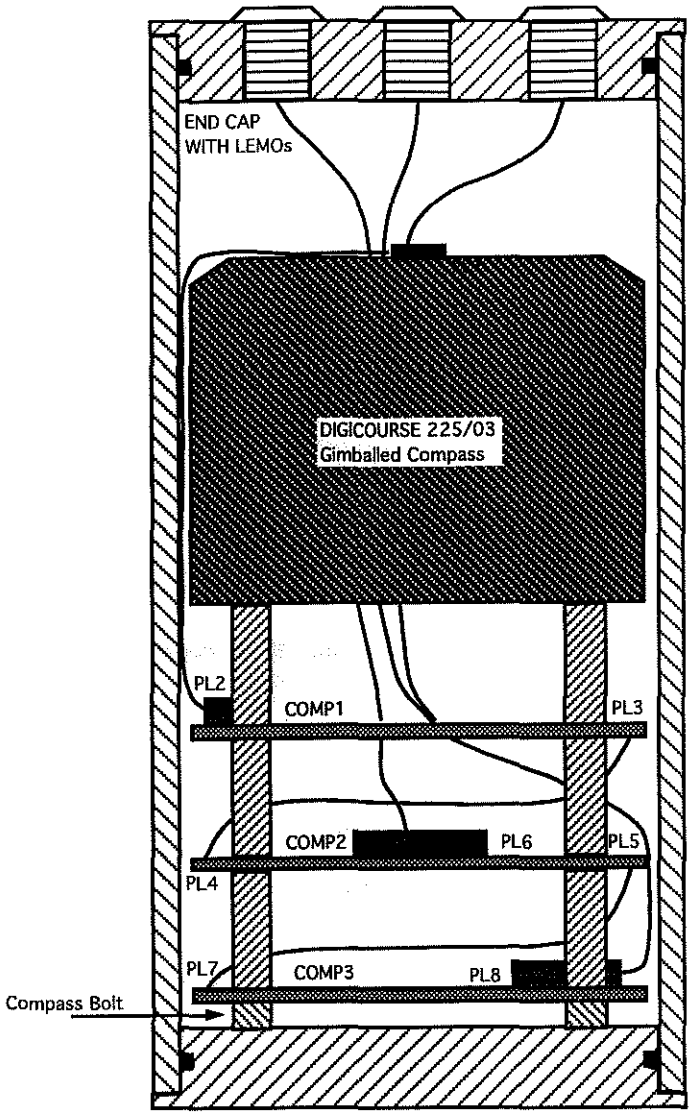
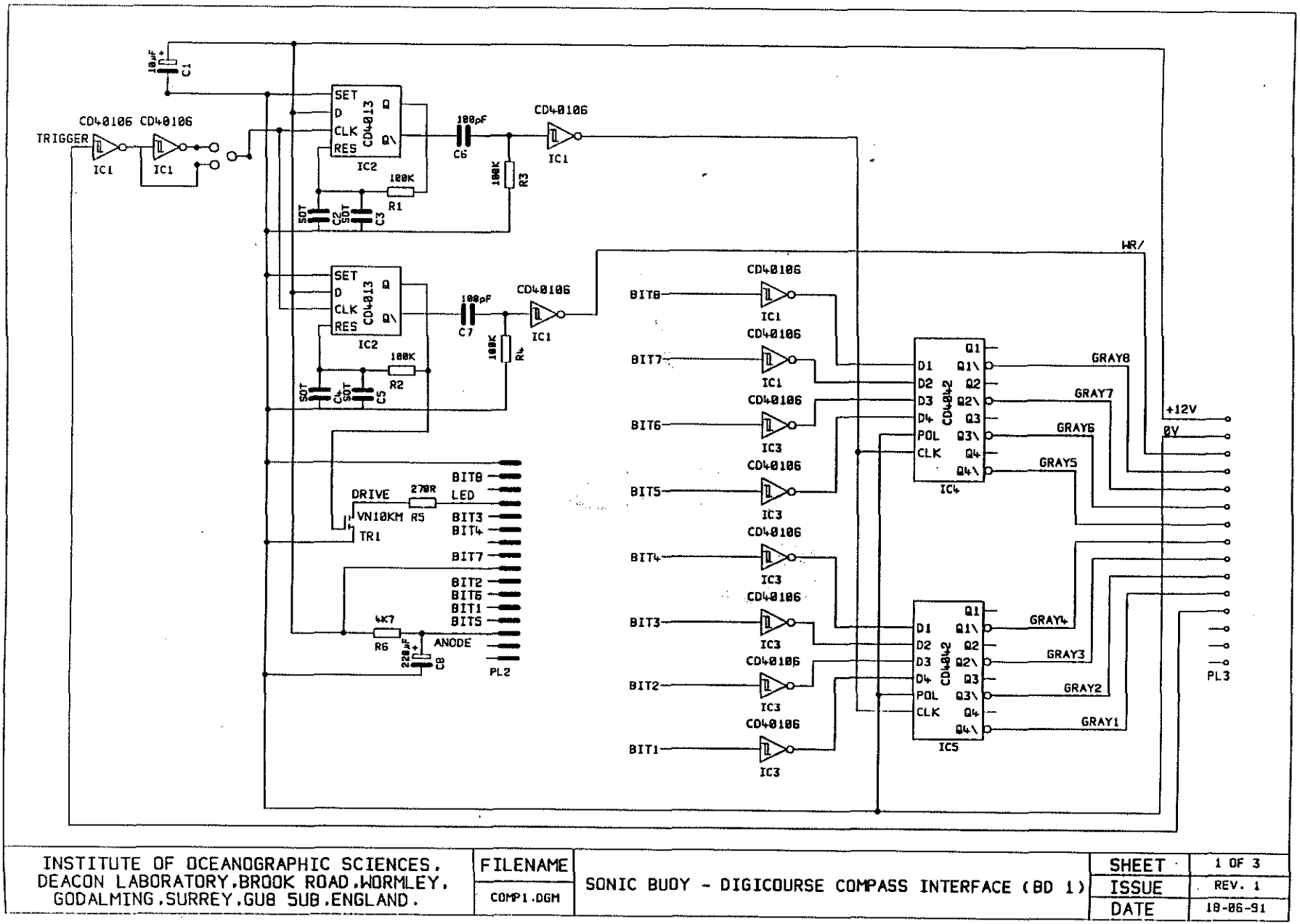


Figure 2. General Assembly Schematic

The compass unit and PCBs are mounted on the lower end cap, using spacers. Sufficient cable length is allowed between the SK6 and SK8 connectors and the Lemo connectors in the upper end cap to allow the lower end cap assembly to be withdrawn from the housing.



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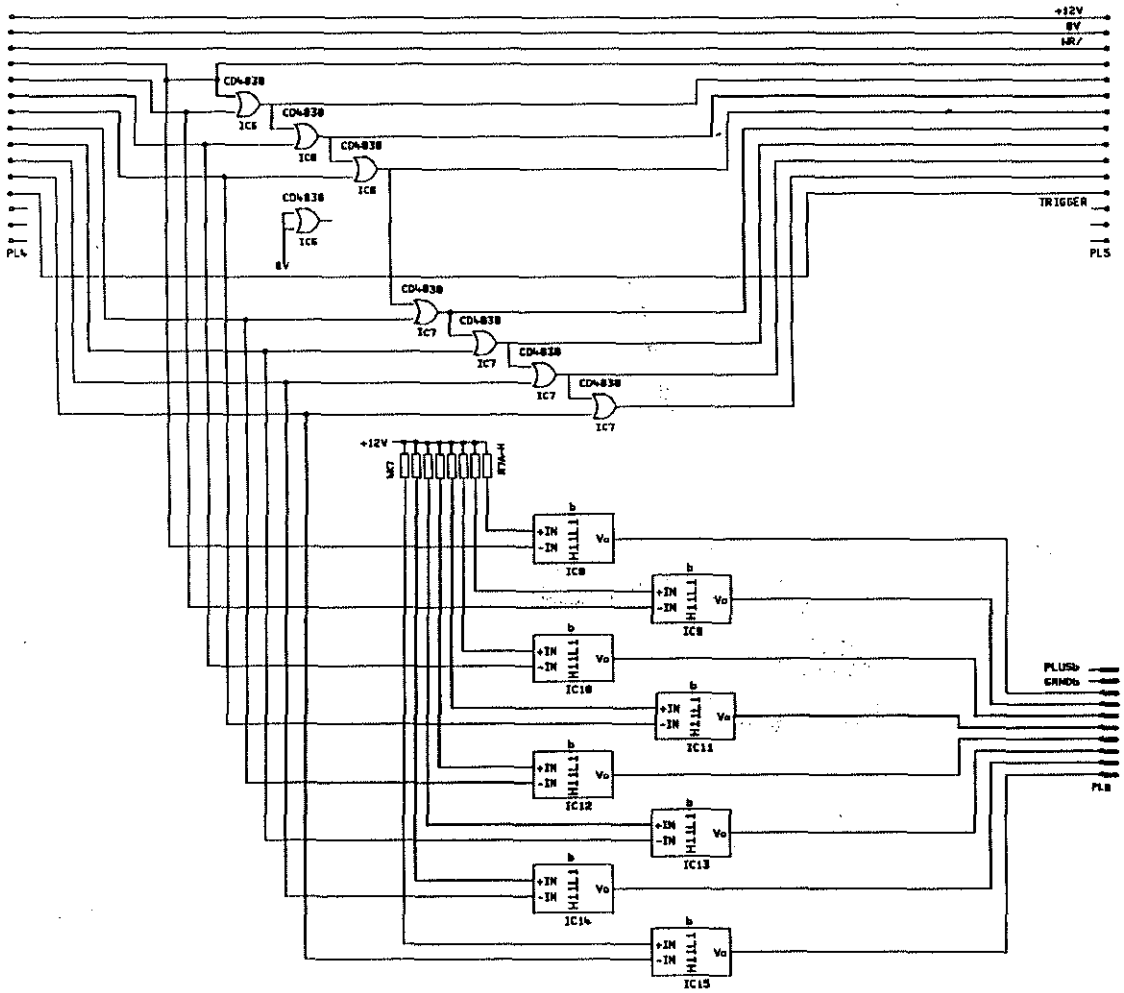

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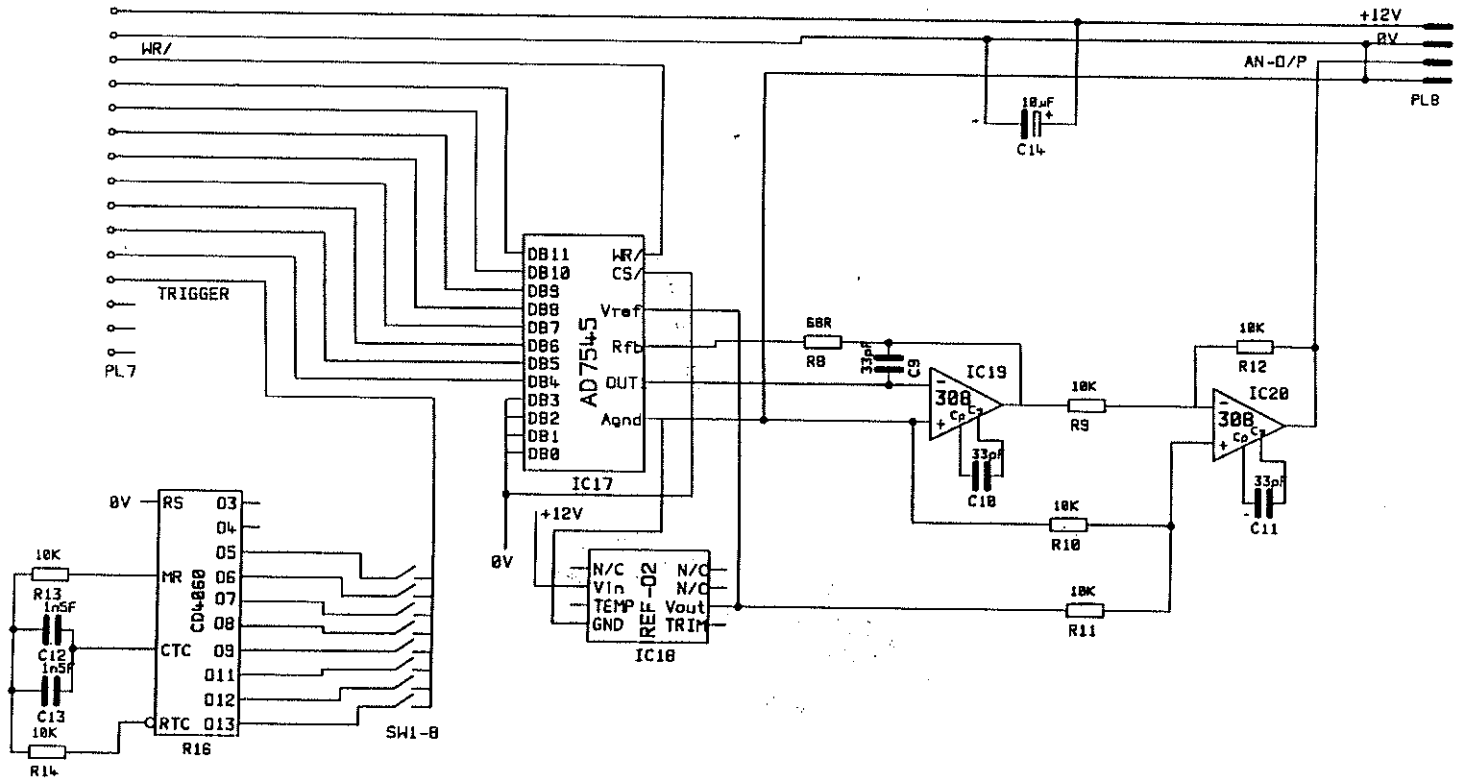

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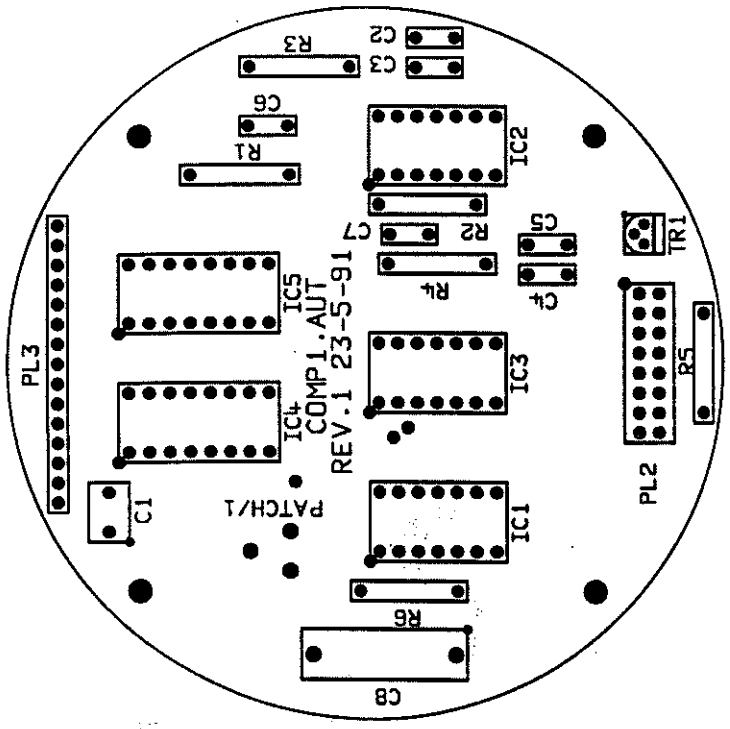
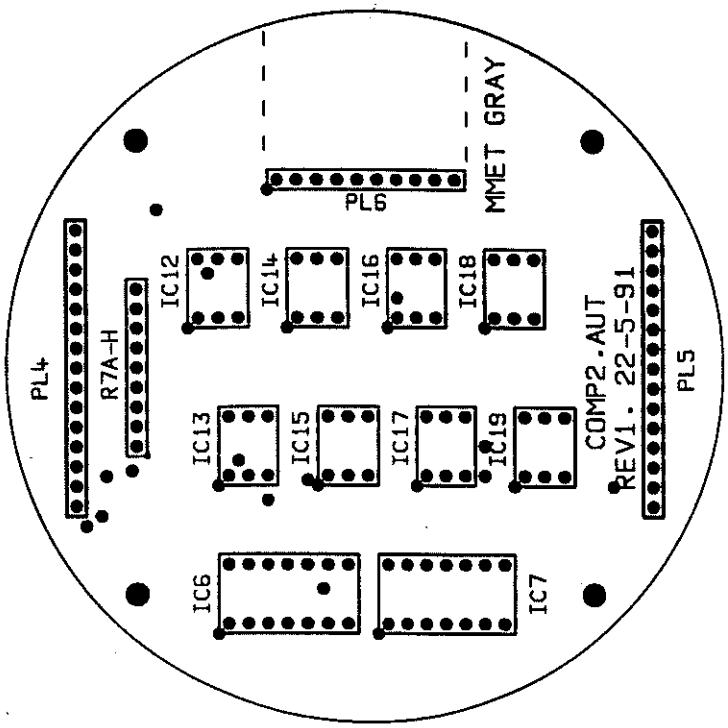
	COMP3.DGM		ISSUE	REV. 1
			DATE	18-06-91

A.6 Printed Circuit Boards COMP1 and COMP2





A.7 Printed Circuit Board COMP3