3_Current source and guard amp

3.6 V to I and guard amp module

The target accuracy and sensitivity of the F18 made it necessary to design the voltage to current converter and guard amplifier and their associated (bridge) current carrying conductors on a separate PCB module. The output stages are physically close together with two power supplies {±15V (LOW) and ±15V (HIGH)} and a combination of twisted triples (±15V), a twisted pair (bridge current) and go/return PCB tracks. The result is minimal transmission of magnetic flux. Some care was also applied to the decoupling: -

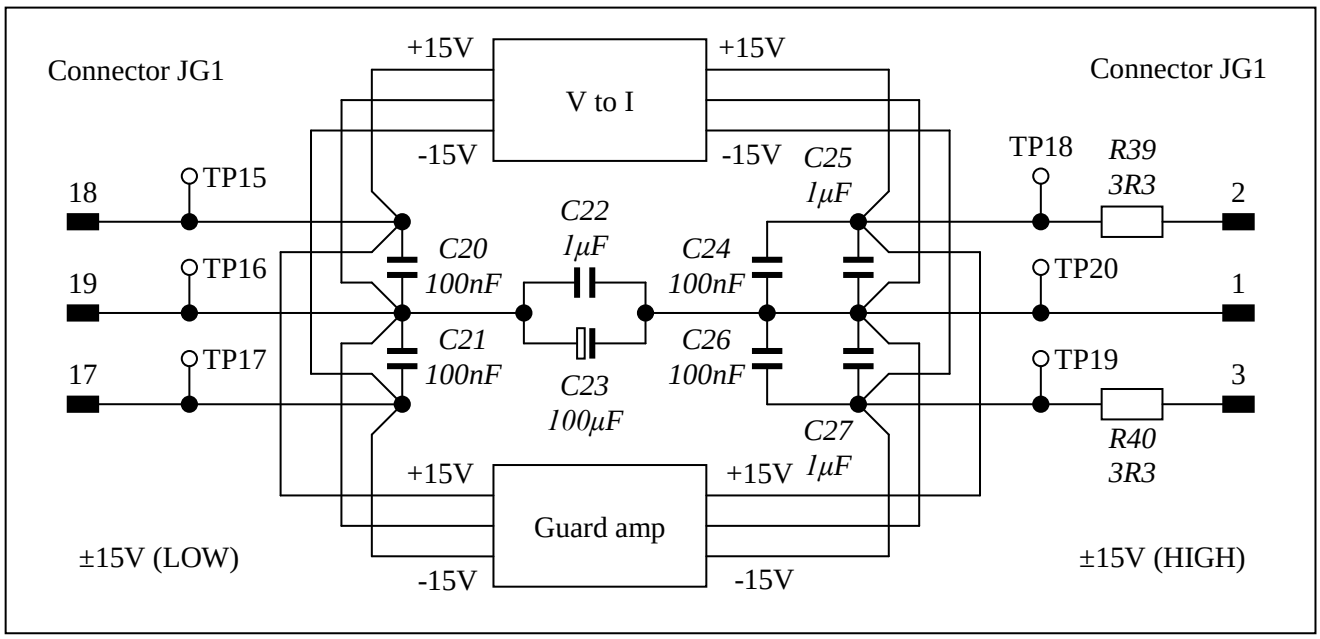

Fig. 3.6.1 LOW and HIGH power supplies

The principle can be best understood by considering the positive half cycle of the sine wave and following the route by which the current flows. Within the module the PCB tracks are routed to keep the area depicted to a minimum: -

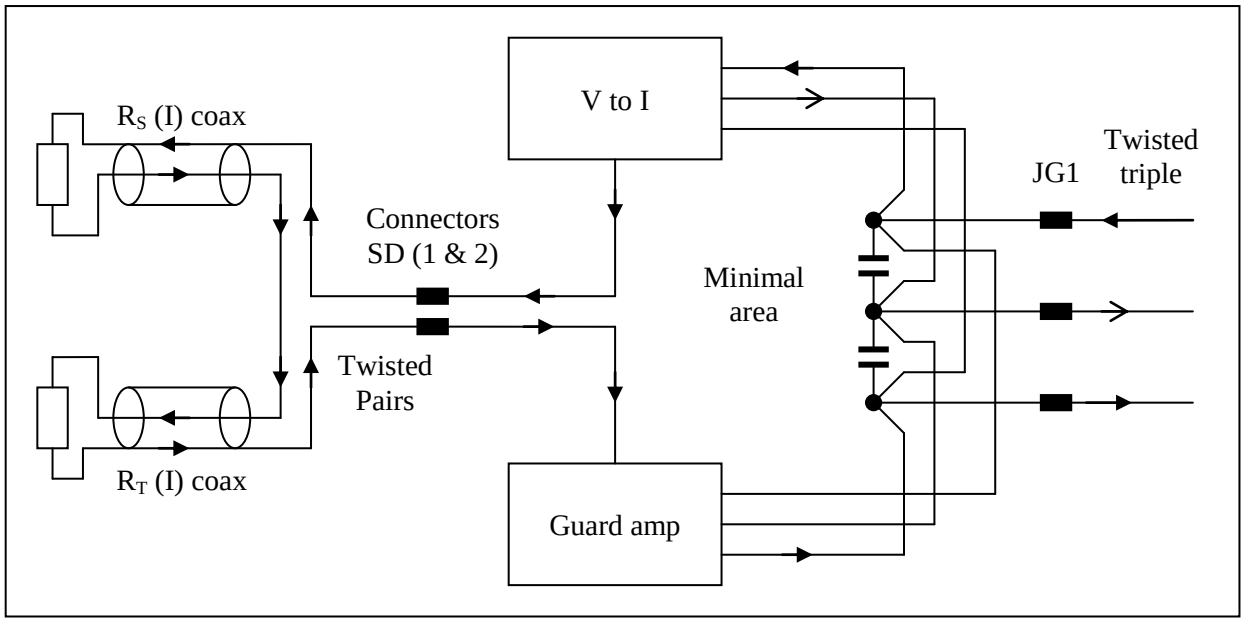

Fig. 3.6.2 Area being kept to a minimum

N.B. A relatively small proportion of the current returns to the PSU via the 0V connection. See section 3.8.

3.7 Current amplitude fine control

This module also includes a multiplying digital to analogue converter (MDAC) for fine control of the bridge current amplitude: -

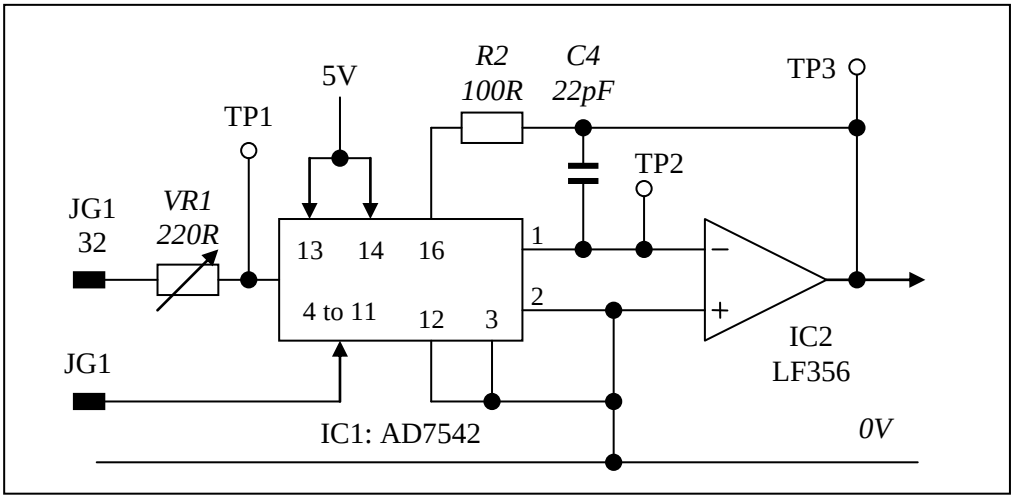

Fig. 3.7.1 Current amplitude fine control

The 5V supply is generated locally with regulator REG 1: 78L05.

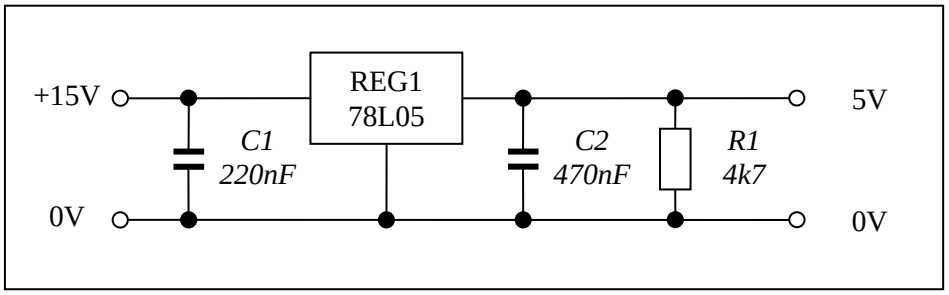

Fig. 3.7.2 Local 5V supply

The data and control lines arrive via connector JG1: -

IC Pin	4	5	6	7	8	9	10	11
Function	D3 (MSB)	D2	D1	D0 (LSB)	Chip select Active low	Write Active low	A0	A1
JG1 pin	13	31	12	30	11	29	10	28

For more detail on the MDAC interface see section 6.4.

The MDAC stage is followed by a two-stage high-pass filter and amplifier (×1.024): -

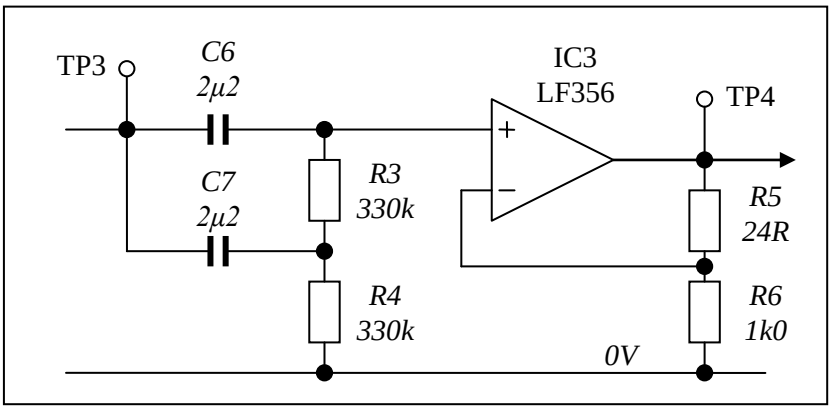

Fig. 3.7.3 High-pass filter and amplifier

The offset trimmer for IC3 (not shown) is *VR2*.

3.8 Voltage to current converter

The voltage to current converter is a "Howland pump" with a discrete transistor output stage to deliver bridge current of up to 100mA. The positive feedback is selectable via glass-encapsulated reed relays: -

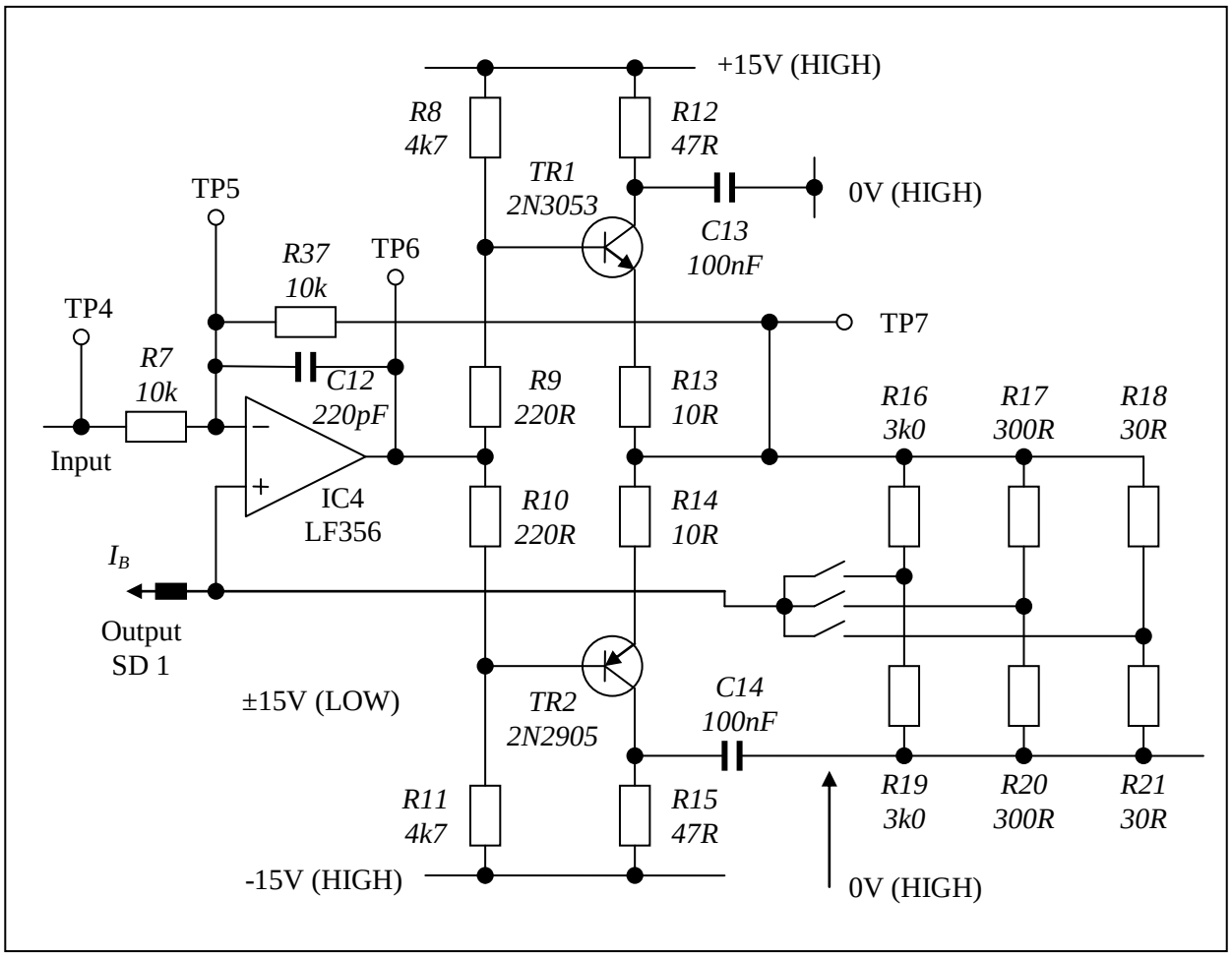

Fig. 3.8.1 Voltage to current converter

The offset trimmer for IC4 (not shown) is *VR3*: -

It is shown elsewhere [1] that the output current is proportional to the input voltage (at TP4).

$$I_B = \frac{-V_{IN}}{R}$$

Where R = 30Ω, 300Ω or 3kΩ.

There are two power supplies: one for the output stage (±15V HIGH) and a separate supply (±15V LOW) for the low current (input) circuits. Both arrive via connector JG1 (a 37 way D-type). See section 3.6.

Whereas most of the bridge current returns to the power supply via the guard amplifier and -15V supply, a small proportion, which flows through the resistors *R18* and *R21* returns via the 0V (HIGH) conductor.

1. Part 4, monograph 4: "The Isotech MircoK Bridge". See section 3.

3.9 Guard amplifier

The guard amplifier is a two-stage high gain block [1] with discrete transistors to deliver the output current (up to 100mA): -

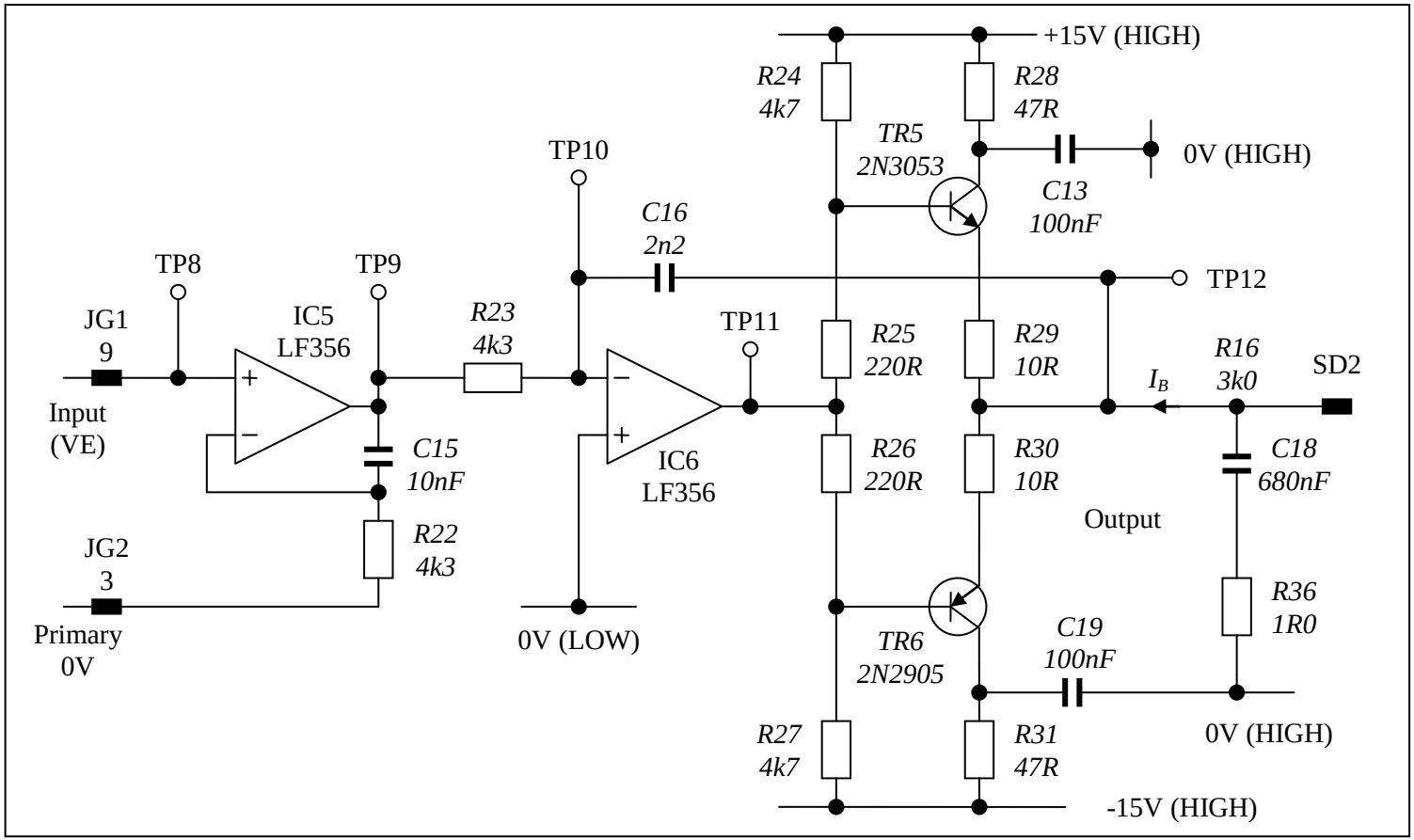

Fig. 3.9.1 Guard amplifier

Note the separate connector JG2 which connects the (non-inverting) input to 0V (LOW) at a point which defines the primary 0V for the bridge.

The offset trimmer for IC5 (not shown) is VR4.

1. Part 4, monograph 1: “High gain blocks”.

3.10 Current amplitude coarse control

The control lines for the relay coils also pass through connector JG1: -

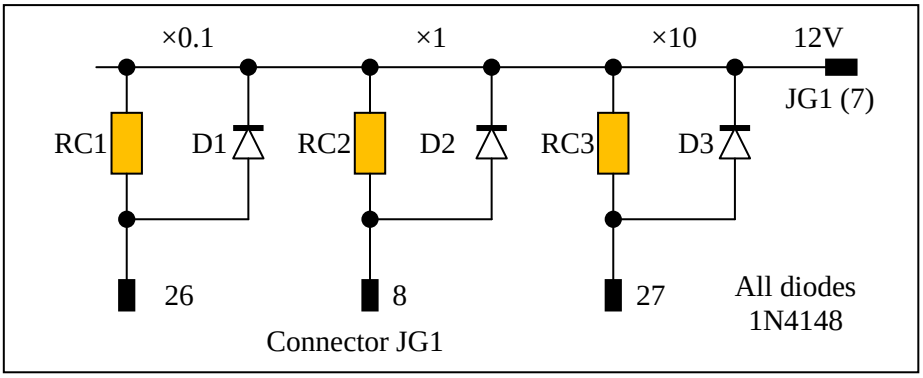

Fig. 3.10.1 Relay coil interface

3.11 Guard amp (carrier) overload detector

The output of the guard amplifier is monitored by an overload detector: -

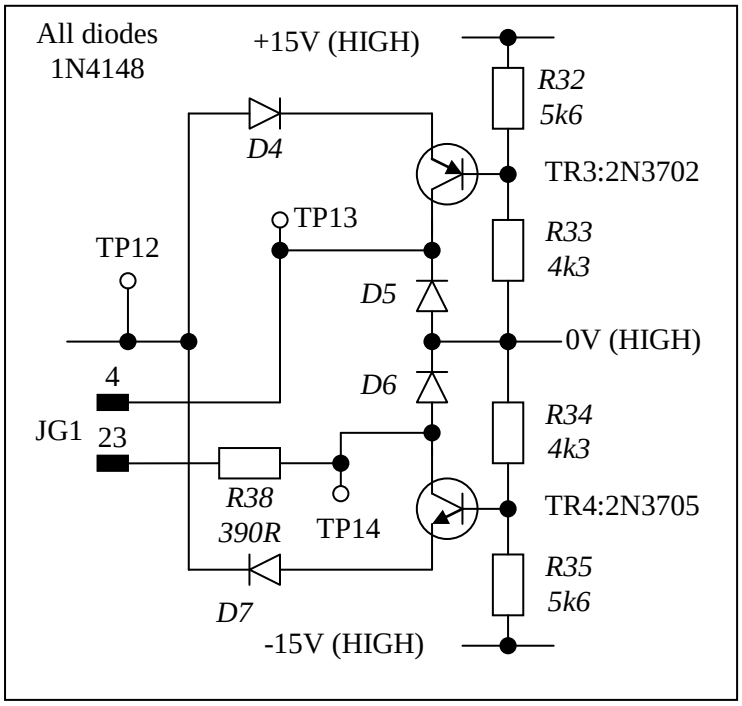

Fig. 3.11.1 Guard amp (carrier) overload detector

The output appears to get to the microcontroller PCB via the interface PCB and null detector PCB2 (in-phase and quadrature servo).

3.12 Interface circuits

The bridge current source control signals are produced in the microcontroller PCB (slot 2 of the card frame, connectors JM1 and JM2) and reach the carrier generator PCBs via the interface PCB (slot 3, connectors JI1 and JI2). The carrier generator PCB is in slot 4 with connectors JC1 and JC2. The guard amplifier and V to I module has main connector JG1.

For details of the power supplies and opto-couplers see section 5.2.12.

For details on the MDAC and carrier overload interfaces see section 6.4.

The V to I controls are opto-coupled: -

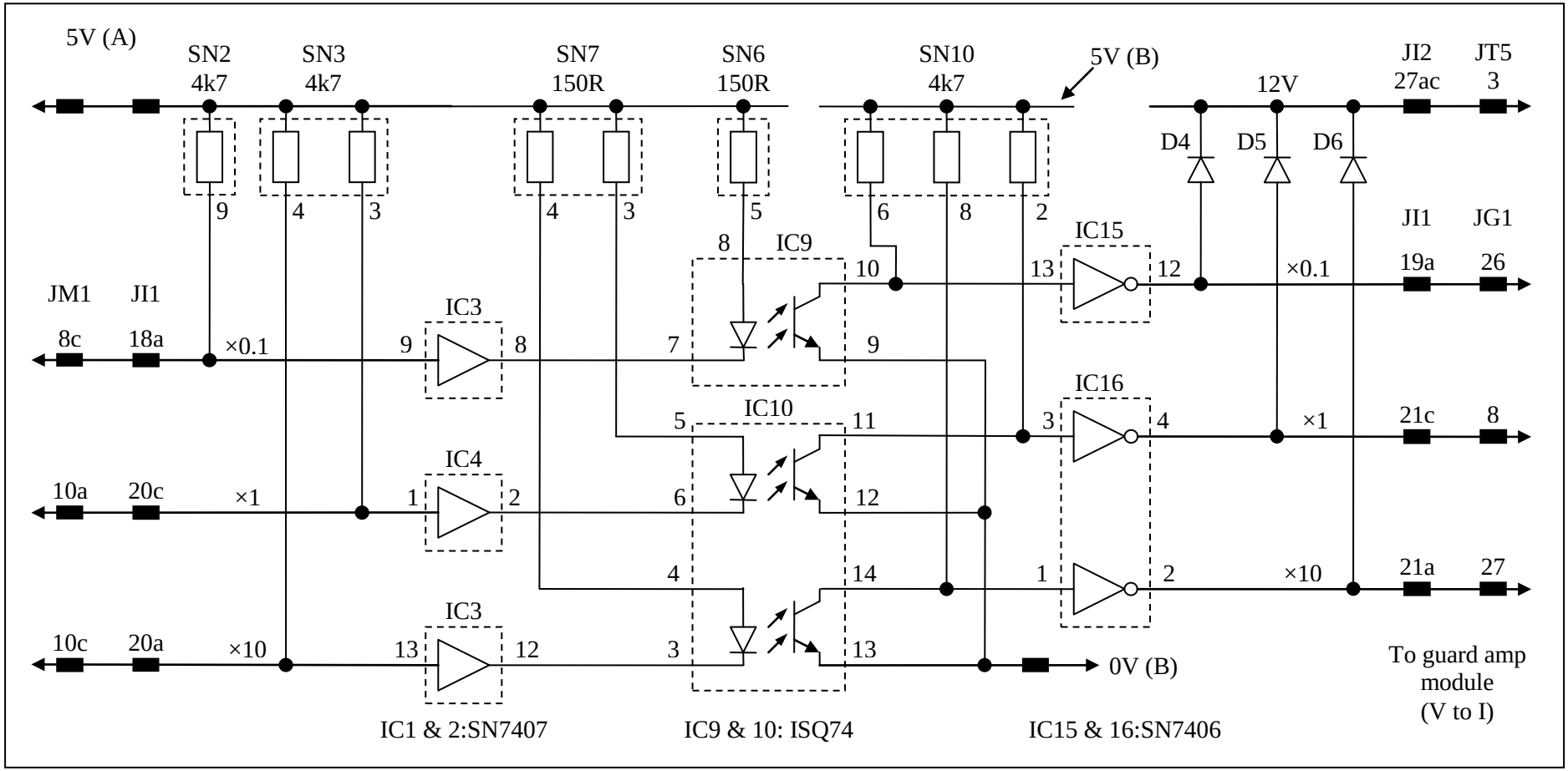

Fig. 3.12.1 Bridge current selector interface

The interface circuit for frequency select (25Hz/75Hz) employs the same opto-coupler but requires a locally derived ±7V5 supply (see fig. 5.2.12.2): -

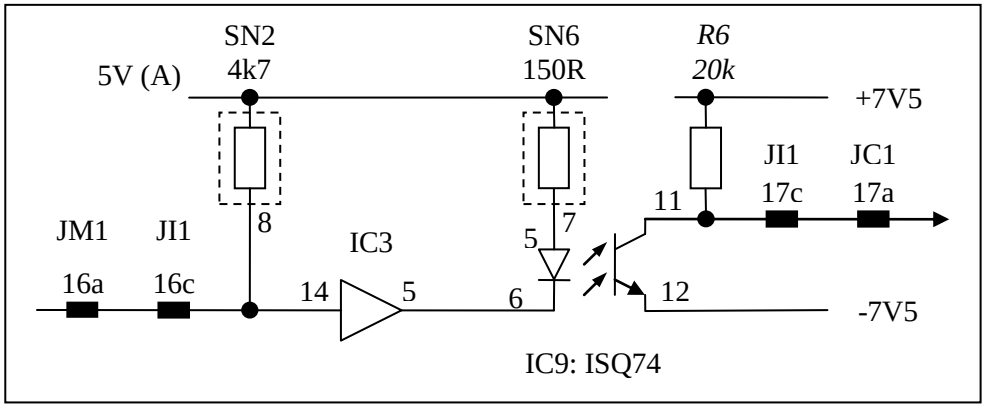

Fig. 3.12.2 Frequency select interface

Similarly for the phase invert control: -

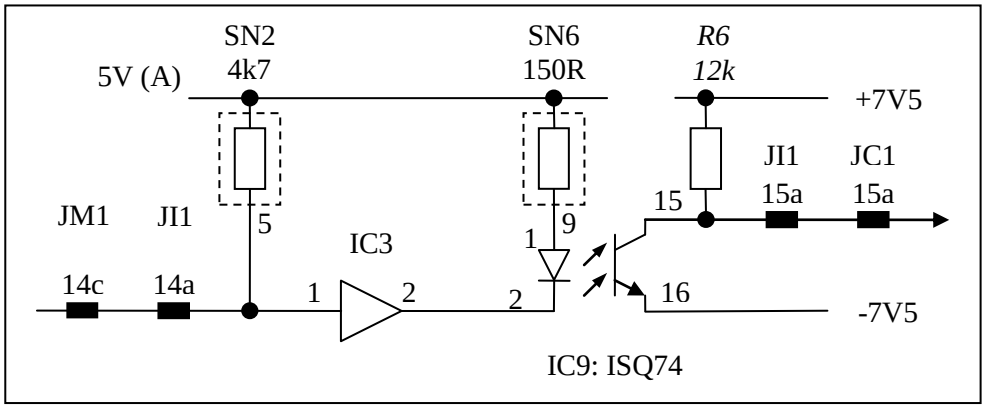

Fig. 3.12.3 Phase invert control interface

The phase-lock loop (PLL1) divider stage produces a 9.6 kHz clock, presumably for synchronising the analogue to digital converter on the microcontroller PCB (see fig. 3.1.4). It passes through the interface PCB via a transistor inverter: -

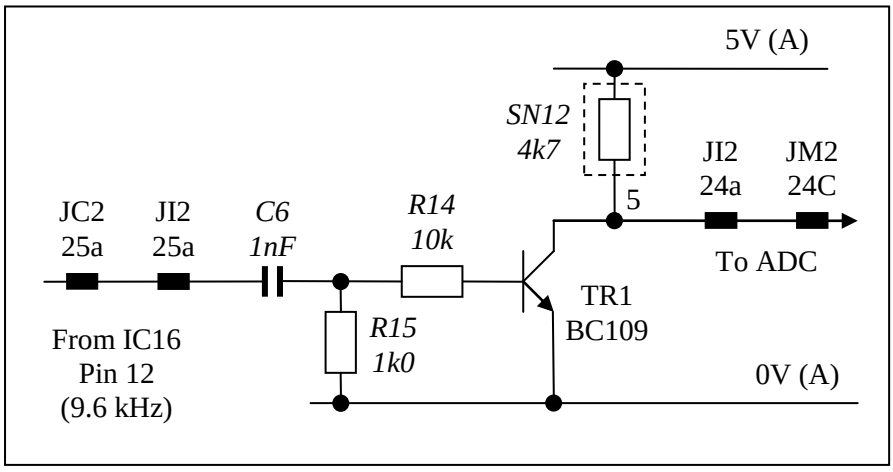

Fig. 3.6.1 ADC synch signal Interface

The power supply 5V (A) and 0V (A) is on the microcontroller side of the opto-couplers. See section 5.2.12 for details.

The connections via JG1 (37 way D-type) are repeated for convenience: -

JG1		Function	MOLEX* 10 way	MOLEX* 5way
1		0V (HIGH)		
2		+15V (HIGH)		
3		-15V (HIGH)		
4		Carrier overload +		
5				1
6				3
7			5	
8		10mA (×1)		
9		Guard amp input (virtual earth)	6	
10		MDAC A0		
11		MDAC Chip select		
12		MDAC D1		
13		MDAC D3 (MSB)		
14	NC			
15			7	
16			9	
17		-15V (LOW)		
18		+15V (LOW)		
19		0V (LOW)		
20	NC			
21	NC			
22	NC			
23		Carrier overload -		
24	NC			
25				5
26		1mA (×0.1)		
27		100mA (×10)		
28		MDAC A1		
29		MDAC Write pulse		
30		MDAC D0 (LSB)		
31		MDAC D2		
32		Active guard input		
33	NC			
34			8	
35	NC			
36	NC			
37	NC			

*Some connections arrive and then exit via 10-way (to the pre-amp module) and 5-way Molex (To rear panel BNC) connectors. What are they?

What other connections are via JG2? Where do they go?

In some documents the current select control lines are referred to as 1, 10 and 100mA, presumably referring to the nominal value when 1mA is selected. The front panel buttons are labelled ×0.1, ×1 and ×10.