Operation Readiness Clearance (ORC) of SpinQuest (E1039) UVA-NMR Test Setup in the Counting-House

ORC - 2186

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Contents

1 Introduction

Figure 1.1: UVA-NMR System (front view (left), back view (right))

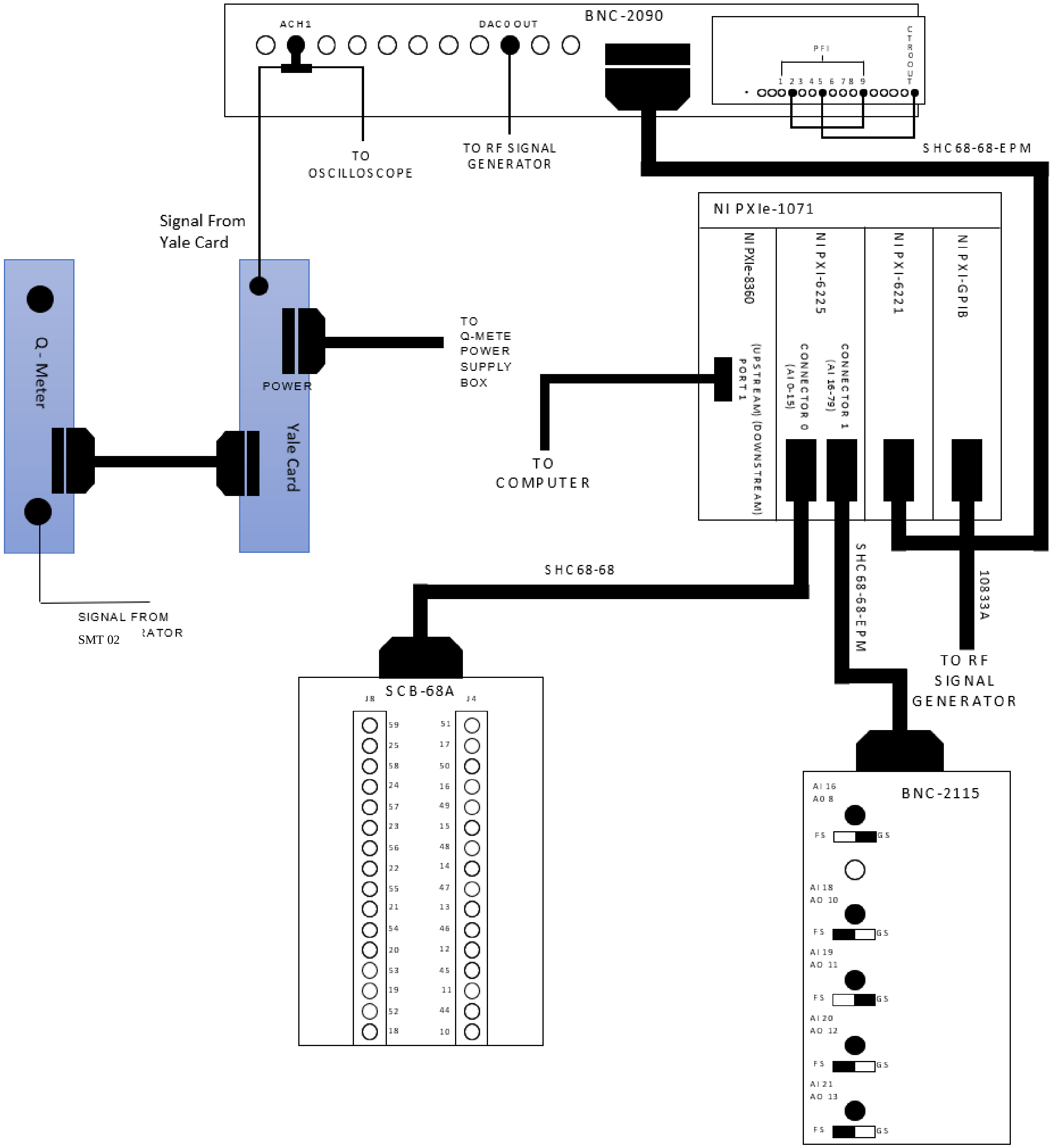


Figure 1.2: Connection Block Diagram of the UVA NMR Test Setup

Component	Voltage (V)	Current (A)	Power (W)
Q-meter and Yale-Card power supply	120	0.3	36.0
DAQ National Instruments (PXle)	120	4.2	504.0
Computer (Dell Precision 3630 Tower)	120	6.0	720.0
Monitor (HP Compaq LA1951G	120	0.36	44.0
RF generator (SMT 02)	120	2.7	324.0
Oscilloscope (Tektronix TDS 3054B)	120	0.62	75.0
Total			**1,703.0**

Table 1.1: Power budget

2 National Instruments Components

The NMR rack contains four National Instruments components. This hardware functions as a Data AcQuisition (DAQ) device and as an Analog-to-Digital Converter (ADC) for the analog signals. They also facilitate communication and control of the NMR system by the computer.

2.1 BNC 2090

The BNC-2090 is a BNC patch panel (see Fig. 2.1.1) that collects analog signals from the box and sends them to the NMR ADC [1].

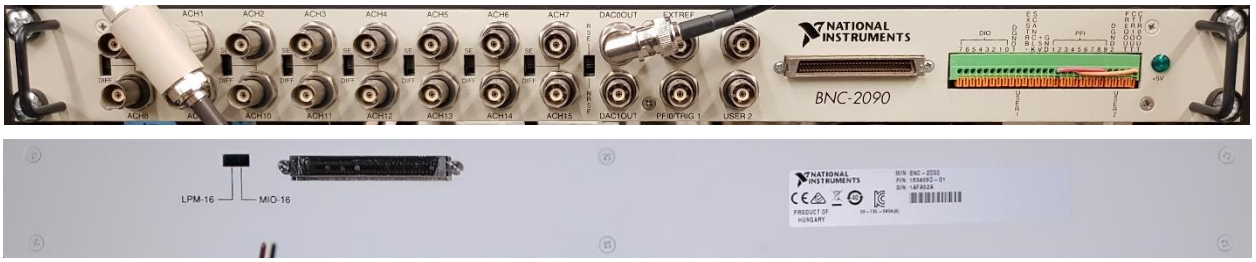


Figure 2.1.1: BNC 2090 (upper: front panel, lower: back panel)

2.2 SCB-68A

The SCB-68A box allows the computer to communicate with the DIO box (will be added later) [3]. This allows the user at the computer to adjust the Yale card gain, DC convert the system, and Select the Q-meter channel, right from the computer.

Figure 2.2.2: SCB-68A

2.3 NI-PXIe-1071

The PXI system (see Fig. 2.4.1) is a platform for PC-computer based measurement and automation systems. The NI PXIe-1071 Express Chassis is a box which manages the PXI system, providing power, cooling, and communication between the PXI modules it houses [4].

Figure 2.4.1: The PXI system

Our PXI system uses four modules:

a) ***NI PXI-6221***: This board is part of the NMR DAQ. It functions as the NMR ADC, or Analog-to-Digital Converter.

b) ***NI PXI-6225***: The PXI-6225 board is an Analog Input Multifunction DAQ. It is the "slow control" ADC, converting the analog signals from the slow control devices to digital signals and sending them to the computer.

c) ***NI PXI-GPIB***: This board is a high performance IEEE488 controller module for the PXI system. It enables control of the RF signal generator by the computer.

d) ***NI PXIe-8360***: Through this PXI module, the LabVIEW based computer system can communicate with the PXIe-1071 chassis and modules and controlling the PXI system.

2.4 BNC 2115

The BNC-2115 is another BNC patch panel which accepts analog signals from the "slow control" devices used in conjunction with the NMR system (see left panel of Fig. 2.2.1). Such slow control devices include temperature sensors and flow meters, among others, which monitor conditions within the refrigerator during operation. The BNC- 2115 passes these analog signals to the DAQ and ADC [2].

Figure 2.2.1: BNC 2115

3 RF Generator (Rhode & Schwartz SMT 02)

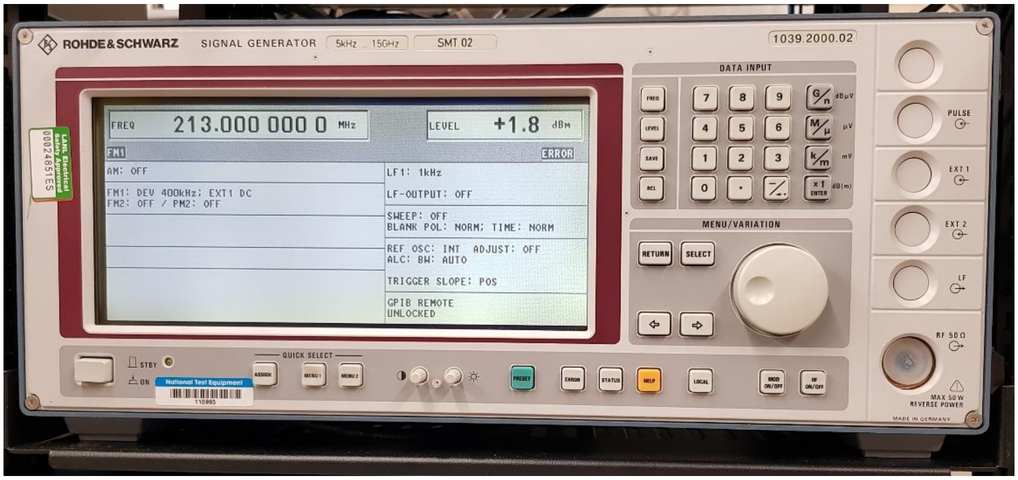


Figure 3.1: RF Generator Rohde & Schwarz SMT 02

The RF signal generator used is a Rohde & Schwarz SMT 02 model, which can provide RF signals from 5 kHz to 1.5 GHz. Please refer to the operations manual [5].

4 Oscilloscope (Tektronix TDS 3054B)

The oscilloscope (see Ref. [6] for the manual), takes the input from “ACH1” and “DAC0 OUT” channels (see Figure 1.2) from Q-meter output (to CH1) and RF generator output (to CH2) accordingly to see the NMR signal.

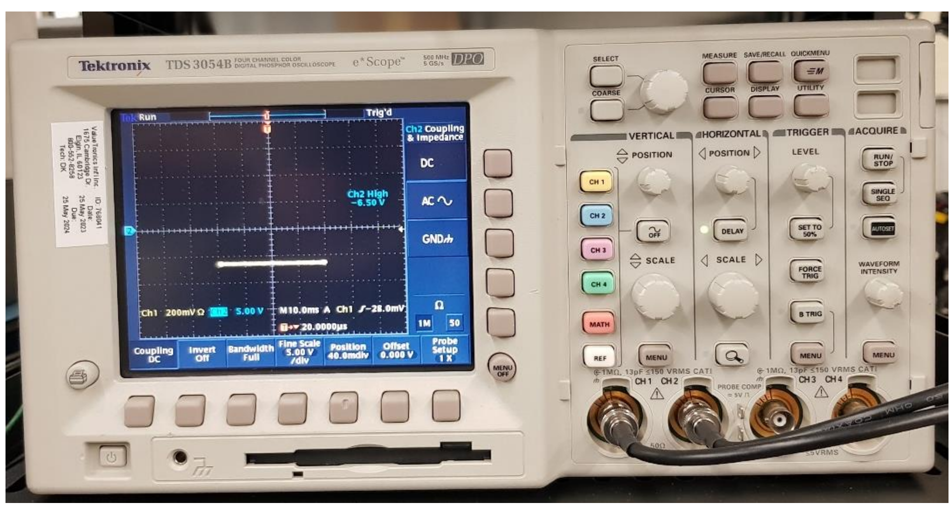


Figure 10: Oscilloscope Tektronix TDC 3054B (see Ref. [10])

5 Power Supply to the Yale Card and Q-meter

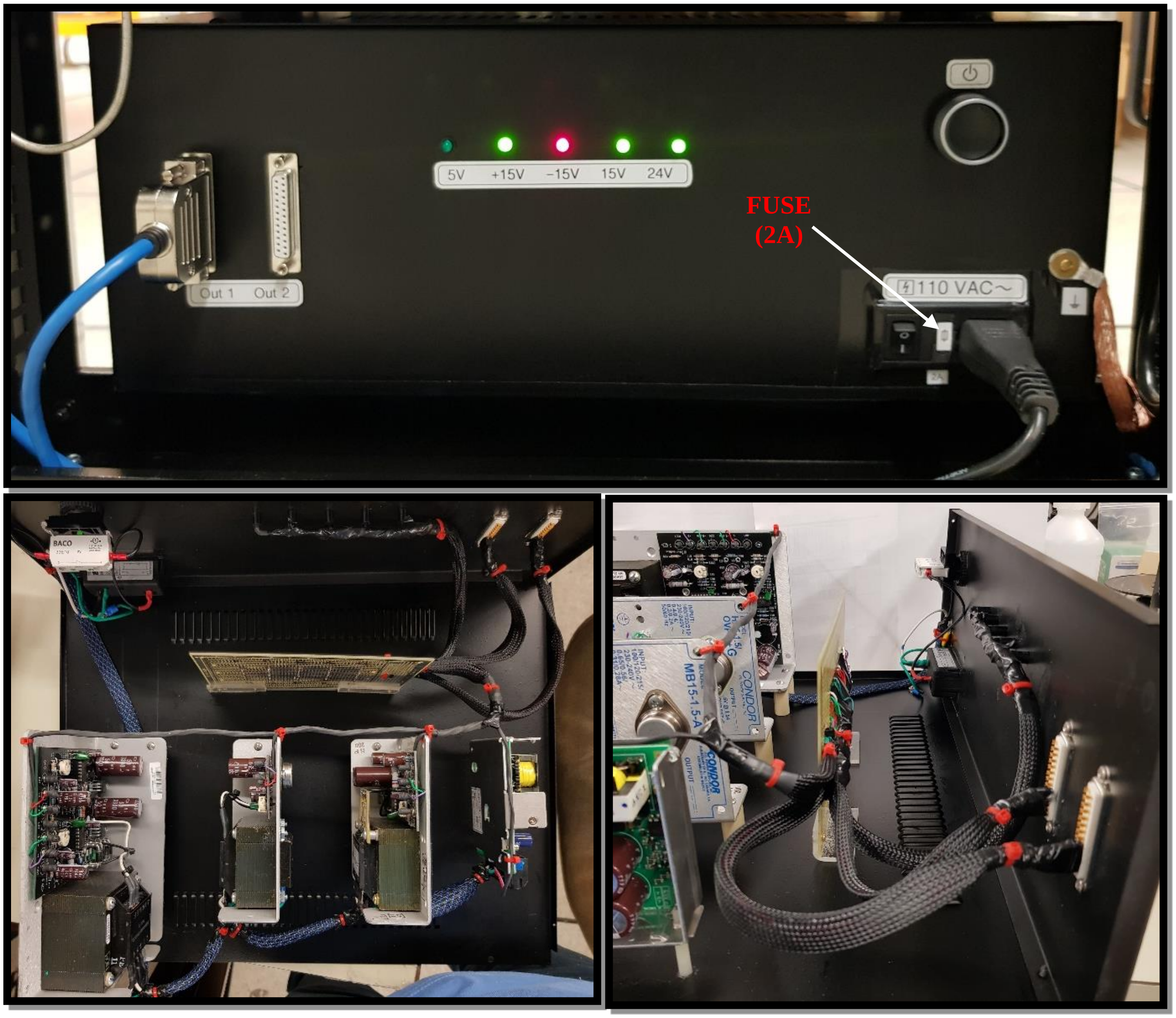


Figure 2.1: Q-meter and Yale-Card power supply box

The power supply provides power to the Yale card and Q-meter. The schematic diagram for this power supply box is given in Fig 2.2. There are two 25-pin D-subminiature (or D-sub) connectors on the back of the power supply to which the power cables of 24 AWG is connected to 25-pin D-sub. The device supplies five unique voltages, +24V, +15V, ±15V, and +5V. The wiring of the power supply output is covered in Table 2.1.

Pin #	Voltage [V]	Pin #	Voltage [V]
1	+24 RF	14	G
2	+15 RF	15	G
3	+15 LF	16	G
4	-15 LF	17	G
5	+5 S	18	G
6	NC	19	NC
7		20	
8		21	
9		22	
10		23	
11		24	
12		25	
13			

Table 2.1: Connections to the power supply

5.1 Internal power supply modules of the power supply chasse

Voltage	Maximum Ratings
±15 V	Model: Condor HBB15-1.5A+ G Input: 120V~ 1.2A 60Hz Output: ±15V@ 1.5A
5 V	Model: Condor HA5-1.5/ OVP-A+G Input: 120V~ 0.4A 60Hz Output: 5V@1.5A OVP Set @ 6.2±0.4V
15V	Model: Conder MB15-1.5-A Input: 120V~ 0.56A 60Hz Output: 15V@1.5A
24 V	Model: TDK Lambda HWS30A – 24/ME Input: 100-240VAC 0.7A Output: 24V 1.3A

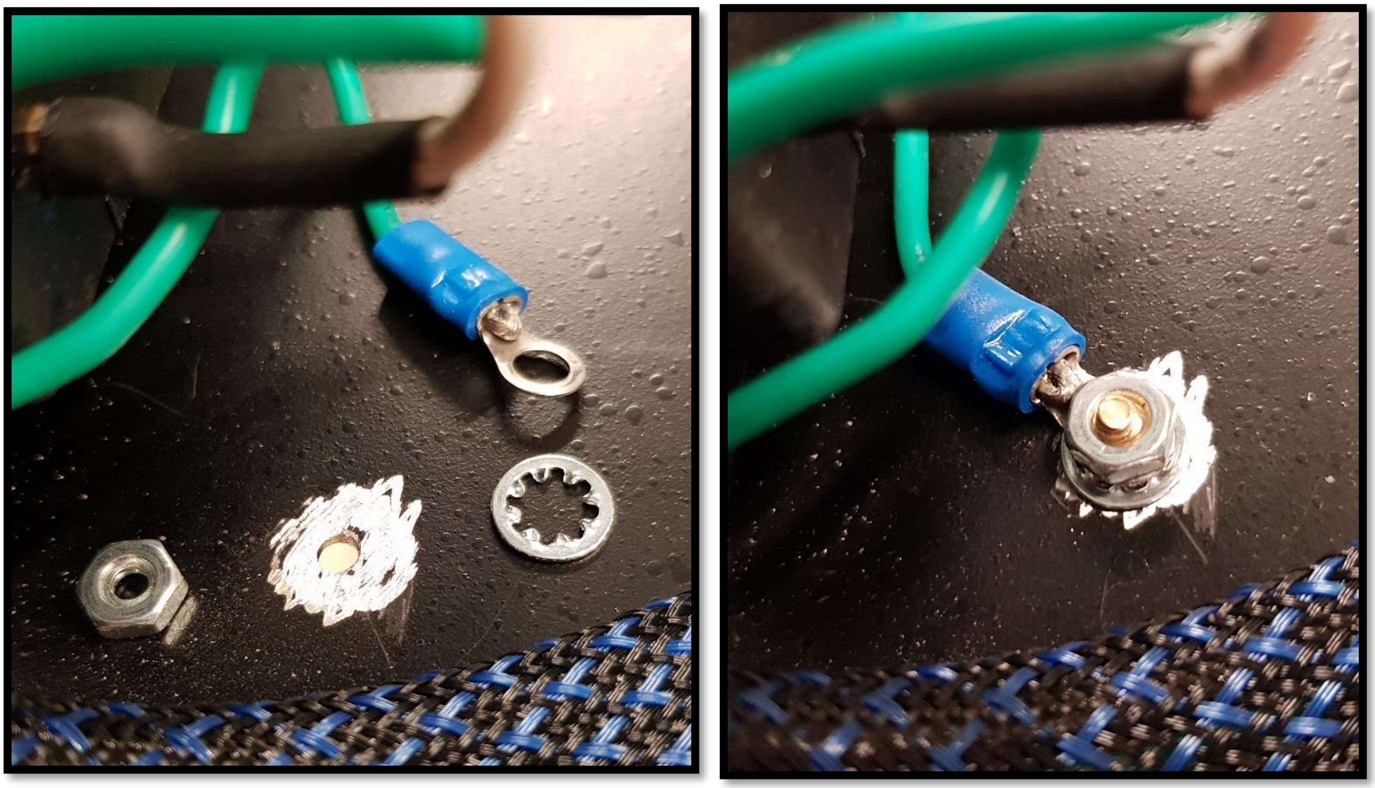


Figure 2.2: Ground connections

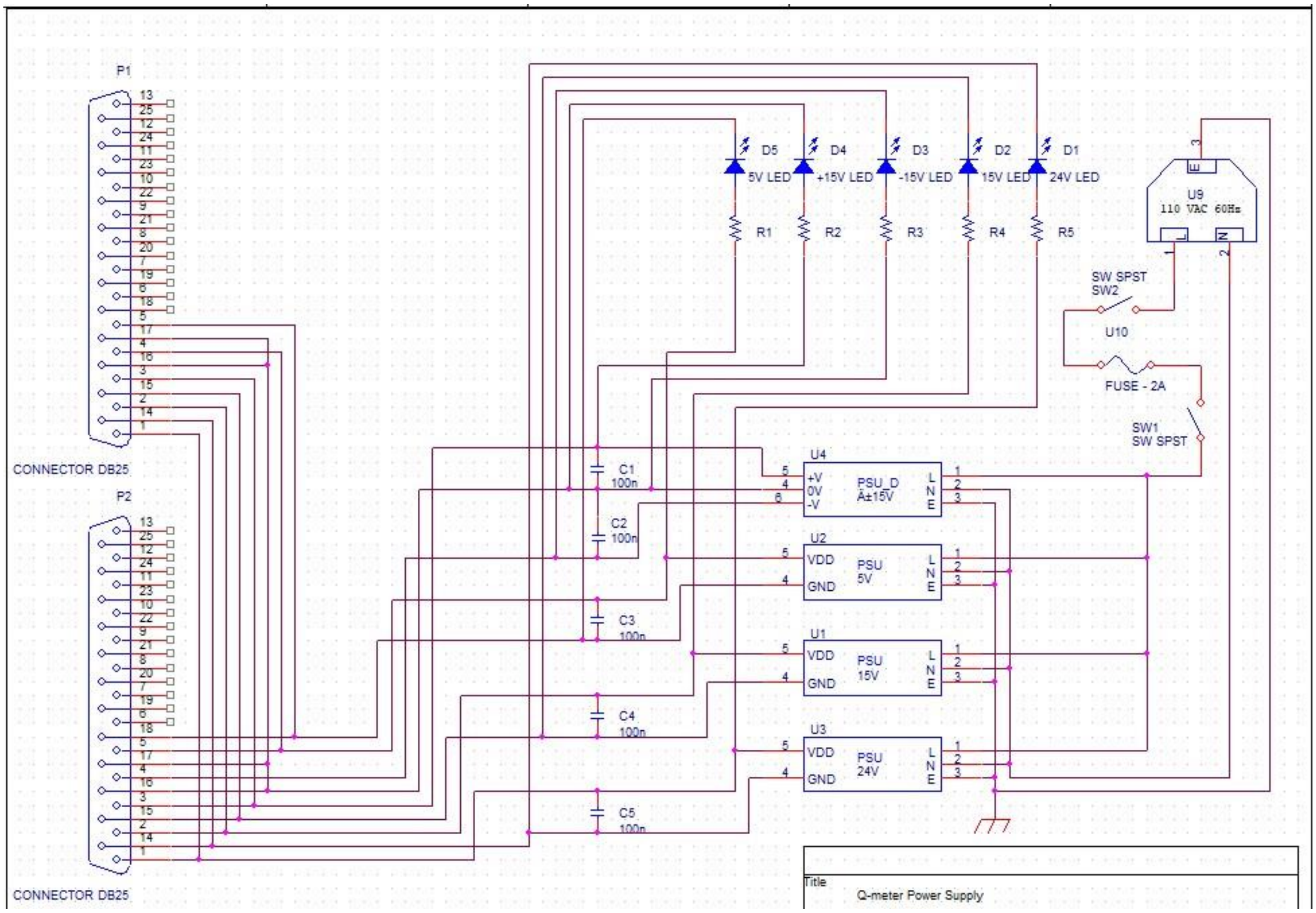


Figure 2.2: Q-meter, Yale card power supply schematic diagram

6 Q-meter

6.1 Q-meter circuitry

A block diagram of the NMR circuit is shown in Fig. 6.1. Everything except the λ/2 cable, the NMR coil, and the RF source are part of the Q-meter.

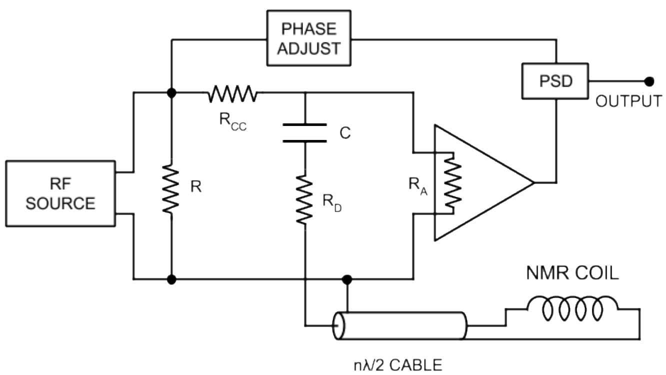


Figure 6.1: Block diagram of the NMR circuit

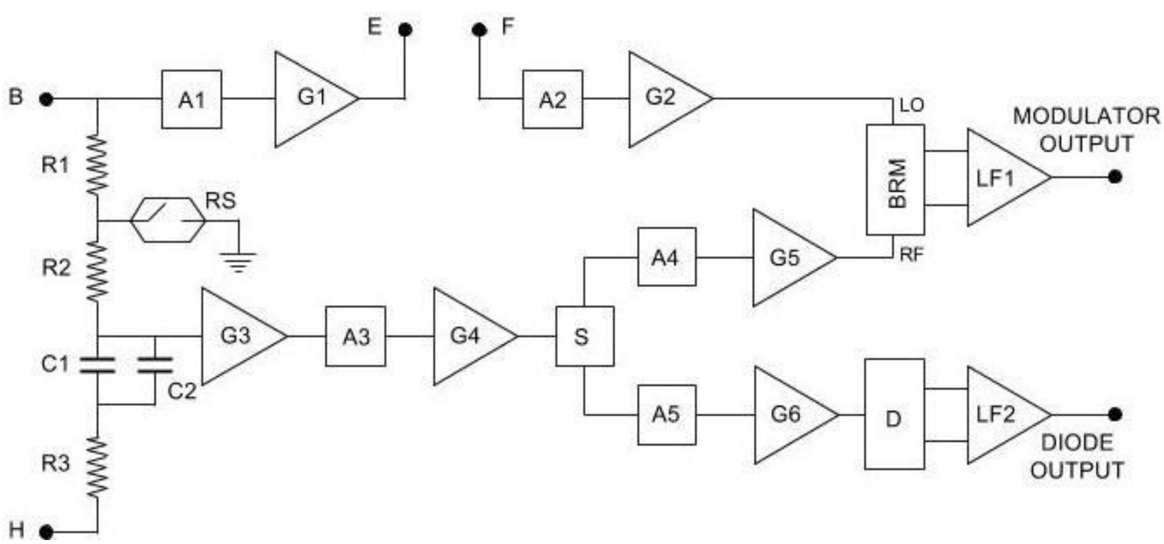
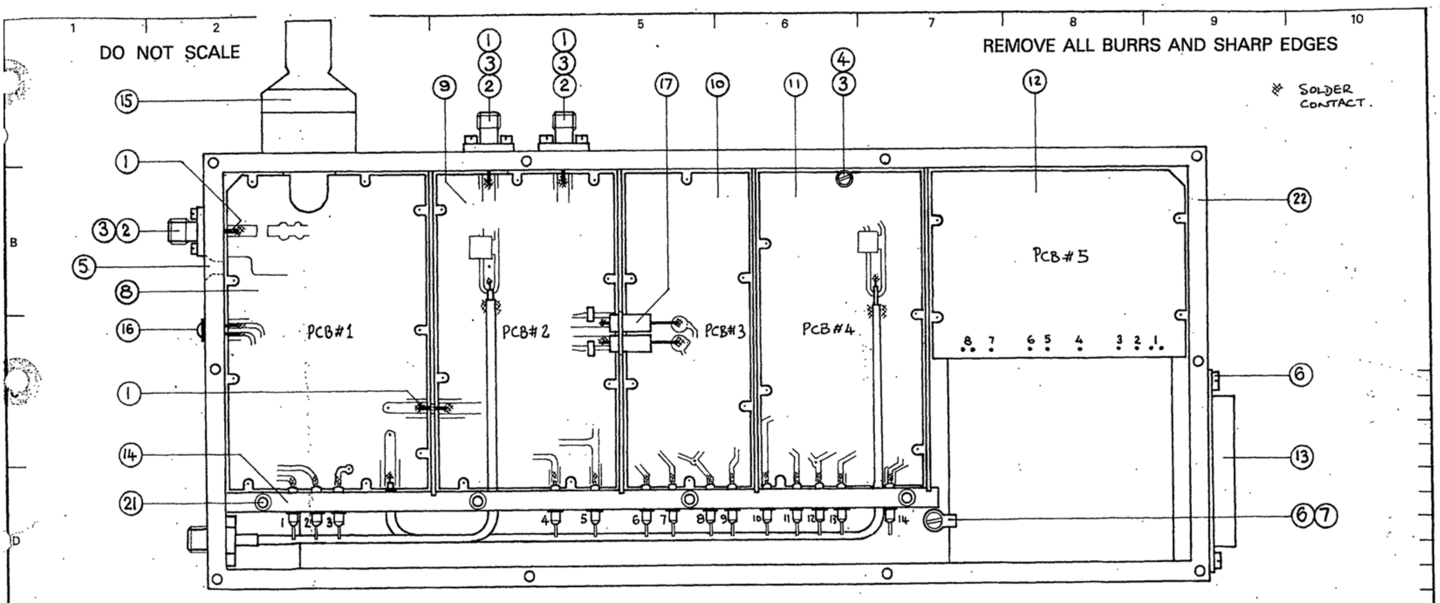


Figure 6.2: Block diagram of the Q-meter's internal circuitry. A1-5 are attenuators. G1-6 are amplifiers. R1 and R2 are the constant-current resistors, and R3 is the damping resistor. C1 and C2 are both tunable capacitors. D is a full wave diode rectifier. BRM is the balanced ring modulator. LF1 and LF2 are both differential amplifiers. S is a two-way splitter and RS is the grounding reed switch (see Refs [1,2]).

Figure 6.2 shows a more detailed block diagram of just the internal Q-meter circuitry. The RF signal generator attaches at socket B, and the λ/2 cable and coil attaches at socket H. Sockets E and F are connected by an SMA cable, the length of which is adjusted to change the phase of the reference signal.

6.2 Q-meter schematics

Q-meter's complete schematic contains five sections (labeled as PCB#1-5 in Figure 6.3) Ref [1,2]. The five PCB schematics corresponding to the five sections are shown through Figures 6.5.1 – 6.5.5.



ITEM	NAME	MATERIAL	REMARKS	DETAIL DRG.	QTY.
22	MODULE FRAME ASSY	COPPER		PTG/NMR/002	1
21	SCREW	BRASS	M2.5 x 16mm CSK/HD		4
20	RESISTOR - RF FEED 330Ω	THICK FILM	SEE PTG/NMR/001 NOTE 7		2
19	WIRE - TWISTED PAIR	PURPLE / WHITE	2 x 1/0.6mm	SAME AS SPECIFIED ON	200mm
18	WIRE - TWISTED PAIR	GREY / WHITE	2 x 1/0.6mm	PTG/NMR/010	200mm
17	INDUCTOR, 10μH		SEE PTG/NMR/001 NOTE 8		2
16	LED		SEE PTG/NMR/001 NOTE 10		1
15	CAPACITOR DRIVE ASSY			PTG/NMR/003	1
14	LEADTHROUGH BULKHEAD ASSY			PTG/NMR/011	1
13	CANNON CONNECTOR ASSY			PTG/NMR/010	1
12	PCB #5 ASSY.			PTG/NMR/009	1
11	PCB #4 ASSY.			PTG/NMR/008	1
10	PCB #3 ASSY.			PTG/NMR/007	1
9	PCB #2 ASSY			PTG/NMR/006	1
8	PCB #1 ASSY			PTG/NMR/005	1
7	SOLDER TAG		M3		1
6	SCREW	BRASS	M3 x 6mm CH/HD		3
5	SCREW	BRASS	M4 x 10mm CSK/HD		1
4	WASHER	BRASS	M2.5		33
3	SCREW	BRASS	M2.5 x 6mm CH/HD		65
2	SMA 4 HOLE FLANGE SOCKET		RADIALL R125-403		3
1	BARE COPPER WIRE		1/0.6mm		-

PARTS LIST

Figure 6.3: Q-meter layout diagram.

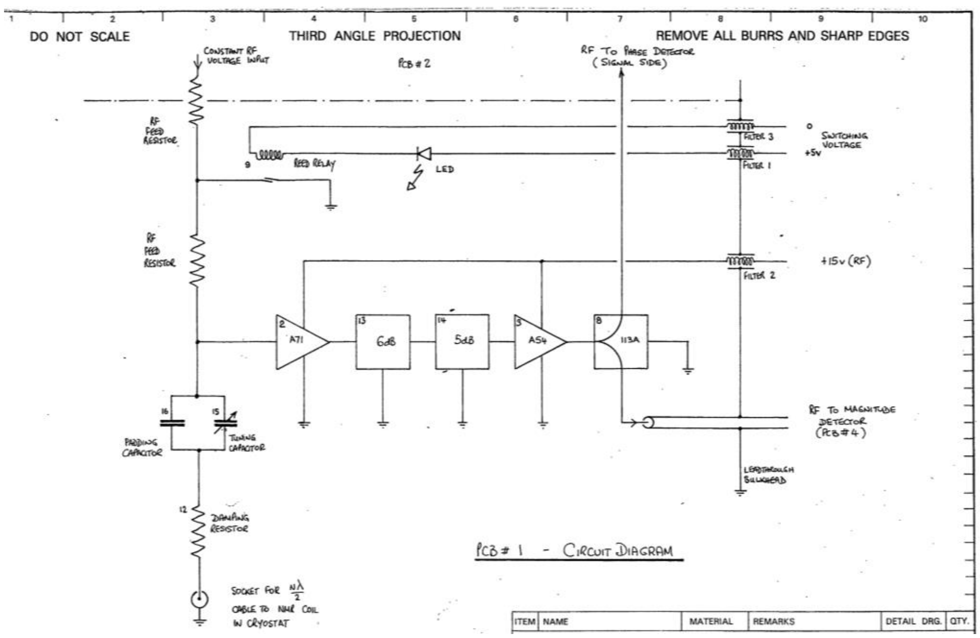


Figure 6.5.1: Q-meter's PCB #1.

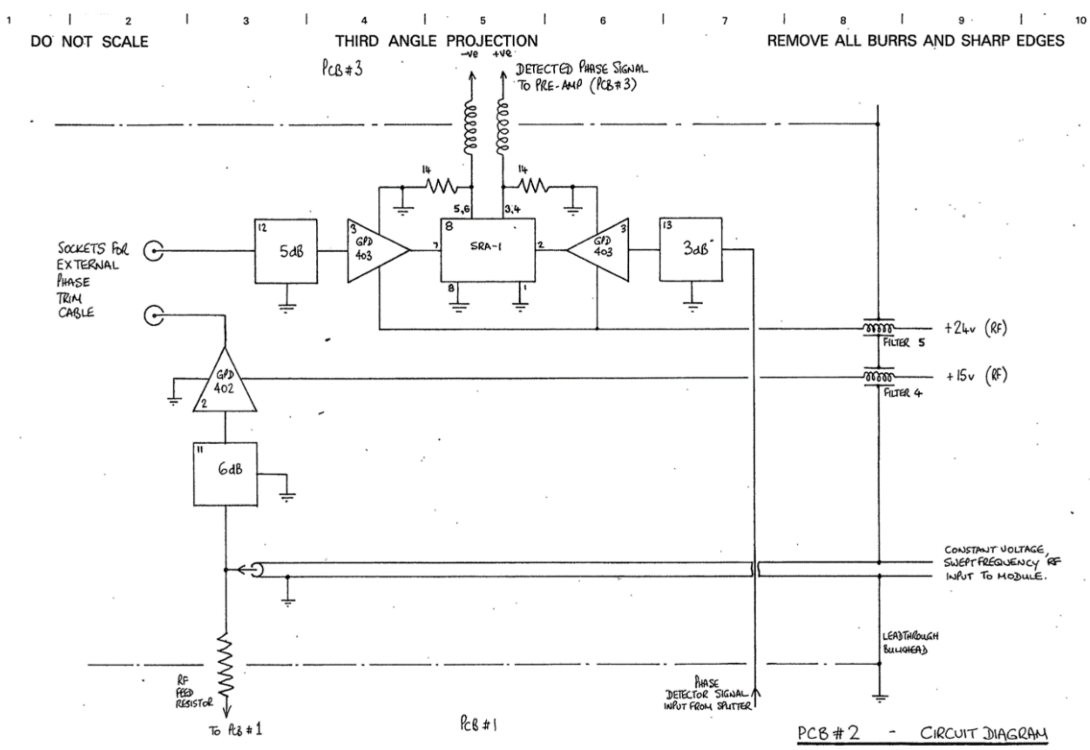


Figure 6.5.2: Q-meter's PCB #2.

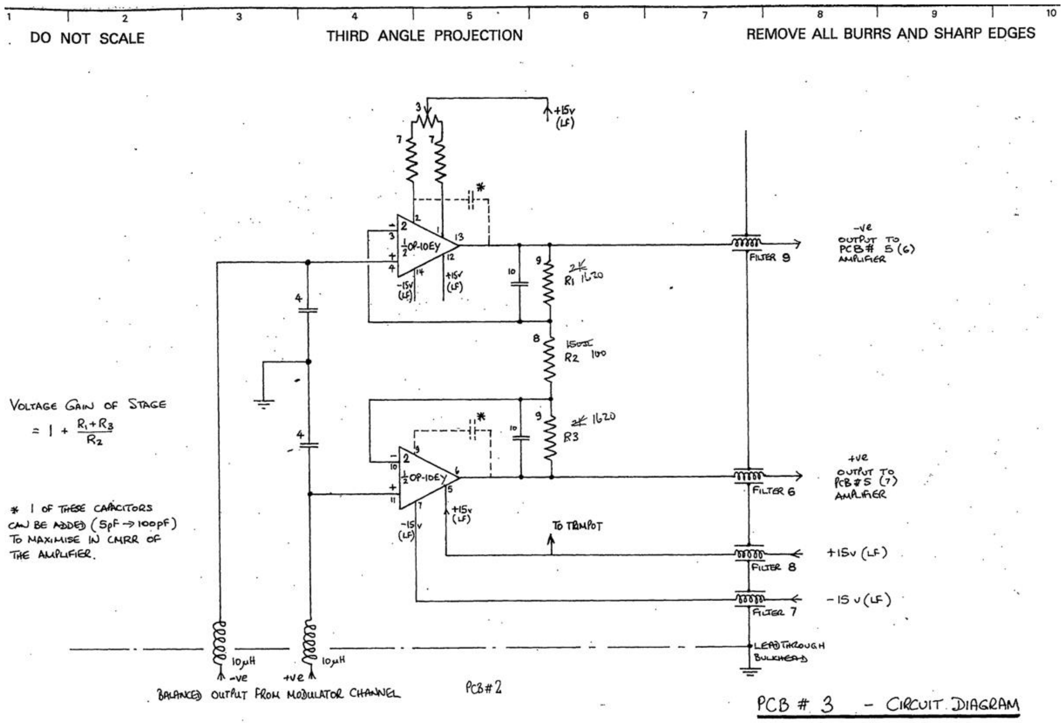


Figure 6.5.3: Q-meter’s PCB #3.

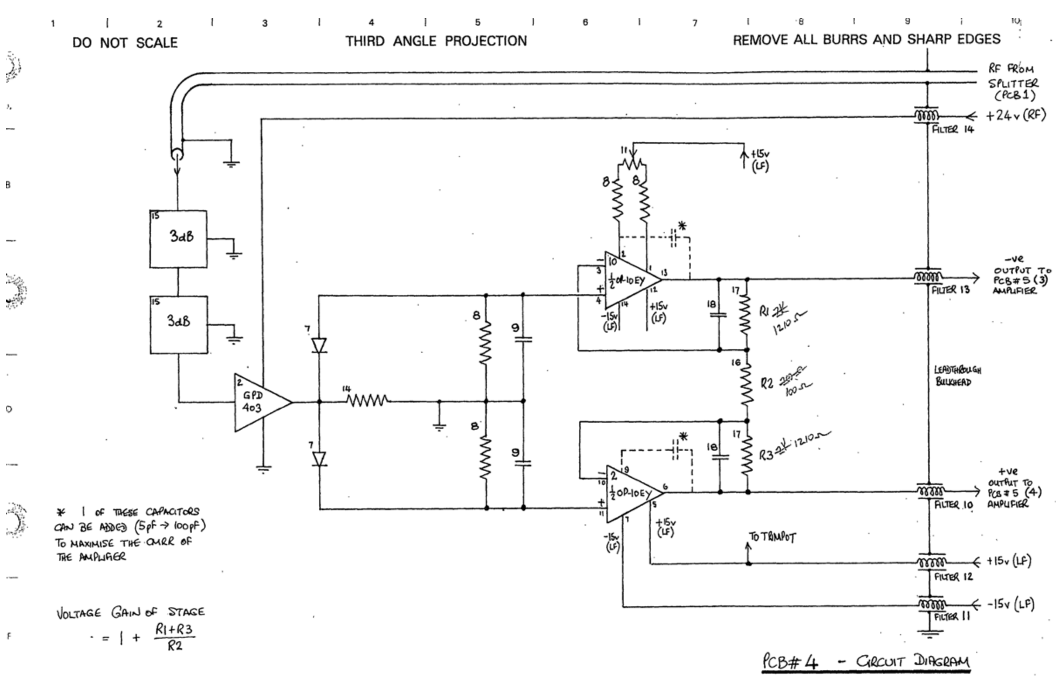


Figure 6.5.4: Q-meter’s PCB #4.

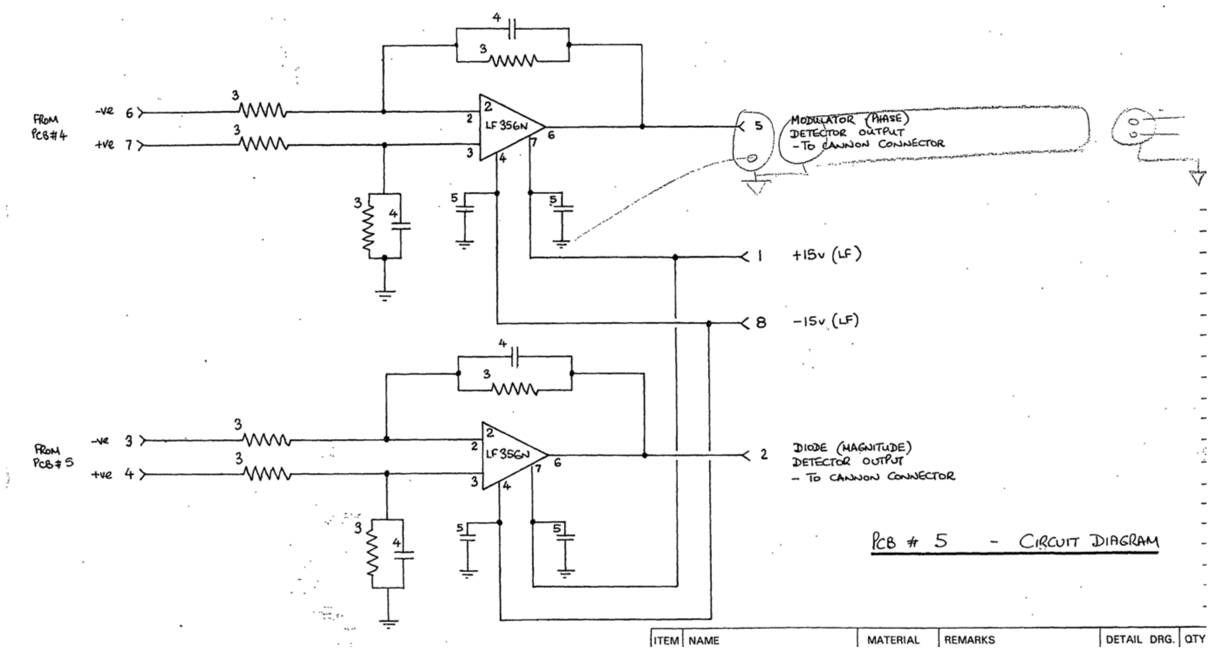


Figure 6.5.5: Q-meter's PCB #5.

6.3 Q-meter housing

(a) (b) (c)

Figure 6.6: Q-meter: (a) front-view (b) top-view (c) back-view

The circuitry just discussed is housed within a rectangular box, which is called a Q-meter. The front of the Q-meter housing, shown in Fig. 6.6 (a), has one 25D connector which accommodates the power supply input and detected outputs. The top of the housing, Fig. 6.6 (b), has two SMA sockets labeled (1) and (2). The knob (3) is a fine adjustment knob for the tuning capacitor. The back of the Q-meter is shown in Fig. 6.6 (c). An RF signal is delivered to the Q-meter through socket (1). The inductive coil is attached at socket (4). The small hole (3) is an access port which allows for coarse adjustment of the internal tuning capacitor (by inserting a small flat-head screwdriver into the access port to adjust the capacitor). The light (2) is an indicator light.

7 Yale-Card

The Yale card is a circuit board used for signal amplification and DC voltage compensation.

7.1 Yale-Card housing

Figure 7.1 (a): Yale-Card front panel

Figure 7.1 (b): Yale-Card back panel

The front of the Yale card housing is shown in Figure 7.1 (a). Power is delivered to the internal circuit board through the 15D connector (1). The 25D connector (2) connects to the Q-meter in a one-to-one manner detailed in Table 5.2.

The back of the Yale card housing, shown in Figure 7.1 (b), holds all the interface ports. There are five 3-pin LEMO connectors for Diode, Select, Signal, DC Level/DC Monitor, and Convert. The two single-pin LEMO sockets and corresponding switches control the gain settings of the Yale card.

The Yale card has three possible gain settings (1, 20, and 50) which can be controlled manually by the switches, or electronically through the LEMO sockets. When both switches are down, there is no gain. Activating the low gain switch gives a gain of 20. Activating both switches gives a gain of 50.

7.2 Yale-Card circuitry

Figure 7.2 (a): Yale card housing with the circuit

Figure 7.2 (b): Yale card housing

The internal wiring of the Yale card housing with (or without) the circuit board is shown in Figure 7.2 (a). The Yale card circuit board is plugged into the 32-pin DIN connector, which is wired to the 3-pin LEMO sockets and the 25D connector according to Table 7.2 (a). The 25D connector is also wired to the 15D power supply connector. The details of this connection, from the perspective of the 25D connector, are shown in Table 7.2 (b).

YC Pin #	Connection Pin #	Connection Name	Wire Color
1 2	NC	N/A	N/A
3	25D20	-	black
4	25D8	-	gray
5	3L	Diode	black
6	3L		blue
7	NC	N/A	N/A
8	25D23	-	black
9	25D11	-	purple
10 11 12 13 14	NC	N/A	N/A
15	3L	Convert	black
16	3L		red
17	-	Reed Switch	black
18	-	H Gain switch	green
19	-	L Gain switch	green
20 21	NC	N/A	N/A
22	3L	Phase/Signal	black
23	3L		orange
24	3L	DC Monitor/Level	black
25	3L		gray
26	NC	N/A	N/A
27	25D4	-	blue
28	NC	N/A	N/A
29	25D17	-	black
30	25D16	-	black
31	25D3	-	red
32	NC	N/A	N/A

Table 7.2 (a): Internal wiring of Yale card Liverpool housing.
(The notation 3LX refers to pin X of a 3-pin LEMO connector)

Pin #	Connection Pin #	Wire Color
25D1	15D1	pink
25D2	15D2	orange
25D3	15D3, YC31	red
25D4	15D4, YC27	blue
25D5	15D5, RR	
25D6	NC	N/A
25D7	NC	N/A
25D8	YC4	gray
25D9	NC	N/A
25D10	NC	N/A
25D11	YC9	
25D12	NC	N/A
25D13	NC	N/A
25D14	15D9	black
25D15	15D10	black
25D16	15D11, YC30	black
25D17	15D12, YC29	black
25D18	RR	white
25D19	NC	N/A
25D20	YC3	black
25D21	NC	N/A
25D22	NC	N/A
25D23	YC8	black
25D24	NC	N/A
25D25	NC	N/A

Table 7.2 (b): Wiring of the Yale card 25D connector.

7.3 Yale-Card schematic

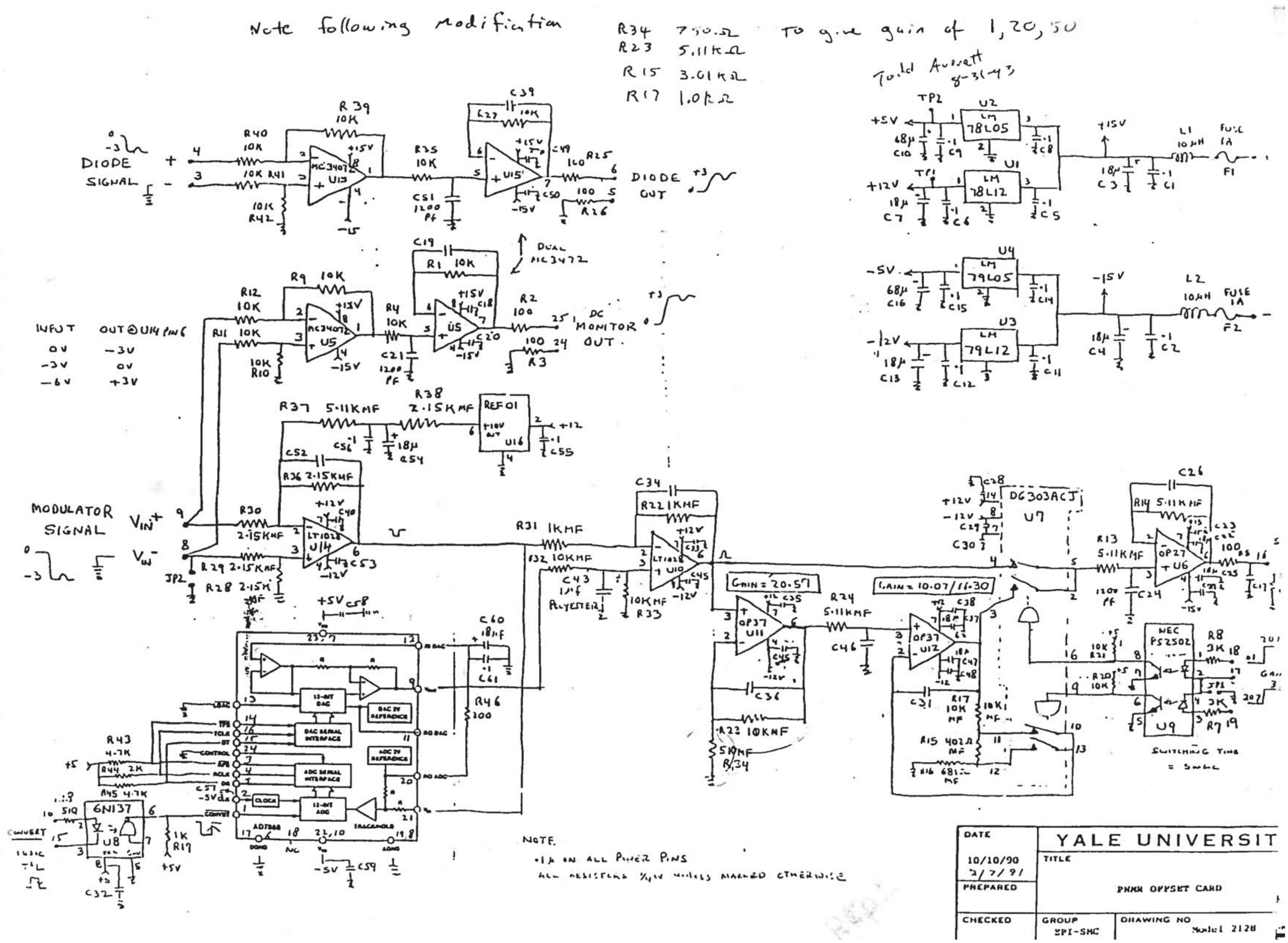


Figure 7.3: Yale-Card schematic (see Ref. [5])

8 Safety

Any component of this UVA-NMR system doesn’t use high voltage or high current. RF signal generator is scanning only up to ~220 MHz. There is about nano-Watt level field strength will be exposed by the crystal that is used to tune the UVA-NMR system, and it is considerably small.

9 References

[1] BNC-2090 manual

[2] BNC-2115 manual

[3] NI SCB-68A manual

[4] NI PXle-1071 manual

[5] RF generator SMT 02 manual

[6] Oscilloscope (Tektronix TDS 3054B)