Run II – Calorimeter Calibration System

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The Electronic Calibration Calorimeter System

The D0 Calorimeter Calibration System consists in twelve identical units used for the Liquid Argon Calorimeter and one slightly modified unit for the Intercryostat Detector (ICD). Each unit (fig.1) is composed of one pulser control board, its power supply and six active fanout boards, three for each half of a pre-amp box. The pulser control boards are controlled via a serial bus to a VME IO register or a DIO interface, which allows to set the amplitude and delay of the calibration signal and to select the channels to pulse. The pulser control board delivers a DC current corresponding to the chosen pulse height for each selected channel to the fanout boards. When a trigger signal from the Timing and Control Card (TCC) is received, a command signal, delayed by the value previously set, is sent from the pulser control board to the fanout, where the calibration pulse is generated and injected into the preamplifiers.

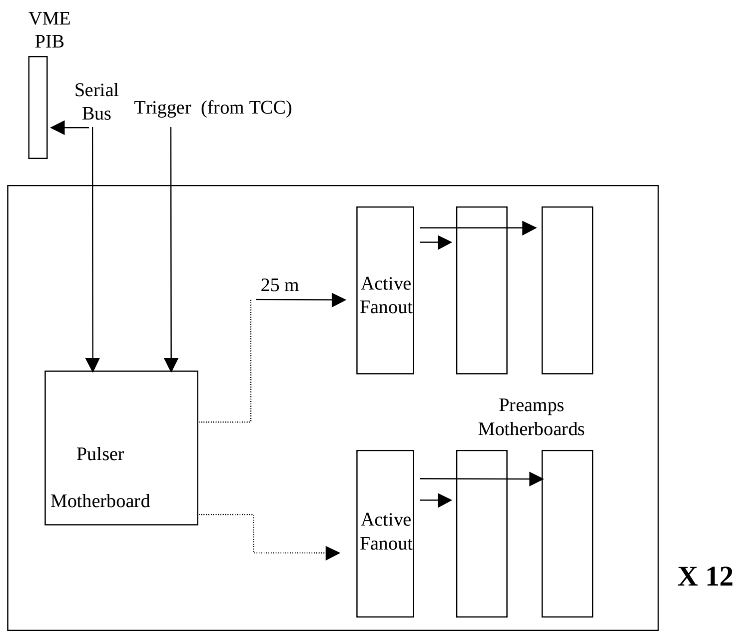

Figure 1: Outlay of the Calorimeter Calibration System

For the final installation of the calibration system in the D0 detector, the pulsers and their power supplies are located below the liquid Argon cryostat for the calorimeter and in the rack P07 for the ICD. The active fanout boards replace the former passive fanouts in the preamplifier boxes, which are located on the upper part of the liquid Argon cryostat. The main advantage of this scheme is that only DC currents and logic signals are sent via long cables, whereas the pulses are generated close to the preamplifiers.
The pulsers are controlled from a GUI running on a PC through the D0 online system. A pulser interface board (PIB), installed in the VME crates of the calorimeter on the third floor of the movable counting house, translates and sends the setting parameters to the pulsers.

The Pulser Control Board

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The purpose of the pulser control board is to deliver a DC current to the active fanout and to send a command signal that initiates the formation of a pulse on the active fanout. The DC current can be enabled for up to 96 different channels and its intensity determines the pulse height. The command signal can be delayed and enabled separately for each of the six fanout boards in one pre-amp box.

Figure 2 shows a schematic outlay of a pulser control board. The complete schemas are given in the appendix. Each pulser includes:

- 1 serial bus interface.
- 1 channel enable register.
- 2 18 bits DAC.
- 6 programmable delays.
- 96 DAC controlled current generators.

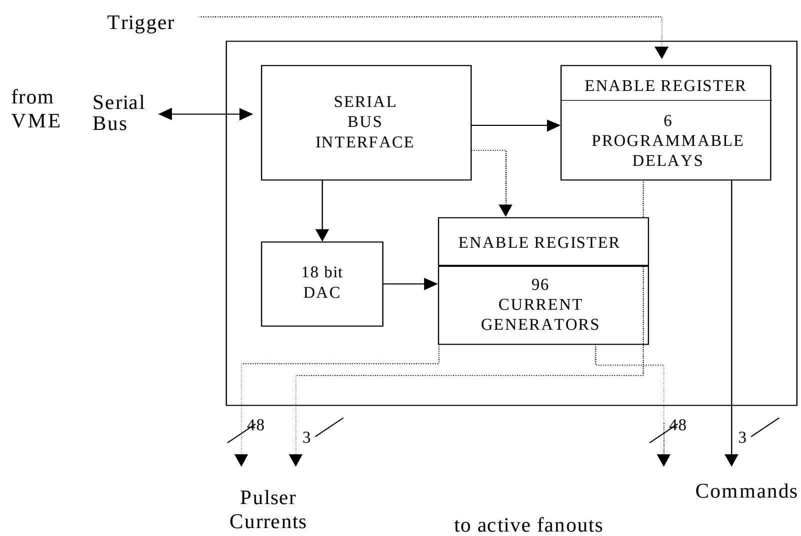

Figure 2: Outlay of the Pulser Control board.

The serial bus, which allows to set the DAC, the delay and the current and command enable registers is made of 4 lines:

- 1 enable which initiates the handshake.
- 1 strobe.
- 1 data in to write in the modules.
- 1 data out to read.

On the reception of a trigger, 6 delayed commands are sent to each active fanout. The commands are differential ECL signals and are sent through the existing 75 Ω cables. Up to 12 DAC controlled currents are sent to each of the fanout board via shielded twisted pair cables. These cables deliver also –5.2 V and +5V for the power supply of the fanout boards, each of them is fused. The DC current per channel is limited to 100mA and the maximum value typically used about 70mA. The voltage to current conversion is performed with a low offset op-amp, a Darlington transistor and a 0.1% precision resistor. The current can be switched off with via the enable register. When the Power is switched on, all currents are disabled.

The pulser control boards are made of 10 layer printed circuit boards with power and ground planes separating layers containing signal traces to minimise cross talk between fast commands and DC currents. All components are located on the upper side of the board. The pulser control board is enclosed in a metallic box with all connectors placed on the back panel (figure 3):

- 1 BNC : input trigger
- 12 SMA : output commands
- 12 HE10 : output DC currents
- 1 JAEGER : power supply
- 2 HE10 : serial bus input VME/DIO

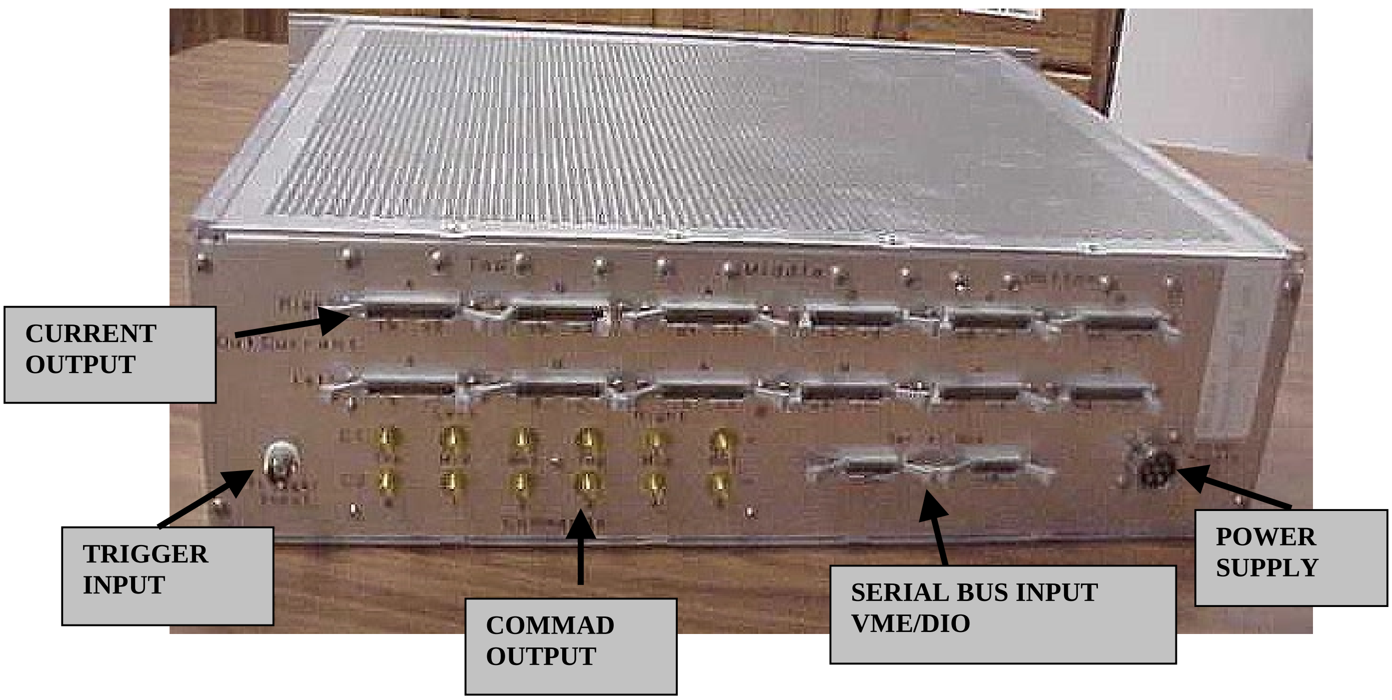

Figure 3: Back Panel of the Pulser Control Board

On the front panel of the pulser (figure 4) various LED indicators are located:

- 1 address indicator.
- 1 power indicator.
- 1 trigger.
- 96 current enable.
- 6 command enable.

These LED indicators will be used for debugging and controlling the status of the pulser boards during the commissioning of the calorimeter electronics and in case of detector access.

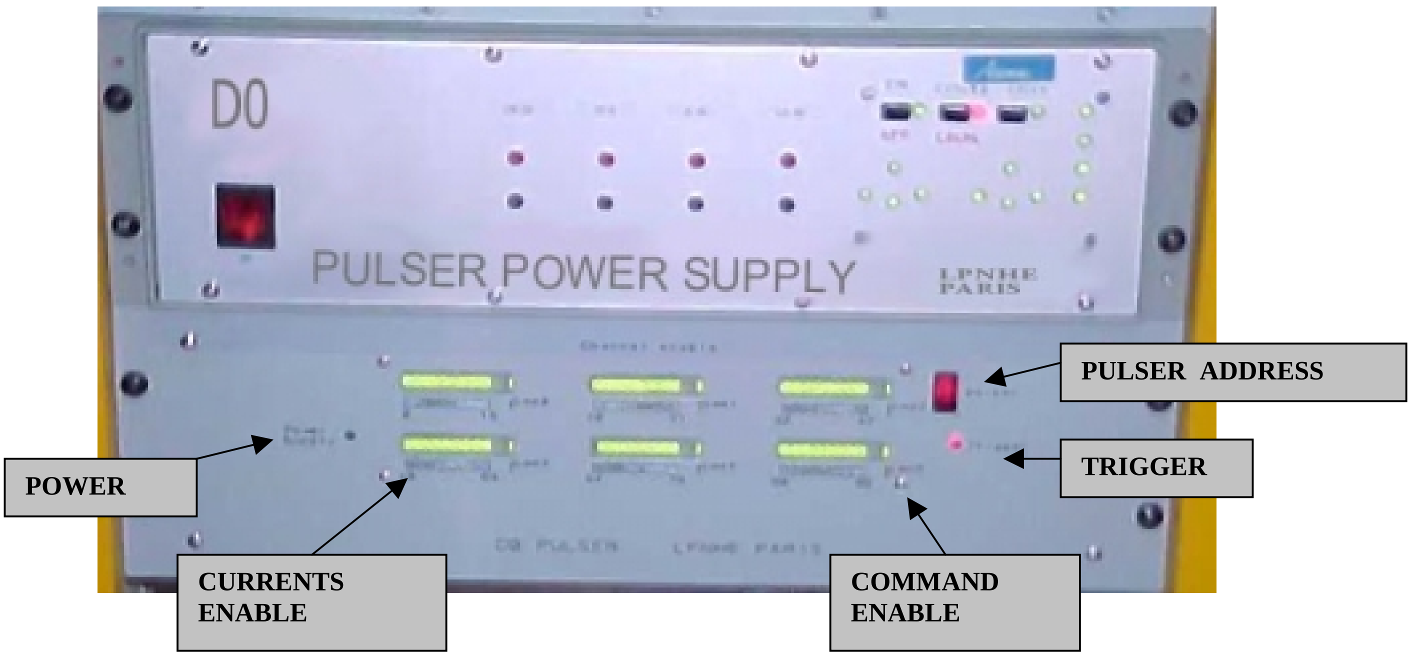

Figure 4: Front Panel of the Pulser Control Board and the Pulser Power Supply

The Pulser Power Supply

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The pulser power supplies deliver four separate voltages to each of the 13 pulser control boards. The power levels are 12V @ 4Amps, 5.8V @ 25Amps, 5V @ 10Amps and -5.2V @ 10Amps. A pulser power supply is built around two commercial VICOR FlatPAC autoranging AC-DC switchers. Testing has shown that the supply works in a magnetic field of 300 Gauss, which is the maximum value of the field expected under the liquid Argon cryostat. In order to reduce the effect of field, the two VICOR modules are enclosed in a drilled steel box (figure 4).

The supplies are fused on the primary AC input and the DC output. A solid state 3-phase relay is used to control application of AC power to the VICOR FlatPAC modules. The same monitoring system as for the Calorimeter pre-amp Power Supply is implemented, so that the voltages and currents can be monitored via the D0 slow control system. This monitoring board contains also local On/Off, Reset and Local/Remote switches on the front panel, allowing to select the operation mode. LED indicators on the front panel are showing the status of the supply.

The VICOR supplies provide monitoring signals for Phase Fault, Over Temperature Warning and AC Power OK, that will be inputs to the logic control circuitry:

- the Phase Fault signal, which is active high, drops low when the input reaches the over-current level of 30 Amps due to a missing phase or severe line imbalance.
- the AC Power OK signal, active high, will drop low about 3ms before the output regulation is lost. An AC Power Fail signal is the complement of the AC Power OK.
- the built-in analog temperature sensing generates a signal of 2.5V/25ºC and has a range of 0-100ºC. The Over Temperature Warning signal, normally high, drops low somewhere between 65-76ºC. The recovery point is 1ºC below the actual trip point. The built-in protection is activated when the inlet temperature exceeds 70-81ºC. Recovery is 10ºC below the actual trip level. This signal is directly ANDed with the External Interlock signal and controls the 208 AC input by operating the solid state relay.

The supply is automatically turned off under two fault conditions:

- the first condition occurs when a monitored supply exceeds a preset level for more than 8 milliseconds. This can be considered a normal fault condition. This type fault inhibits the outputs of the VICOR and latches the fault until cleared.
- the second condition occurs when either an External Interlock, phase fault or temperature warning from the VICOR is false. The main 208 AC power to the supply will be removed when this occurs. The idea here is that a more serious fault or problem has happened and more direct measures should be taken. This might be caused by a direct failure of a module which does not respond to a normal inhibit signal or smoke or water was detected.

A third and final level of protection are in-line fuses on each output of the supply. These ensure that wire currents do not exceed a safe level. The fusing will be above the normal operating levels and should not open under a normal fault condition.

Logic control is implemented with a programmable logic gate array. This provides the best flexibility and size reduction for the power supply system. The Control power (+5V and +/-15V) is delivered by a separate supply that will be ON whenever the AC is applied to the box. This small supply has a line fuse. An additional temperature sensor is instrumented to reflect the plate temperature for the current sensing shunts.

The Active Fanout Board

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The active fanout boards generate a pulse from the DC current and the command signal delivered by the pulser control board. The fanouts are locate inside the pre-amp boxes: one rail, composed by three fanout boards, calibrates one half pre-amp box. The fanouts are 6 layer boards, with power planes (+5V, -5.2V) and ground. The components on one fanout board are listed in table 2. The fanout boards schemas are given in the appendix.

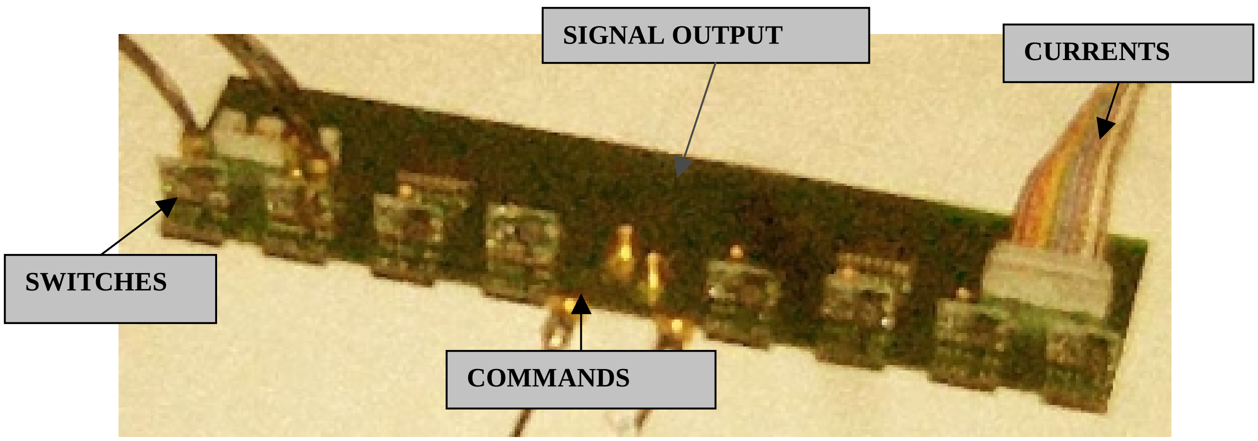

Figure 5: Active Fanout Board with Switches and cables

Description	Reference	Quantities
ECL to TTL translator from Motorola.	MC10125P	2
Surface mounted polarized (tantal) capacitance 10µF, 20V	CPOL	4
Surface mounted capacitance. 100nF, 100V, 5%	CAP0805	6
Surface mounted resistor. 150Ω, 125mW, 1%	RES0805	4
Surface mounted resistor. 30Ω, 125mW, 1%	RES0805	32

Table 1: Components on the fanout boards.

Each fanout control board contains 16 switches, which convert DC current to a calibration signal. The switches are plugged vertically into sockets which are surface mounted on the fanout board. Each switch pulses 2 channels. The principle of the distributions is shown in figure 6. The switches are 2 layer boards with a ground plane. The components on one switch are listed in Table 2. The switch schemas are given in the appendix.

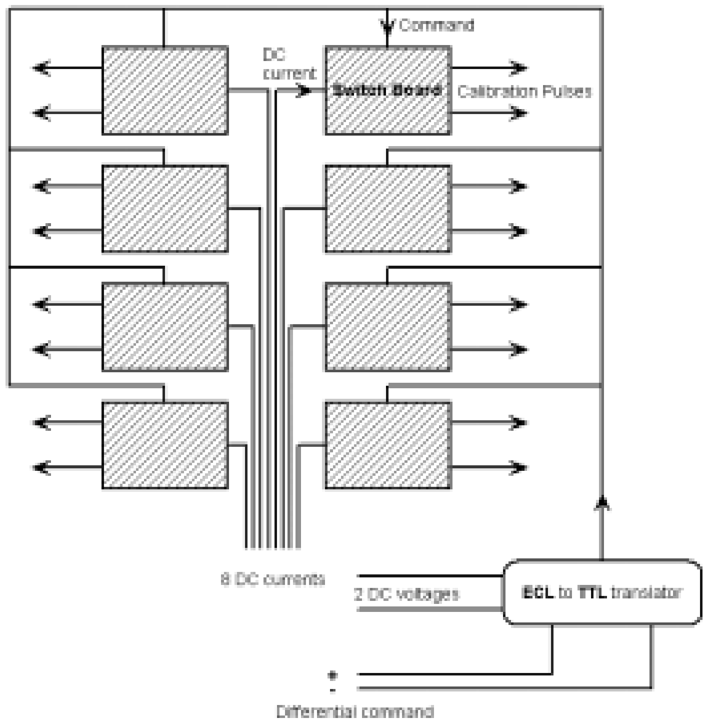

Figure 6: Principle of half a fanout board.

Description	Reference	Quantities
NPN transistor from Phillips. SOT23	BFR92A	1
PMOS transistor from Fairchild. SOT23	FDV302P	1
Surface mounted capacitance. 390pF, 100V, 1%	CAP0805	1
Surface mounted resistor. 100Ω, 125mW, 1%	RES0805	1
Surface mounted resistor. 82Ω, 125mW, 0.1%	RES0805	1
Inductance from Banelec. 1mH, 10%.	3090F	1

Table 2: Components on a switchboard.

The power consumption of a fanout board is divided in three “modes”.

- The “offline” power consumption corresponds to the 10125 chips with no command. This consumption is 40mA*5V on positive and negative supplies giving 400mW per chip.
- The “online” chip power consumption, which corresponds to the 10125 chips with a command signal driving all the switchboards. As each switch board plugged consumption is a mean of 5mA of positive supply (command *ON* with the “worst case duty cycle” 0.5), the maximum current consumption for the 10125 chip is 80mA on +5V and 40mA on –5V and then consumption is 400mW on voltage + and 200mW on voltage -, then 600mW per chip.
- The DC current value flowing (I_o) in each switchboard raises from 0 to 70mA typically, 100mA maximum. This current is dissipated in a 5Ω load (resistance of the inductance). Then the maximum power dissipation is 40mW per switch.

Thus the power dissipation for one fanout board is:

- 2*200mW = 400mW when the board is “offline”.
- 2*600mW + 16*50mW = 2W when accidentally all the maximum currents are reached on all the channels. This is a theoretical consumption, as the DC currents are limited per pulser (as seen in another section).

The DC voltages are protected by fuses on the pulser board. As seen previously the maximum current consumption for the 10125 chip is 100mA on +5V and 38mA on –5V. One pulser drives 12 chips, then 1.2A on +5V and 0.46A on –5V. A standard 2A fuse can be used.

The fanout board power dissipation stays in usual norms, and there appears no intrinsic fire risk. The current is limited by the line resistance value, and the total current per fanout board is overall limited at the emission by the pulser.

The fanout boards are connected to the pulser control board with 2 flat cables and 2 coaxial cables, and to the back plane of the pre-amp boxes with 2 short cables (figure 7). Each flat cable provides 8 DC currents proportional to the pulse height and 2 DC voltage for the powering of the fanout boards, whereas the coaxial cables provide the command signal. The pulser sets DC currents in flat cables (from 0 to 70mA) and sends a differential command to the fanout board. The command switches the DC current from ground to a load, which shapes the calibration signal.

The flat cables are approximately 25 meters long. Their lineic resistance is 8mΩ/meter and their total resistance per channel is roughly 2Ω. As the current sources have a 5Ω impedance in series, and 5Ω on the switchboard, and as the maximum power supply is 5V, each channel is internally limited to 5V/12Ω = 417mA.

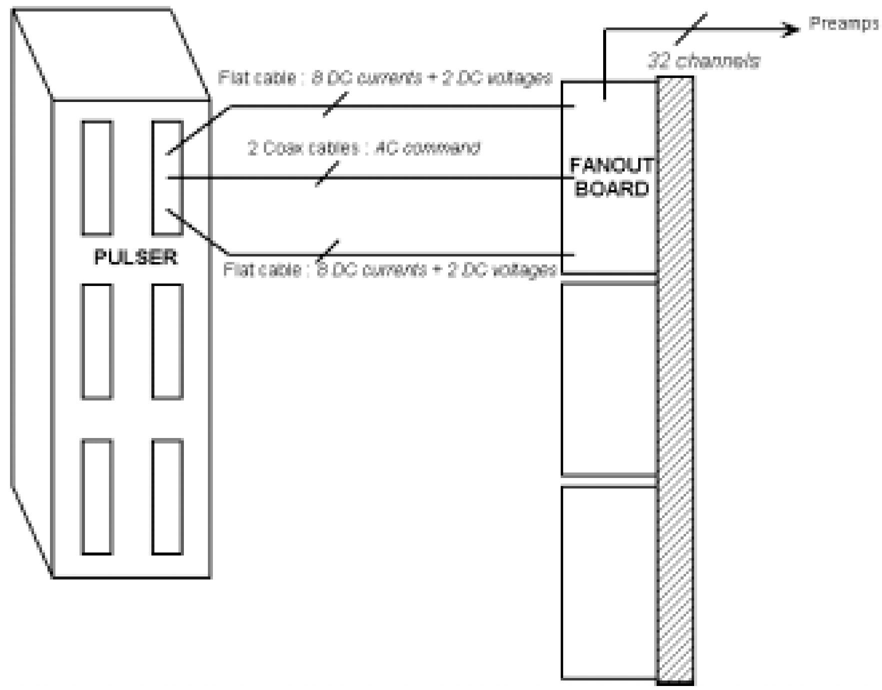

Figure 7: General cabling between pulser and fanout boards.

The cable characteristic is the followings:

- Section: 10 channels * 2 (ground and signal) * 0.22 mm^2

- Cable weight: 115 g/meter
- Temperature range: -5°C to 80°C
- Nominal Voltage: 30V
- Nominal capacitance between conductors: 40pF/m
- Nominal capacitance conductor-screen: 75pF/m
- Characteristic impedance: 109Ω
- Minimum insulation resistance: 2.5KΩ.m
- Bending radius: 12 x D
- Flame retardant in accordance to UNE 20.432 p.l (IEC 332-1)

According to the specification AIR 7822, the maximum current per channel (section 0.22mm2) is 4A (ten times the overall maximum current possible in case of worst dysfunction –see previous section)

APPENDIX: Schemas

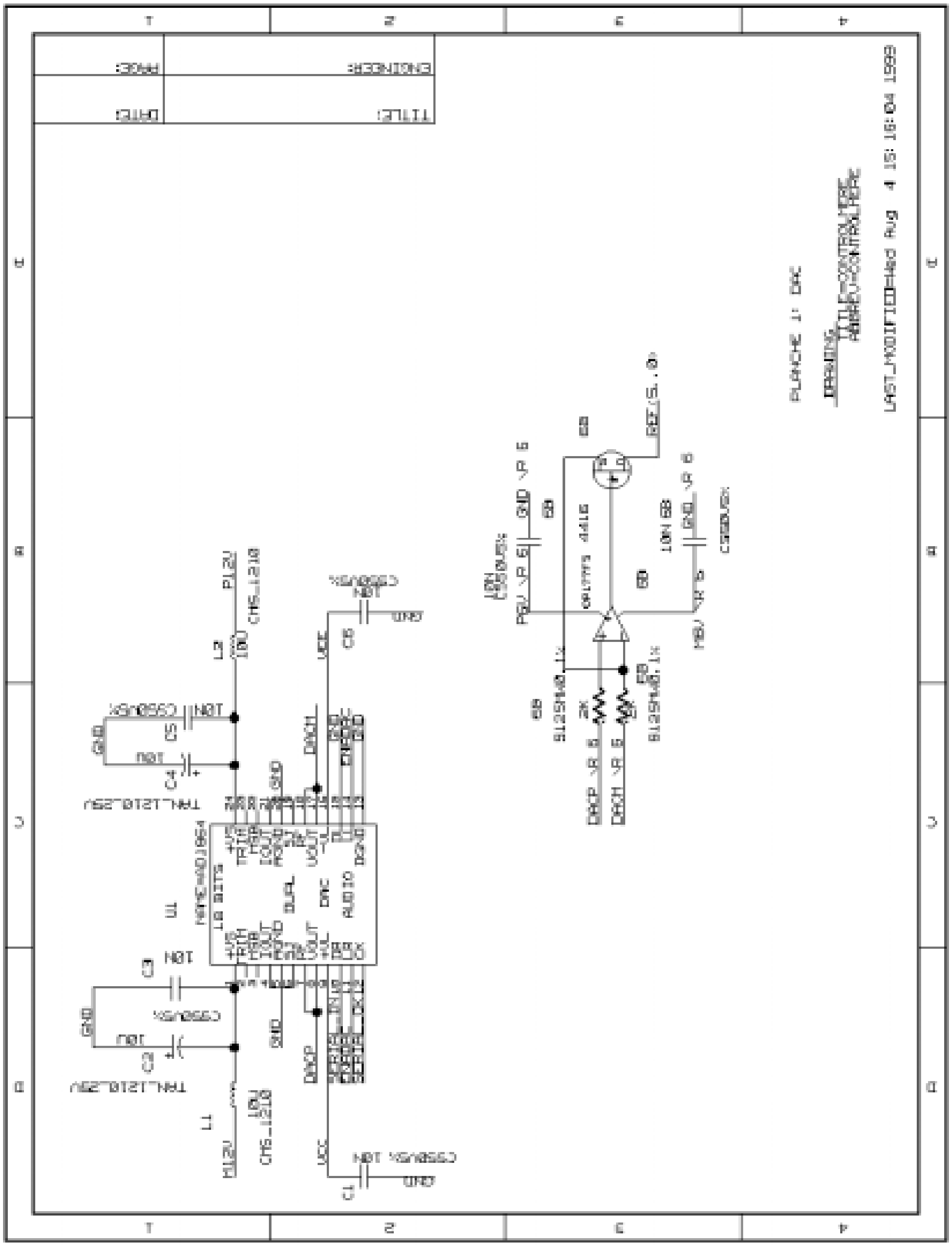

Figure 8: Schema of the Pulser Control Board – DAC

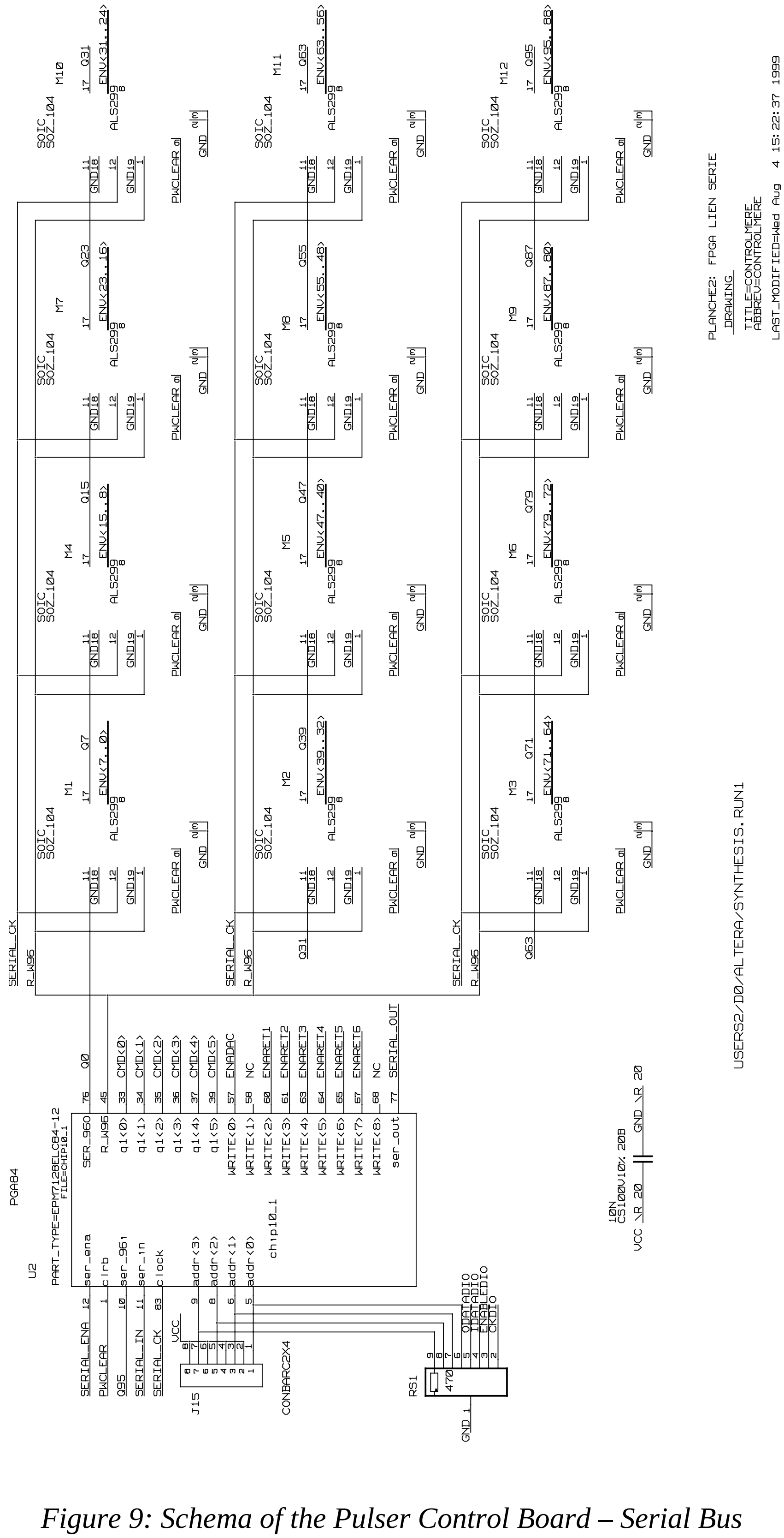

Figure 9: Schema of the Pulser Control Board – Serial Bus

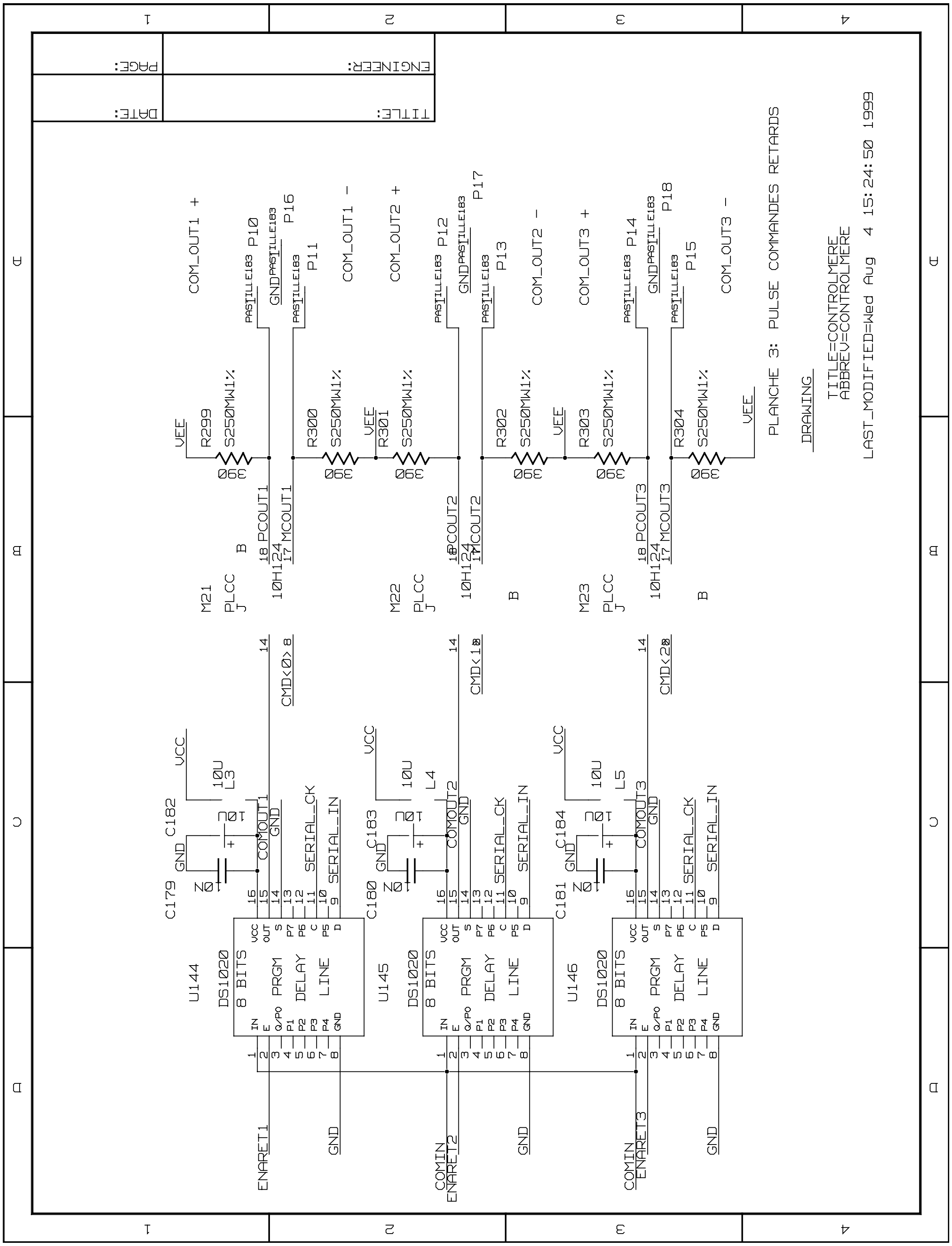

Figure 10: Schema of the pulser Control Board – Command Delays

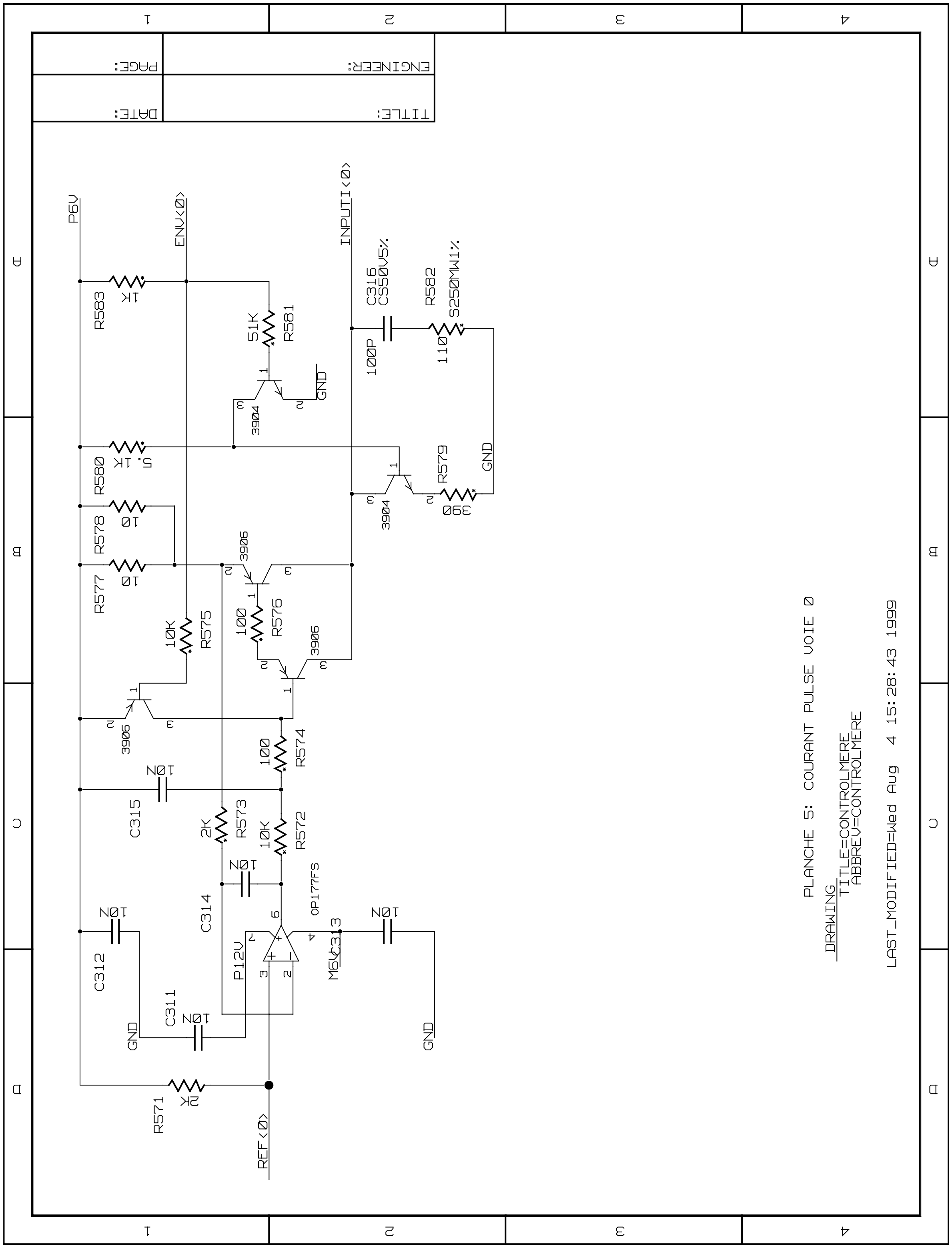

Figure 11:Schema of Pulser Control Board – Pulse Current

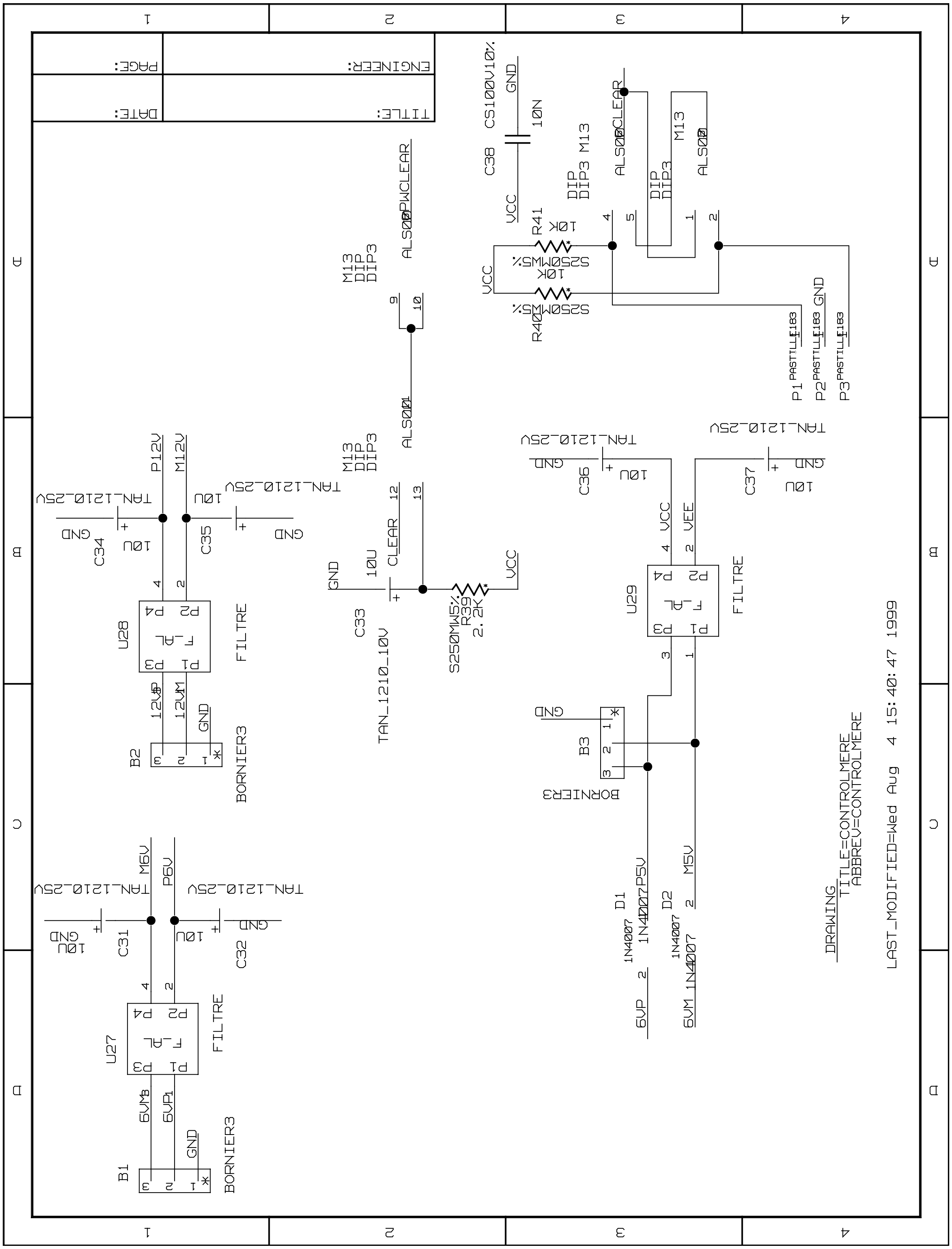

Figure 12: Schema Pulser Control Board

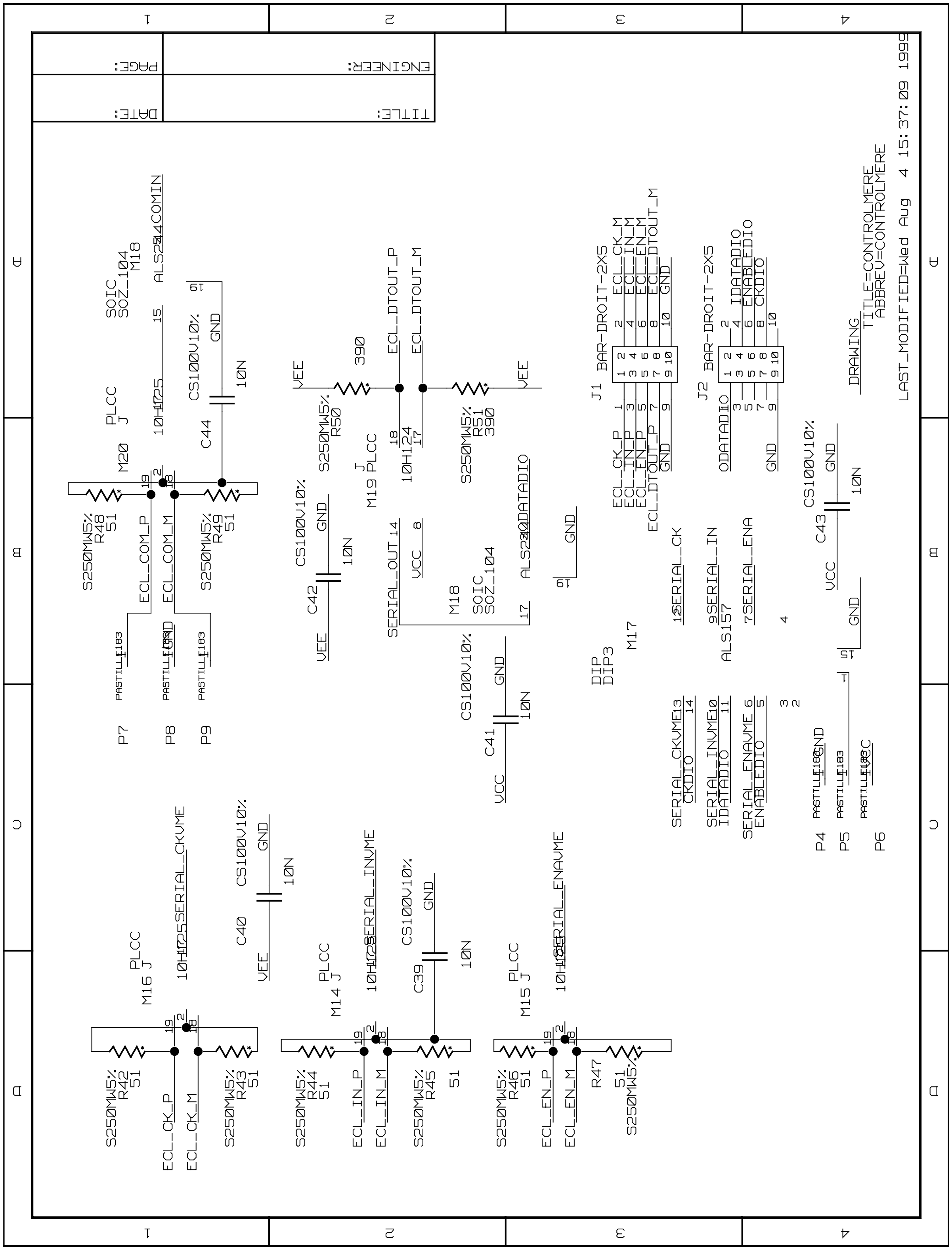

Figure 13: Schema Pulser Control Board

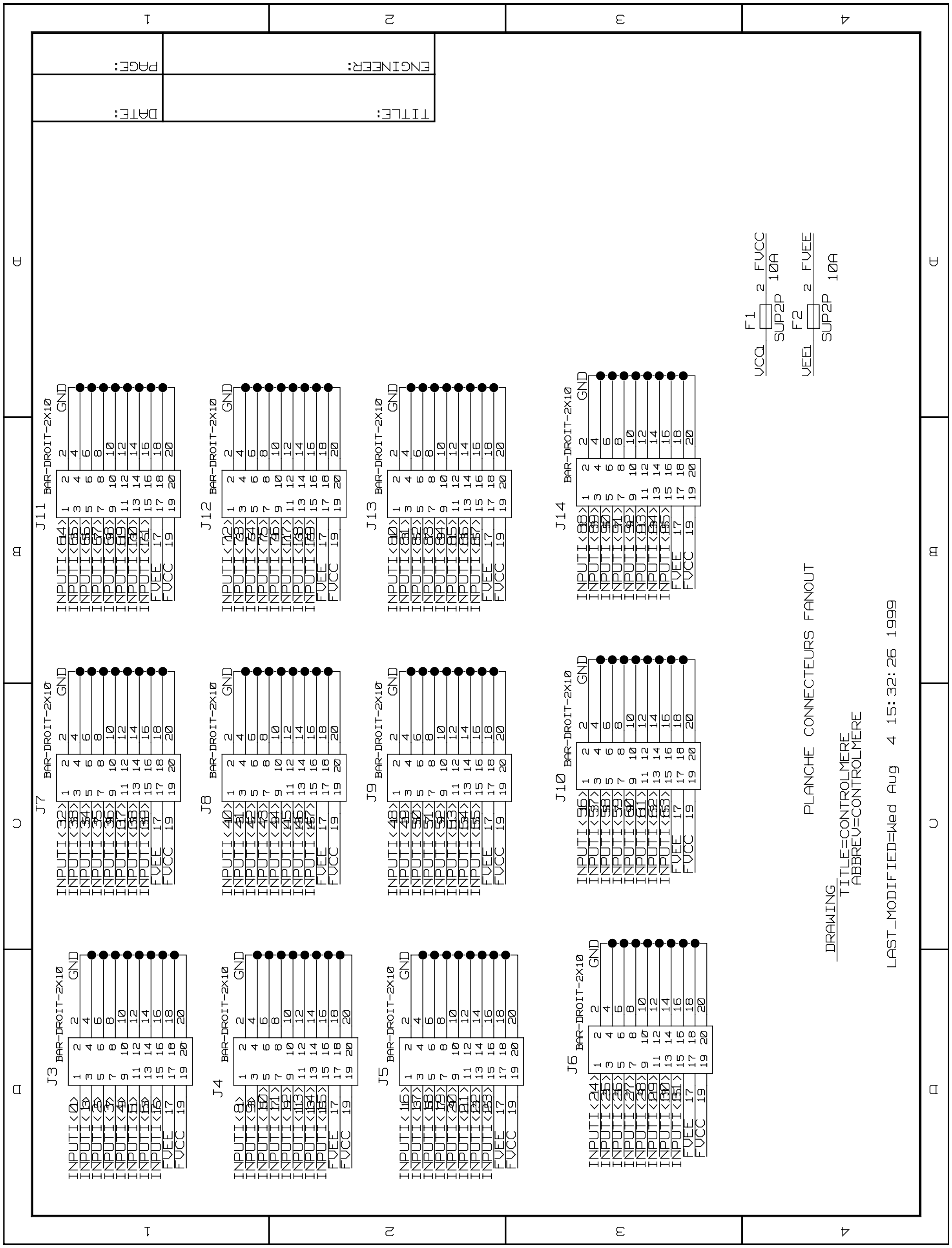

Figure 14: Schema Pulser Control Board – Connector Fanout

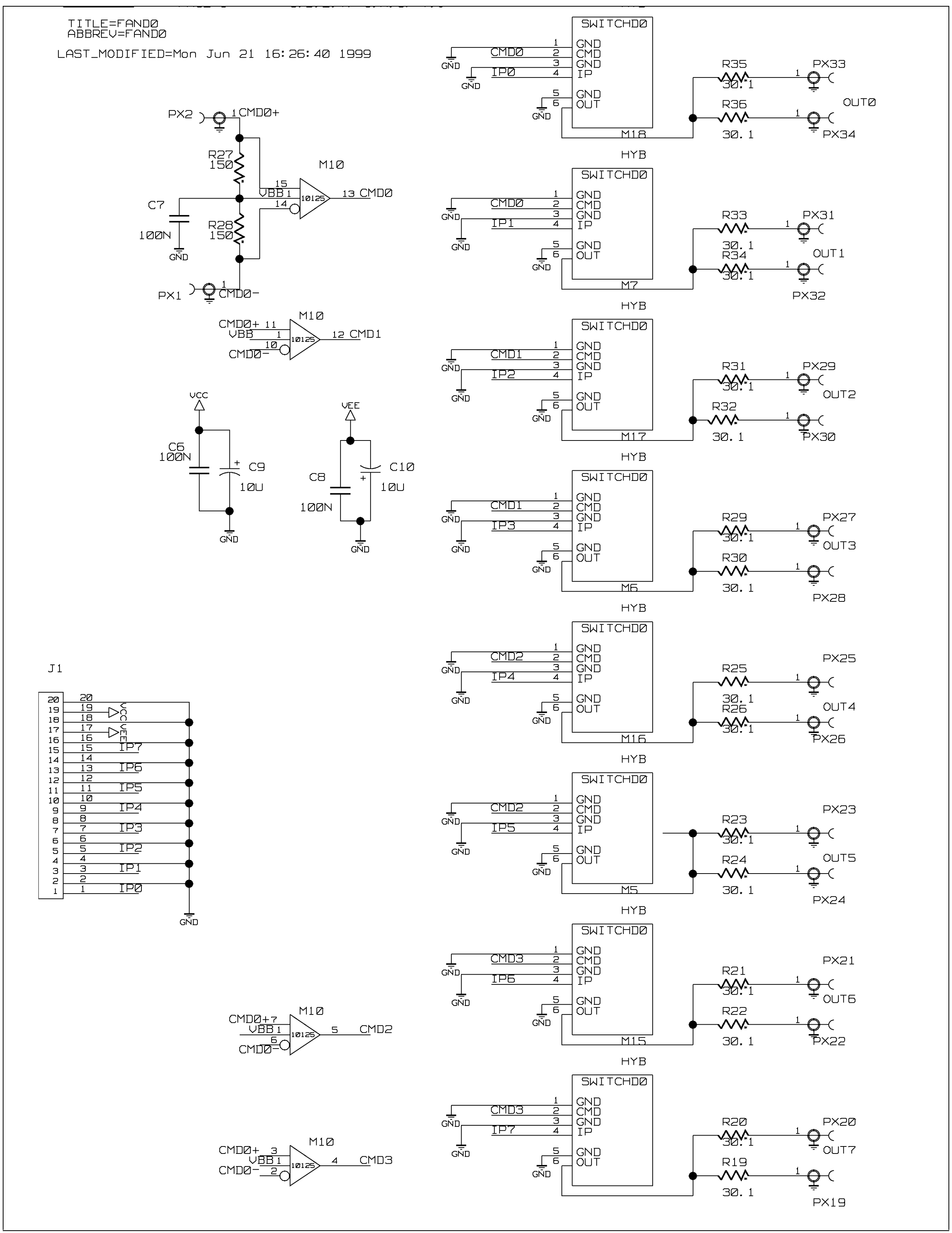

Figure 15: Schema Fanout Board

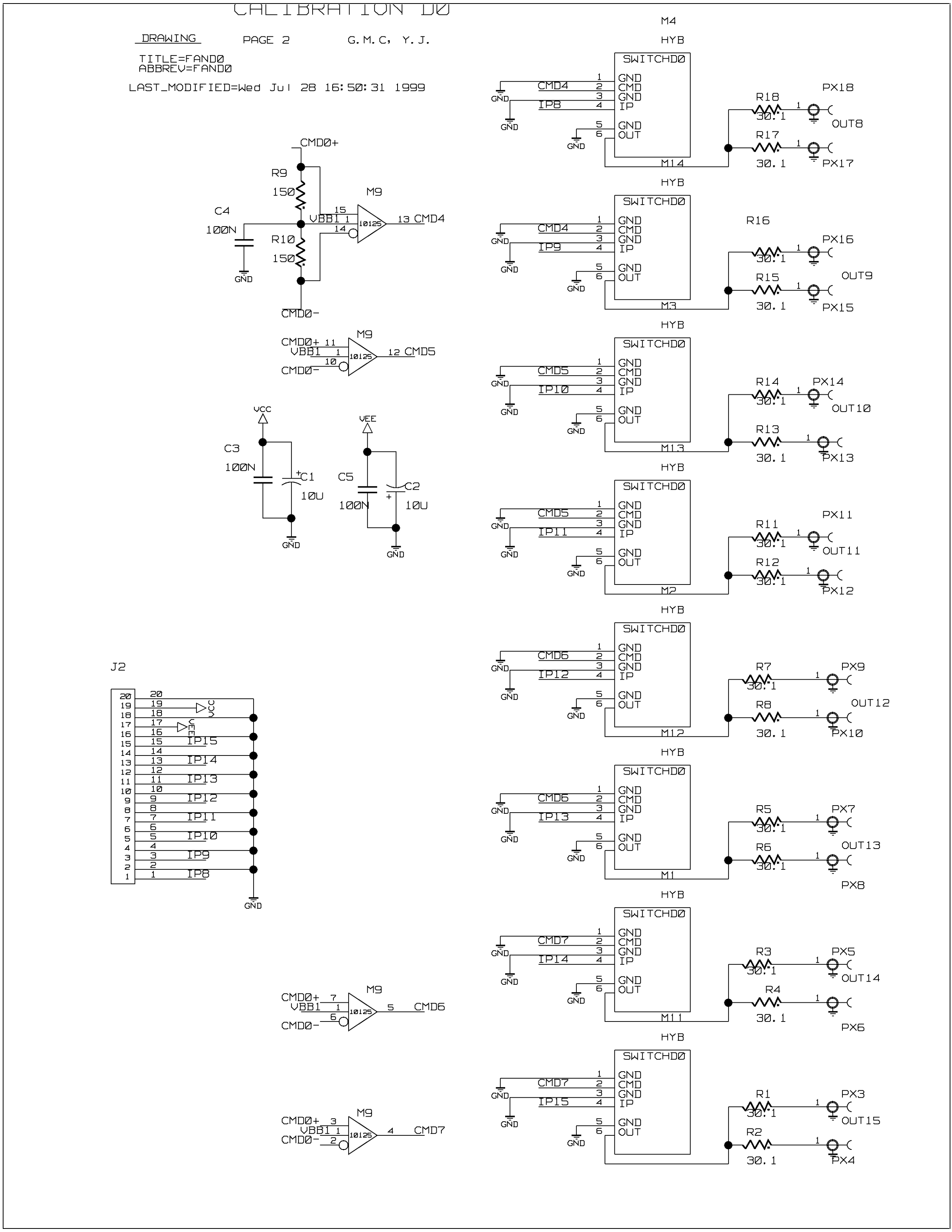

Figure 16: Schema Fanout Board

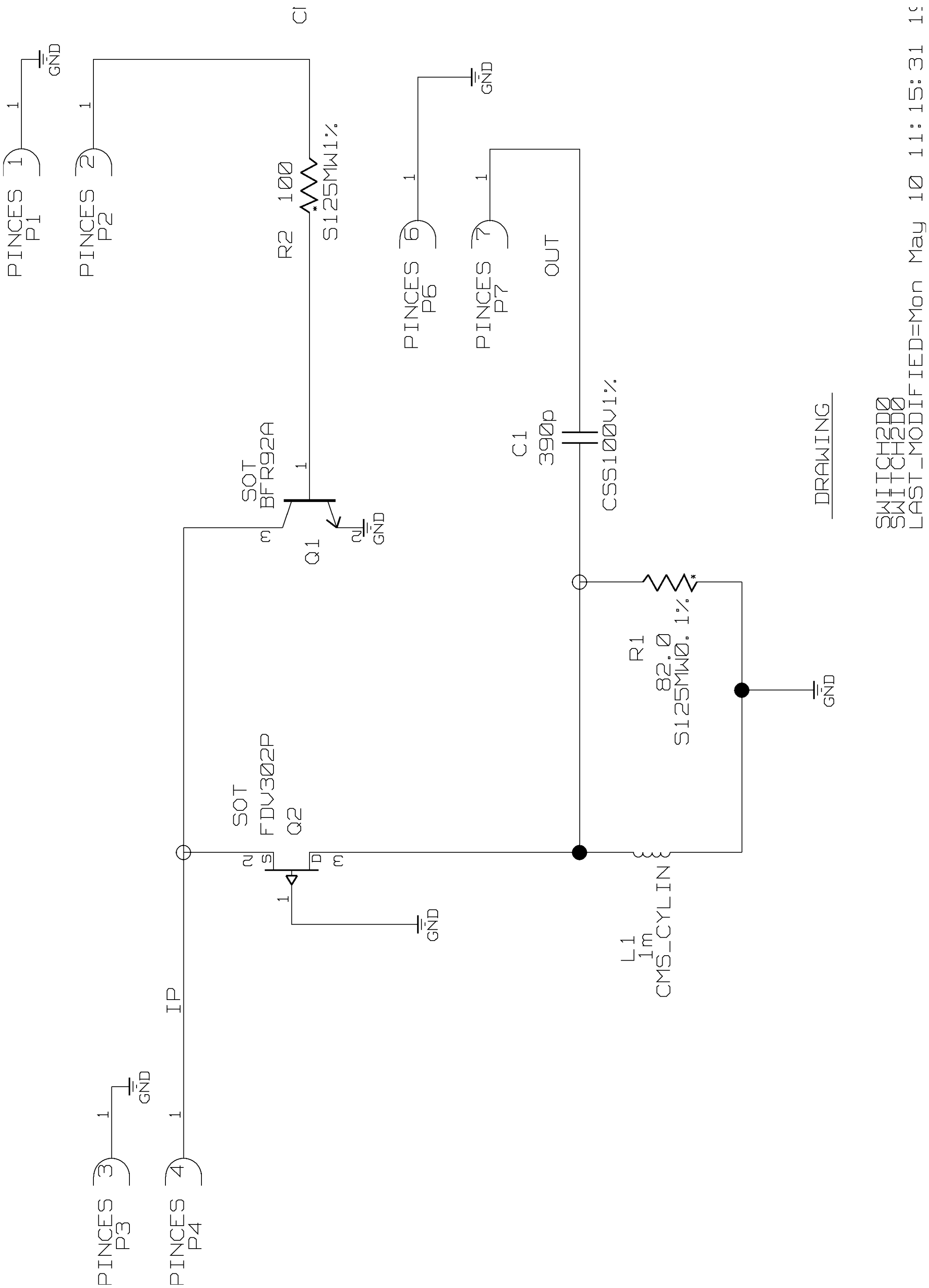

Figure 17: Schema Switch Board