FTLMC Control System Board Specification V2

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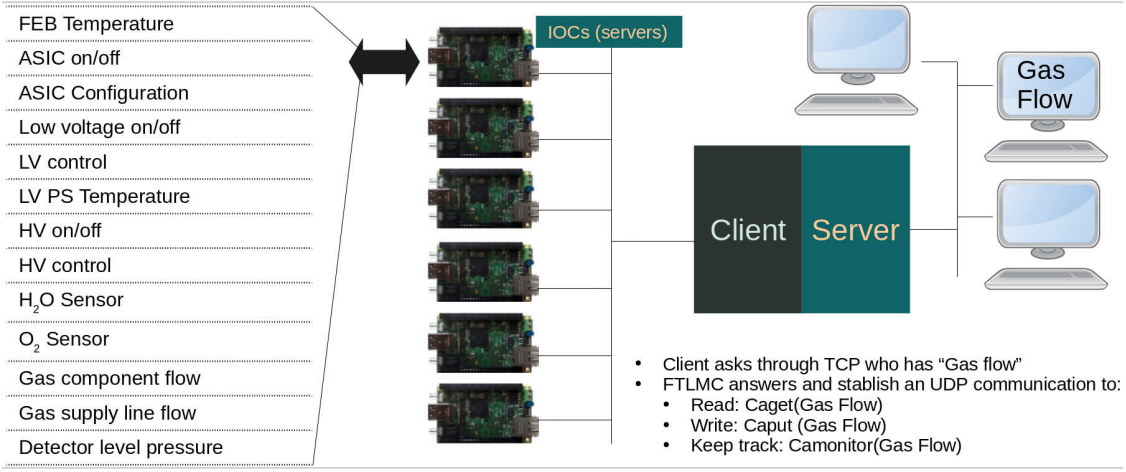
Contents

The FTLMC is to be used for Detector Control System. The task covered by the FTLMC is local overview of all parameters in its surroundings, an example of the parameters to be monitored is:

- FEB Temperature
- ASIC on/off
- ASIC Configuration
- Low voltage on/off
- LV control
- LV PS Temperature
- HV on/off
- Gas component flow
- Gas supply line flow
- Detector level pressure



The FTLMC acts like an Input Output Controller, which in the EPICS Network point of view is a server that provides the data that other nodes request or that they periodically transmit according to the configuration. The EPICS network protocol is called Channel Access (CA). The parameters are the data that can be requested to the IOC's through the CA. They are called Process variables and are requested by a TCP request. There are 3 FTLMC prototype iterations. Two of them have been built, the first had no version number and the V1 is the second iteration.

- Hardware
  - Through holes and SMD for aircore coils are included to test Magnetic field capability
  - Board can be also powered from a stackable board through GND, 3v3 and an J3

  - Ethernet through holes are directly connected to the phyter. An alternative to magnetics (ethernet coild) can be implemented in a stackable board. Eg. Optocouplers
  - In FTLMC V2 errors in the RS485 and CanBus are fixed, FTLMC V1 RS485 and CanBus are still useful for testing
  - V1 Interfaces tested
    * Ethernet Works
    * I^2C Works
    * RS232 UART Works
  - Interfaces to be tested
    * SPI
    * CAN Bus
    * RS485
  - **Only TMS570** Was tested in beamtime
    * Exposed the MCU directly to the beam during 13 hours
    * $2Gev$ Protons
    * Flux in spike: 7×10^7
    * Flux in normal extraction: 2×10^8
    * Total detected and corrected errors: 1404
    * No unrecoverable errors
    * Failure registers continuously monitored
    * Database with error time-stam
    * No errors during beam off times detected

- Software
  - EPICS (3.16.1) is running on RTEMS (4.11) libraries on the FTLMC
  - First tests show that ethernet driver is working properly
  - I2C is written and working
  - SPI Driver is being written
  - RTEMS 5 is being written for FTLMC since RTEMS 4.11 is not officially supported by EPICS
  - EPICS developers are working on RTEMS 5 support now.

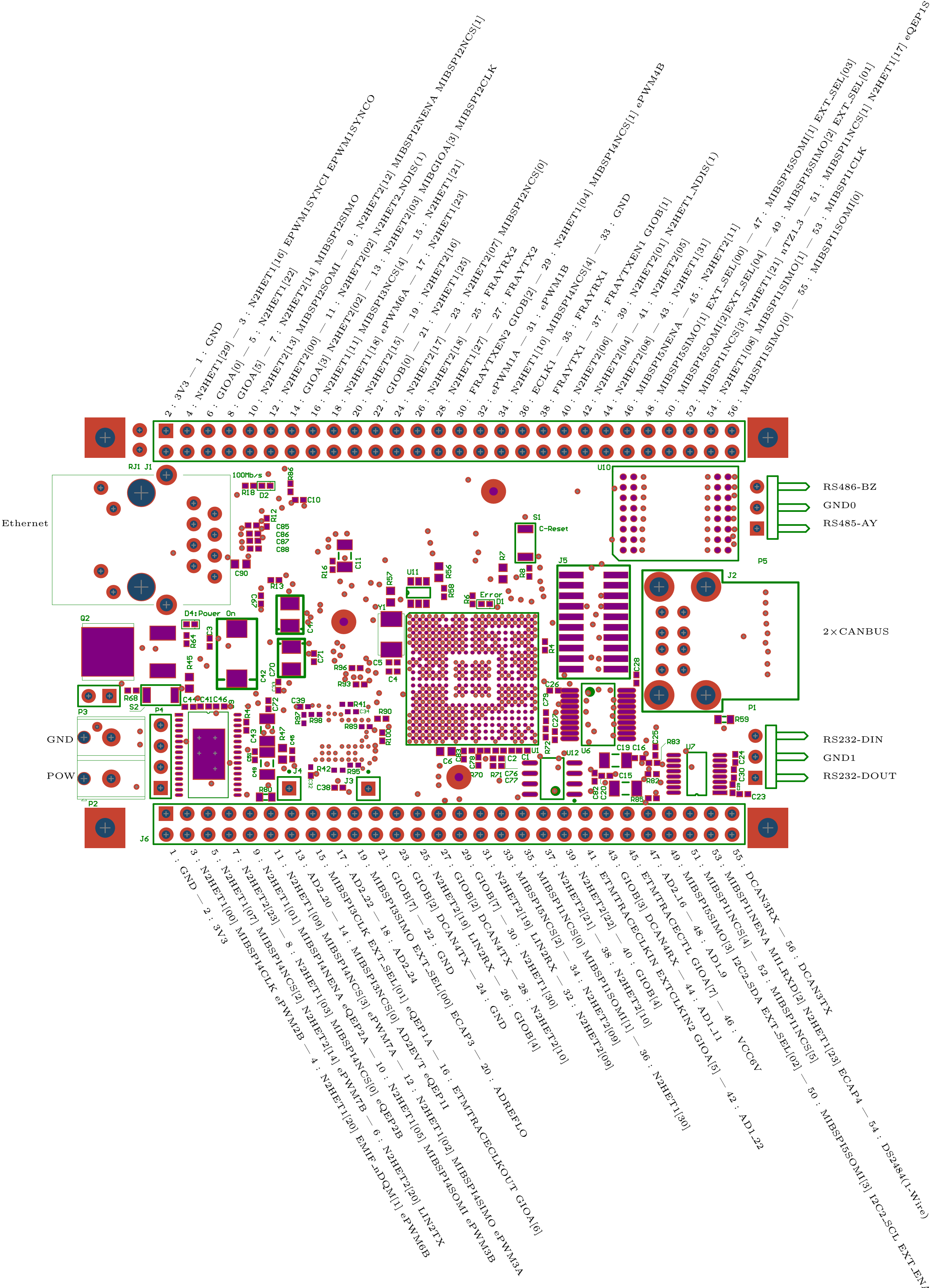
1 Introduction

The FTLMC (Fault Tolerant Local Monitoring Control) Board is intended to perform basic tasks for FAIR experiments and detectors. The basic tasks to be performed are:

- temperature monitoring
- voltage control and monitoring
- ON/OFF status checking
- enabling modules

- checking operational status
- settings adjustments

The FTLMC Board should be able to monitor any kind of sensor that gather information in the detector surroundings. Furthermore it should withstand extraordinary conditions that appear in the detectors due to the ionizing radiation. In terms of software the FTLMC Board must be able to run EPICS IOC as a SCADA interfacing to the FAIR FTLMC. Any complex system requiring of some I/O controlling should be able to use this easy to interface FTLMC Board.


2 : 3V3 — 1 : GND
4 : N2HET1[29] — 3 : N2HET1[16] EPWM1SYNCI EPWM1SYNCO
6 : GIOA[0] — 5 : N2HET1[22]
8 : GIOA[5] — 7 : N2HET2[14] MIBSPI2SIMO
10 : N2HET2[13] MIBSPI2SOMI — 9 : N2HET2[12] MIBSPI2NENA MIBSPI2NCS[1]
12 : N2HET2[00] — 11 : N2HET2[02] N2HET2_NDIS(1)
14 : GIOA[3] N2HET2[02] — 13 : N2HET2[03] MIBGIOA[3] MIBSPI2CLK
16 : N2HET1[11] MIBSPI3NCS[4] — 15 : N2HET1[21]
18 : N2HET1[18] ePWM6A — 17 : N2HET1[23]
20 : N2HET2[15] — 19 : N2HET2[16]
22 : GIOB[0] — 21 : N2HET1[25]
24 : N2HET2[17] — 23 : N2HET2[07] MIBSPI2NCS[0]
26 : N2HET2[18] — 25 : FRAYRX2
28 : N2HET1[27] — 27 : FRAYTX2
30 : FRAYTXEN2 GIOB[2] — 29 : N2HET1[04] MIBSPI4NCS[1] ePWM4B
32 : ePWM1A — 31 : ePWM1B
34 : N2HET1[10] MIBSPI4NCS[4] — 33 : GND
36 : ECLK1 — 35 : FRAYRX1
38 : FRAYTX1 — 37 : FRAYTXEN1 GIOB[1]
40 : N2HET2[06] — 39 : N2HET2[01] N2HET1_NDIS(1)
42 : N2HET2[04] — 41 : N2HET2[05]
44 : N2HET2[08] — 43 : N2HET1[31]
46 : MIBSPI5NENA — 45 : N2HET2[11]
48 : MIBSPI5SIMO[1] EXT_SEL[00] — 47 : MIBSPI5SOMI[1] EXT_SEL[03]
50 : MIBSPI5SOMI[2]EXT_SEL[04] — 49 : MIBSPI5SIMO[2] EXT_SEL[01]
52 : MIBSPI1NCS[3] N2HET1[21] nTZ1_3 — 51 : MIBSPI1NCS[1] N2HET1[17] eQEP1S
54 : N2HET1[08] MIBSPI1SIMO[1] — 53 : MIBSPI1CLK
56 : MIBSPI1SIMO[0] — 55 : MIBSPI1SOMI[0]
Ethernet
RS486-BZ
GND0
RS485-AY
2×CANBUS
GND
POW
RS232-DIN
GND1
RS232-DOUT
1 : GND — 2 : 3V3
3 : N2HET1[00] MIBSPI4CLK ePWM2B — 4 : N2HET1[20] EMIF_nDQM[1] ePWM6B
5 : N2HET1[07] MIBSPI4NCS[2] N2HET2[14] ePWM7B — 6 : N2HET2[20] LIN2TX
7 : N2HET2[23] — 8 : N2HET1[03] MIBSPI4NCS[0] eQEP2B
9 : N2HET1[01] MIBSPI4NENA eQEP2A — 10 : N2HET1[05] MIBSPI4SOMI ePWM3B
11 : N2HET1[09] MIBSPI4NCS[3] ePWM7A — 12 : N2HET1[02] MIBSPI4SIMO ePWM3A
13 : AD2_20 — 14 : MIBSPI3NCS[0] AD2EVT eQEP1I
15 : MIBSPI3CLK EXT_SEL[01] eQEP1A — 16 : ETMTRACECLKOUT GIOA[6]
17 : AD2_22 — 18 : AD2_24
19 : MIBSPI3SIMO EXT_SEL[00] ECAP3 — 20 : ADREFLO
21 : GIOB[7] — 22 : GND
23 : GIOB[2] DCAN4TX — 24 : GND
25 : N2HET2[19] LIN2RX — 26 : GIOB[4]
27 : GIOB[2] DCAN4TX — 28 : N2HET2[10]
29 : GIOB[7] — 30 : N2HET1[30]
31 : N2HET2[19] LIN2RX — 32 : N2HET2[09]
33 : MIBSPI5NCS[2] — 34 : N2HET2[09]
35 : MIBSPI1NCS[0] MIBSPI1SOMI[1] — 36 : N2HET1[30]
37 : N2HET2[21] — 38 : N2HET2[10]
39 : N2HET2[22] — 40 : GIOB[4]
41 : ETMTRACECLKIN EXTCLKIN2 GIOA[5] — 42 : AD1_22
43 : GIOB[3] DCAN4RX — 44 : AD1_11
45 : ETMTRACECTL GIOA[7] — 46 : VCC6V
47 : AD2_16 — 48 : AD1_9
49 : MIBSPI5SIMO[3] I2C2_SDA EXT_SEL[02] — 50 : MIBSPI5SOMI[3] I2C2_SCL EXT_ENA
51 : MIBSPI1NCS[4] — 52 : MIBSPI1NCS[5]
53 : MIBSPI1NENA MII_RXD[2] N2HET1[23] ECAP4 — 54 : DS2484(1-Wire)
55 : DCAN3RX — 56 : DCAN3TX

2 Features

2.1 Overview

- a Safety Micro- Controller (μC) TMS570 with error mitigation mechanisms
- EPICS Ioc running with RTEMS capable of giving and gathering information from any device connected to it
- PC-104 connectors to attach stackable boards for further interfacing
- Handy sized ($\approx 90 \times 60 \times 15$)mm

2.2 Interfaces

- 85 GPIOs through pc-104 pin connector
- 7 ADC's 0-5 Volts (usefull as 4-20mA)
- 4 CAN terminals
  - 2×CAN terminals for the board, connection through USB
  - 2×CAN terminals added in the PC-104 connector for other type of external connectors without signal driver
- 2×SPI terminals to interface with slave sensors or other boards, 1×SIMO pins and 1×SOMI pins if not otherwise specified
  - 1×SPI-1 terminal with 5× NCS (Chip select) signals (up to 5 slaves),2×SIMO pins and 2×SOMI pins. Note: MCU actually has 6 terminals but one is multiplexed with an Ethernet MAC pin, thus it is not considered
  - 1×SPI-4 terminal with 5× NCS (Chip select) signals (up to 5 slaves),1×SIMO pins and 1×SOMI pins. Note: Actually 4 pins of both SIMO and SOMI available from MCU, but one of each are multiplexed with important Ethernet MAC pins
  - SPI-1 and SPI-5 terminals shall be connected to the PC-104 connector
- 2×PWM terminals to control power systems
- 2×SCI terminals connected to 1×RS-232 and 1×RS-485 drivers, whose bus output then is connected to a screw terminal
- 2×FlexRay terminals through the PC-104 connector
- 1×Ethernet interface which will connect to the EPICS Process variables being managed by this FTLMC Board

2.3 PC-104 Pinout Description

Multiple signals are listed per pin because they are multiplexed inside the MCU, please refer to page 5, where such signals are listed. $N2HET*$ and $GIO*$ signals are GPIOs, $MIBSPI$ are SPI signals and $ePWM$ are signals from PWM module. $AD*$ Are Analog-Digital Converter $(0-5V)$. MIBSPI and PWM can be used also as GPIO.

2.4 Isolation

Anything connected to the board interacting with different ground sources should be optionally ground isolated, since long cables, which may cause considerable resistance, yield a potential difference in the ground signals. Three aspects should be taken care of:

1. LAN Ethernet
2. CAN BUS
3. RS485/Profi Bus

2.5 LAN Ethernet

The μC has an Ethernet MAC which is connected in the DCS Board with a physical Ethernet interface. The interface provides 10/100 Mbit/s data transfer bandwidth.

2.6 Power Supply

The board is to be fed with 6V DC with 1 Ampere capacity. The voltage defining ADC inputs ranges should be 5 Volts.

2.7 Key Components

- Micro- Controller
  - TMS570LC4357
  - Up to 300 Mhz CPU Clock
  - Up to 145 GPIO pins

3 Electrical

3.1 Architecture

The main building blocks of the FTLMC Board V2 are shown in next section.

3.2 Micro- Controller Usage

The TMS570LC4357 has:

- $5\times SPI$ interfaces,
- $2\times I^2C$ interfaces,
- $4\times SCI$, two of them with LIN support,
- $7\times PWM$ interfaces,
- $4\times CAN$ controllers,
- $16\times$ GPIOs with External Interrupt Capability,
- $2\times FLexRay$ Channels Controller and

- 10/100 Mbps Ethernet MAC.

Most of the signals of these interfaces are multiplexed with signals of different modules inside the μC.

3.2.1 The CAN interfaces connection

The CANbus controller requires CANbus transceivers for signal conditioning. Three out of four CAN controllers included in the TMS-570 are not pin-multiplexed, they can be thus connected directly to the CANbus transceiver. Two out of these three not multiplexed CANbus controllers shall be connected directly to transceivers which then lead to USB mechanical connectors.

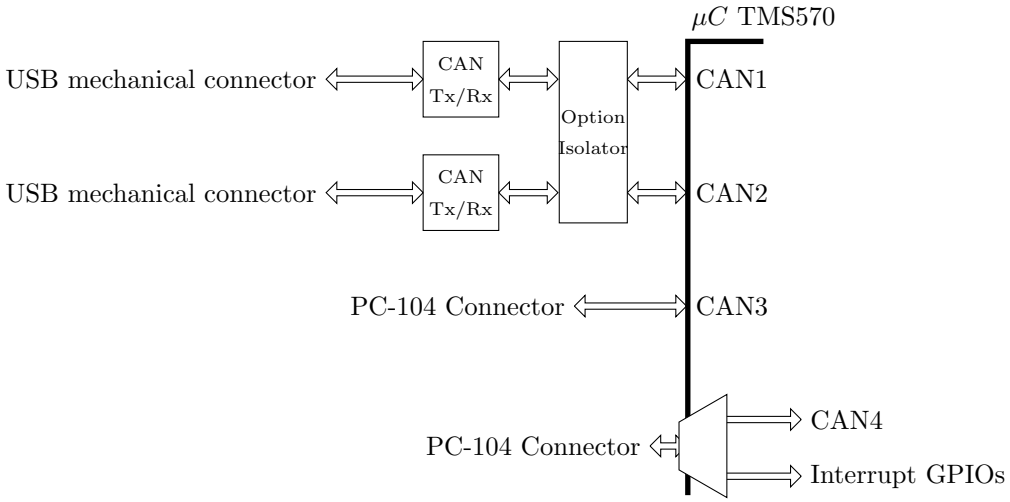


Figure 1: CAN FTLMC Board connection

The third non-multiplexed CAN controller is also connected to a CAN transceiver, but the latter leads to the PC-104 connector for additional CAN interfaces. The multiplexed fourth CAN controller signals is connected to to the PC-104 connector.

3.2.2 The FlexRay interfaces connection

The FlexRay bus protocol requires a Bus Driver but was not included in FTLMC V2, every signal is ported to PC-104 as shown.

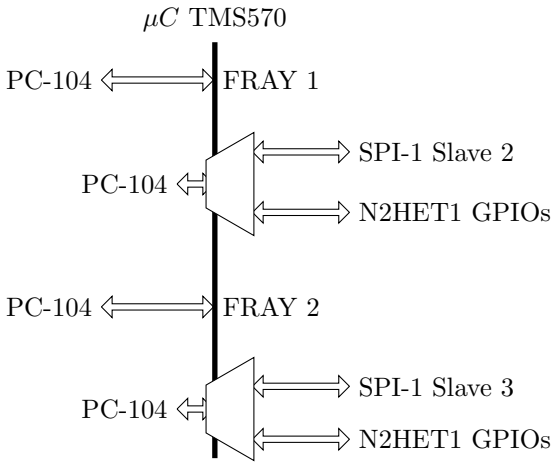


Figure 2: FlexRay FTLMC Board connection

The signals multiplexing require interface configuration of the μC.

3.2.3 The remaining SPI interfaces connection

The remaining interface connections of SPI-1 and SPI-5 shall be connected to output connector PC-104 to have extra communication protocols to stackable boards. As long as the other device shares the same voltage ranges no interface is required

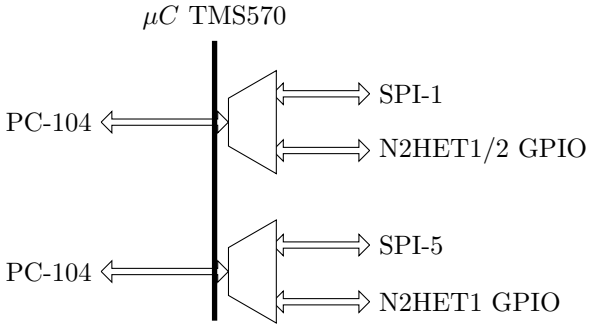


Figure 3: FlexRay FTLMC Board connection

The pins for SPI-1 and SPI-5 are multiplexed with other protocol signals inside the μC.

3.2.4 The UART interfaces connection

Four Serial Communication Interfaces (SCI) are available in the μC. One interface is connected with a RS-485 electrical characteristics transceiver. The second one is connected to a RS-232 transceiver. Both are intended to be used for UART communications.

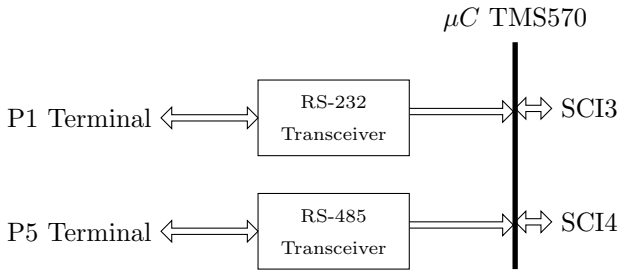


Figure 4: Serial Communication Interface FTLMC Board connection

SCI signals are multiplexed inside the μC with signals from other protocols. The other protocols (GPIO) are not used.

3.3 SDRAM Program Memory

The program should run in the SDRAM memory, which shall be directly connected to the EMIF interface included in μC

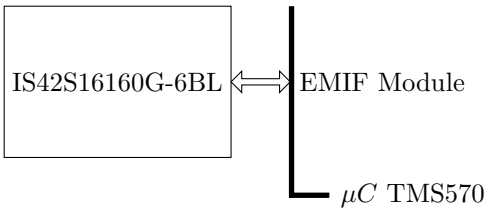


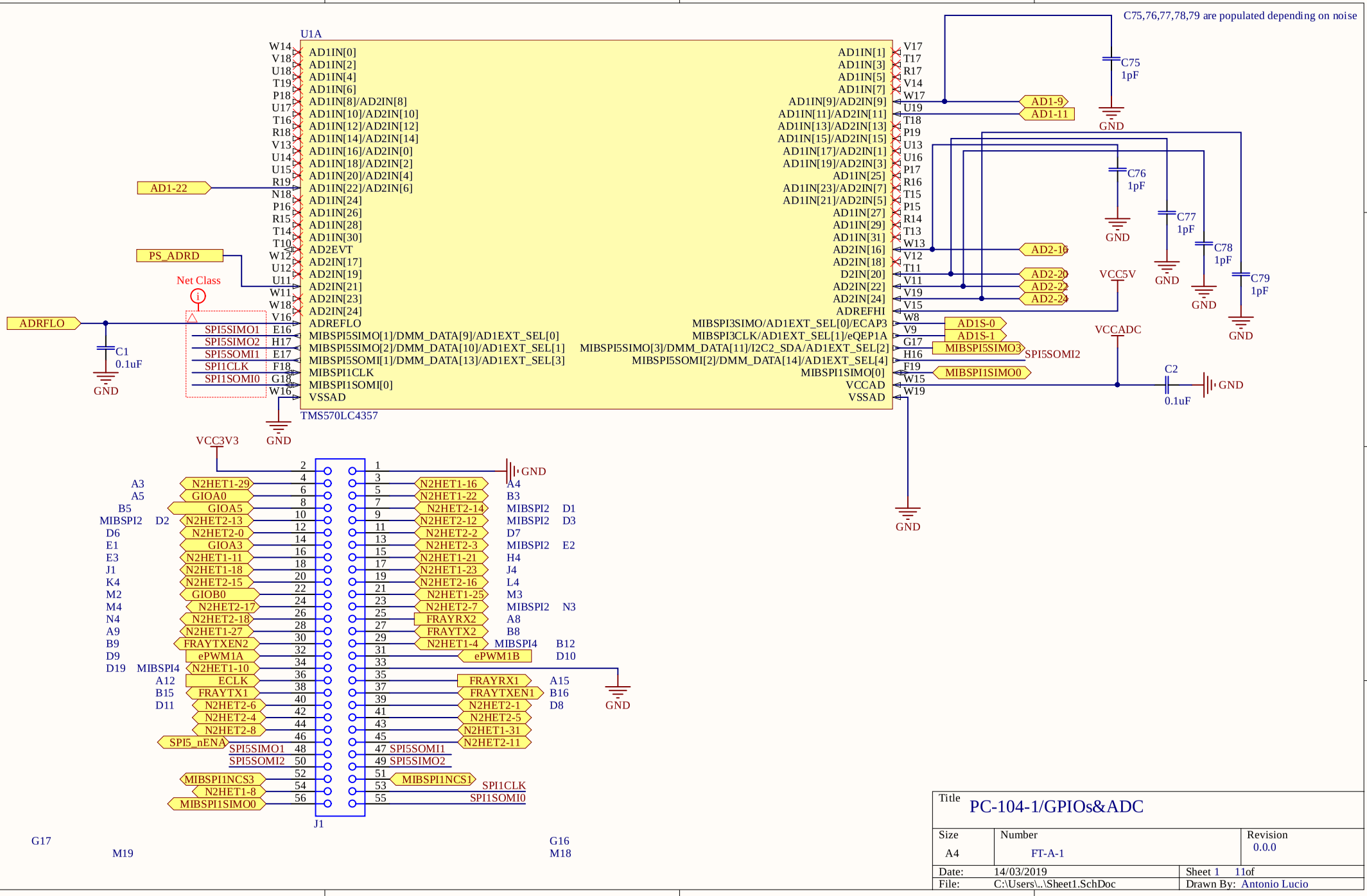
Figure 5: SDRAM connection diagram

4 Semiconductor parts (From BOM)

U1	TMS570LC4357	HerculesTM Microcontroller Based on the ARM Cortex-R Core
U2	DP83640TVV/NOPB	Precision phyterTM - IEEE 1588 Precision Time Protocol Transceiver
U4 & U5	SN65HVDA1040AQDRQ1	EMC-OptimizedHigh-SpeedCAN Bus Transceiver
U6	ADUM3482BRSZ	Small, 3.75 kV RMS Quad Digital Isolators
U7	TRSF3232ECPWR	3-v to 5.5-v two-channelrs-232,1-Mbit/Slinedriver/receiver
U8	IS42S16160G-6BL	256Mb synchronous dram
U9	TPS65381A-Q1	Multirail Power Supply for Microcontrollers in Safety-Relevant Applications
U10	LTM2881IV-5#PBF-ND	Complete Isolated RS485/RS422 Module Transceiver + Power
U11	DS2484	DS2484 Single-Channel 1-Wire Master with Adjustable Timing and Sleep Mode
U12	REF02AU	5V Precision voltage reference
D1	SML-P12U2TT86R	LED RED CLEAR 1006 SMD
D2 & D4	SML-LX0402USBC-TR	SMD Blue Water Clear 470nm 20mcd
D3	MBRS340T3	ON Semiconductor Schottky Diode
D5-D8	SMBJ30CA-13-F	600W Surface mount transient voltage suppressor
Q1	NVR5124PL	Power MOSFET
Q2	FDD8444	N-Channel PowerTrench MOSFET $40V$, $50A$, $5.2m\Omega$

References

[1] Texas Instruments, *TMS570LC4357 Datasheet*, SPNS195C, February 2014, Revised June 2016.



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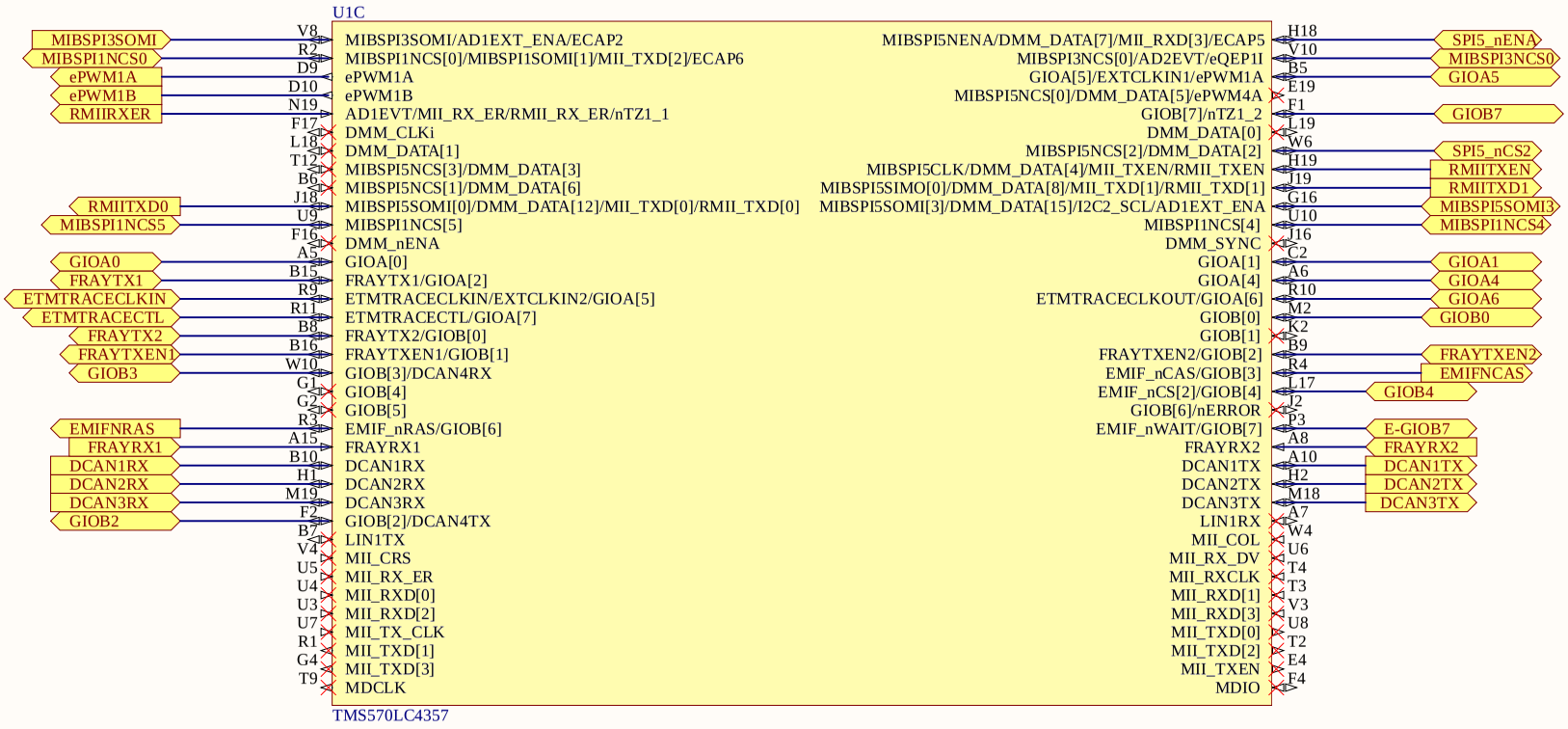

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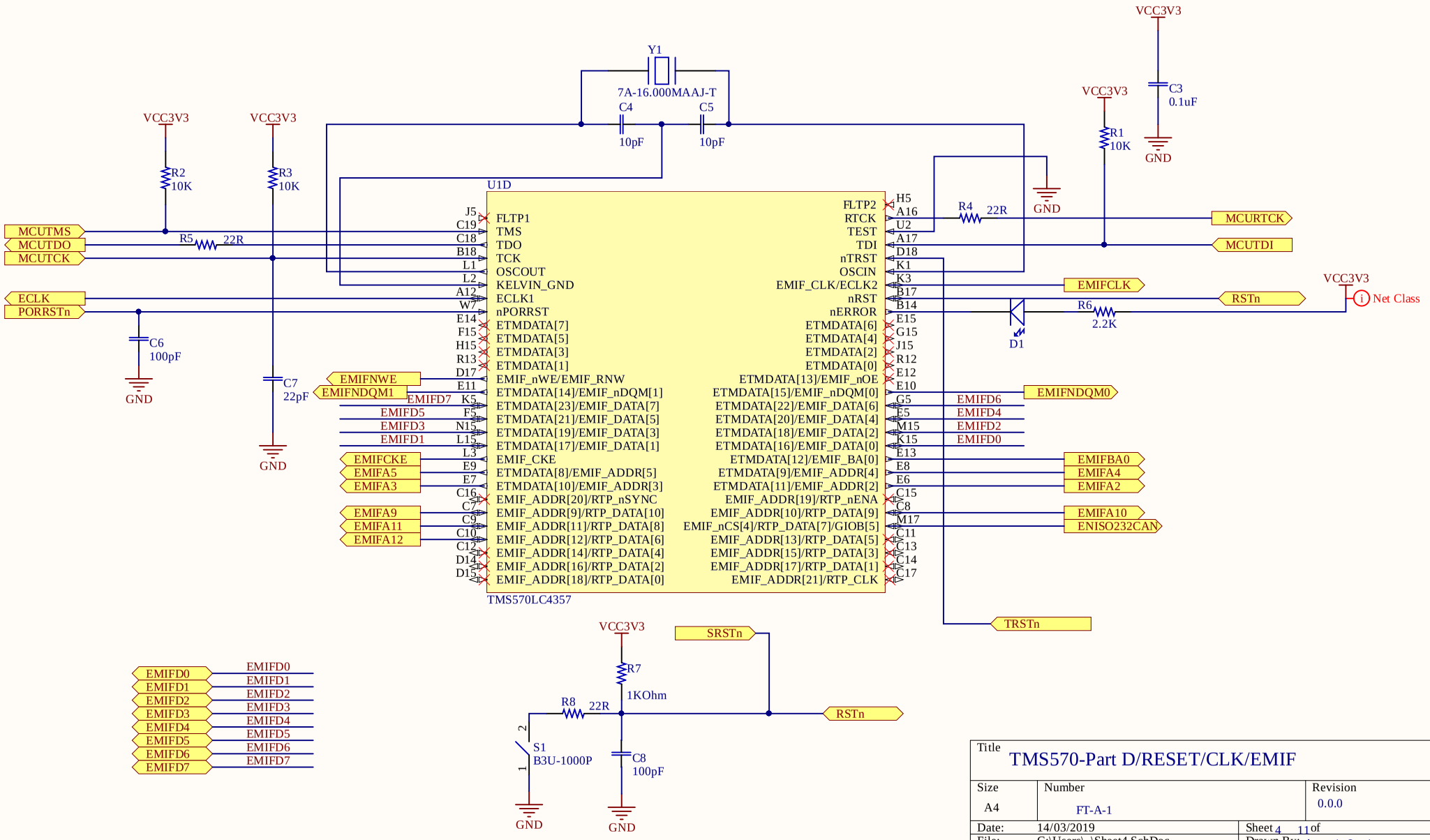

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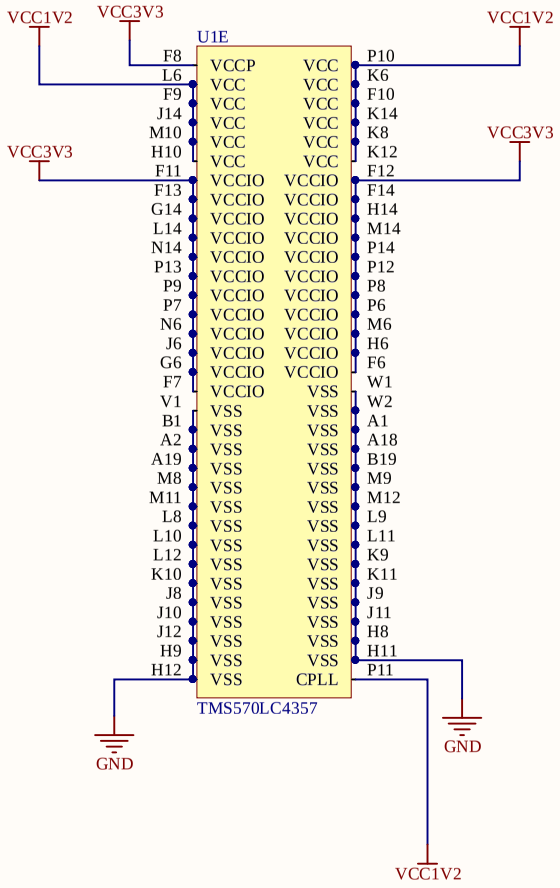

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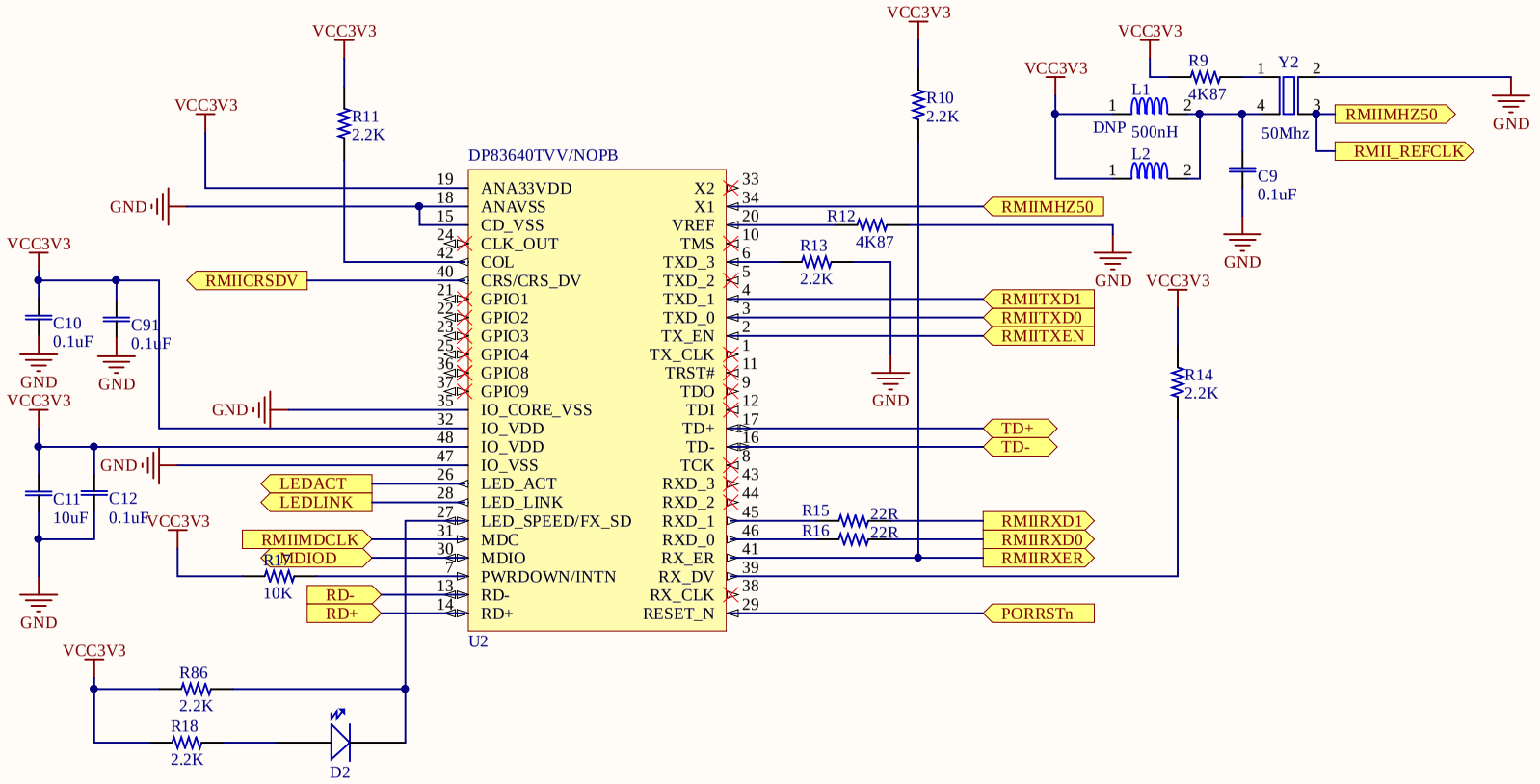

The three LED inputs (LED_ACT, LED_LINK & LED_SPEED) work as configuration inputs on Power-up, This is why resistorts like R86 are placed. This configures among other things the speed mode

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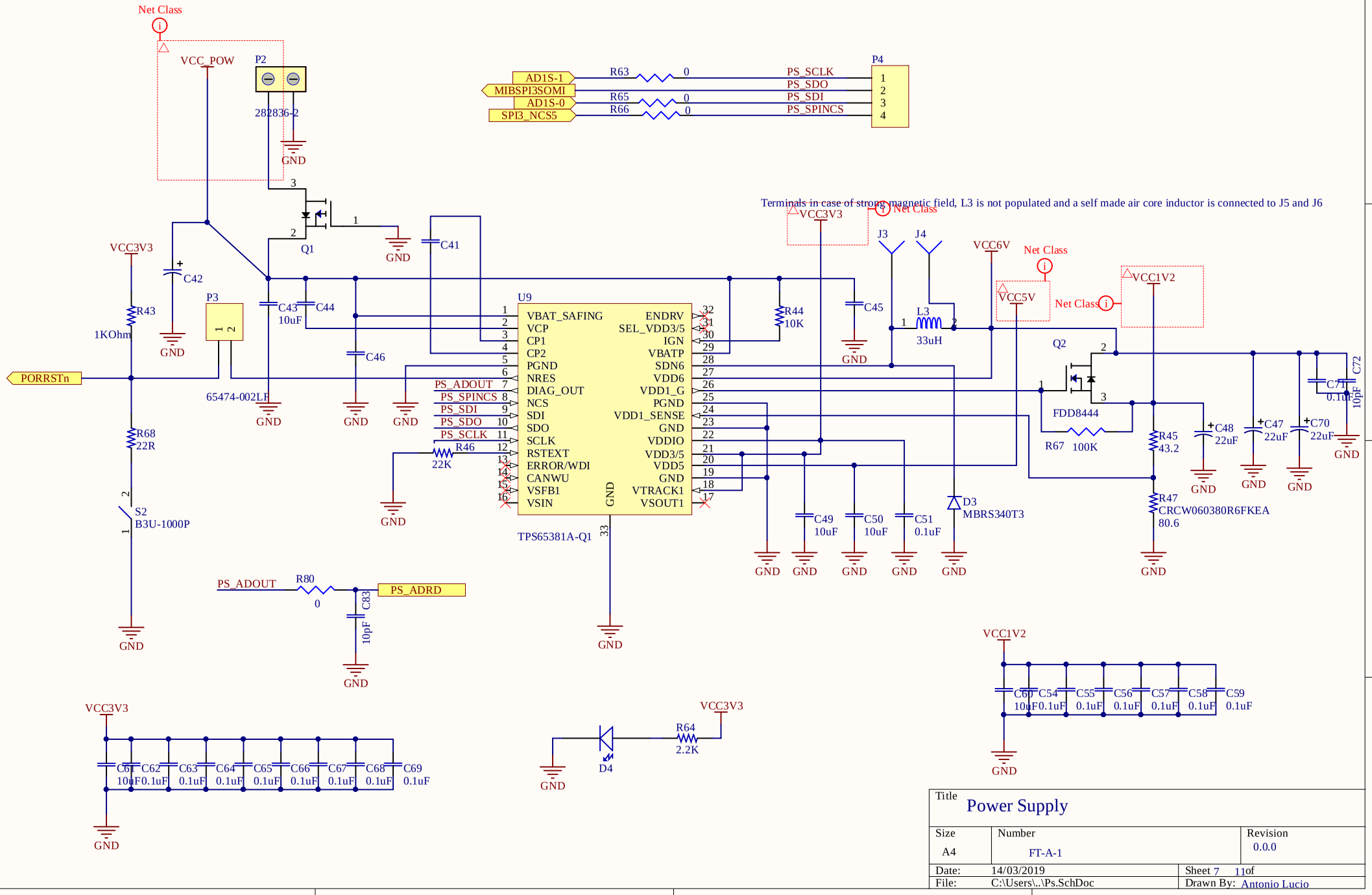

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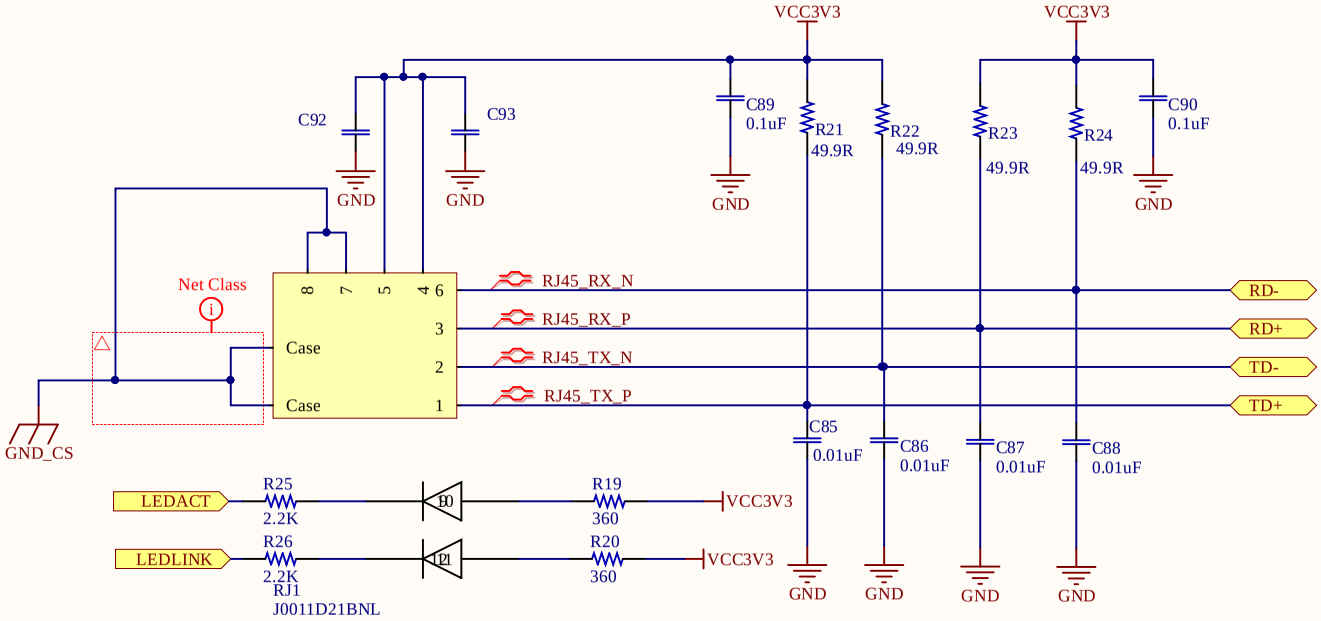

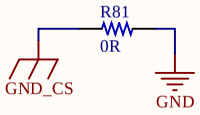

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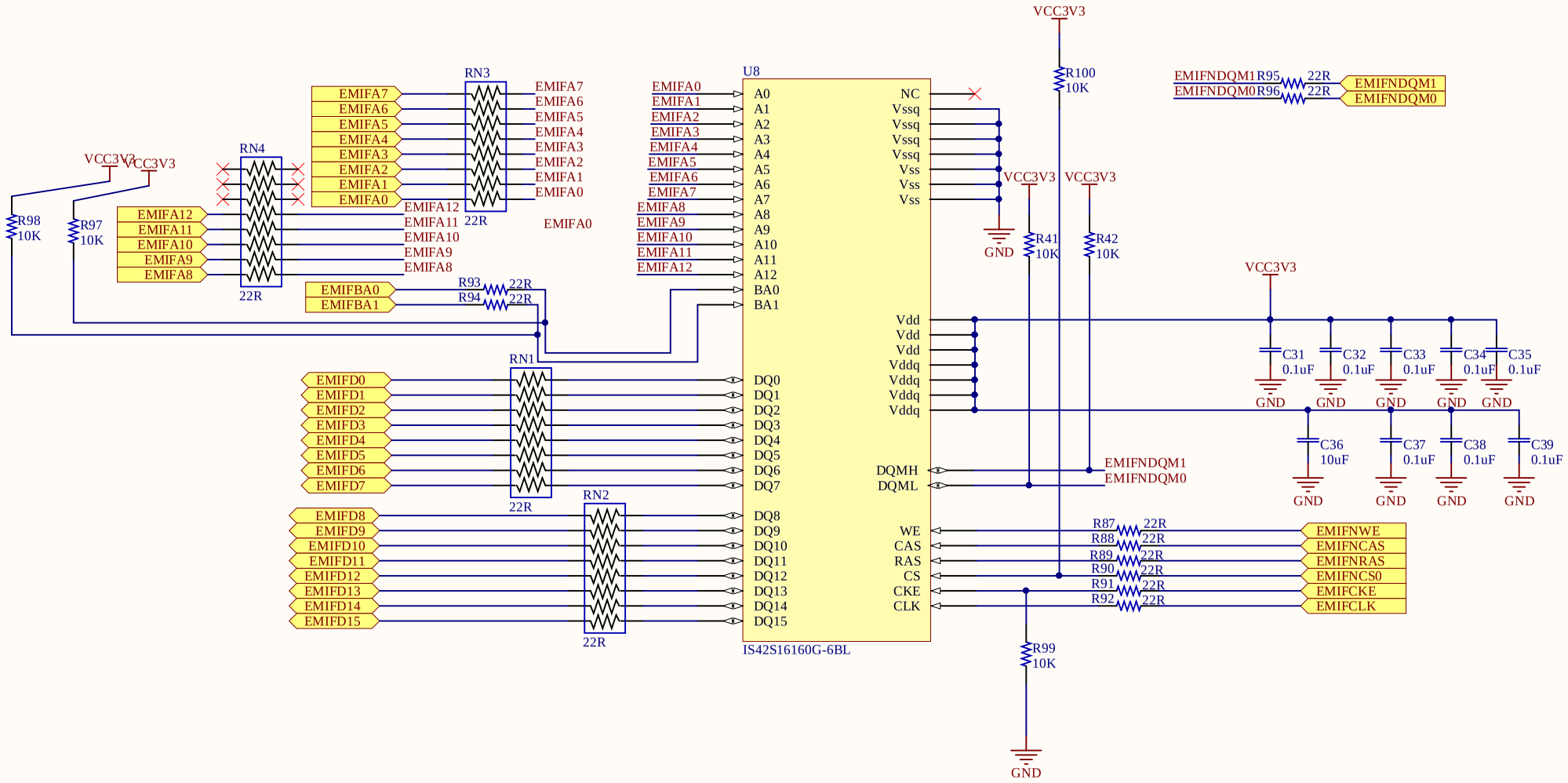

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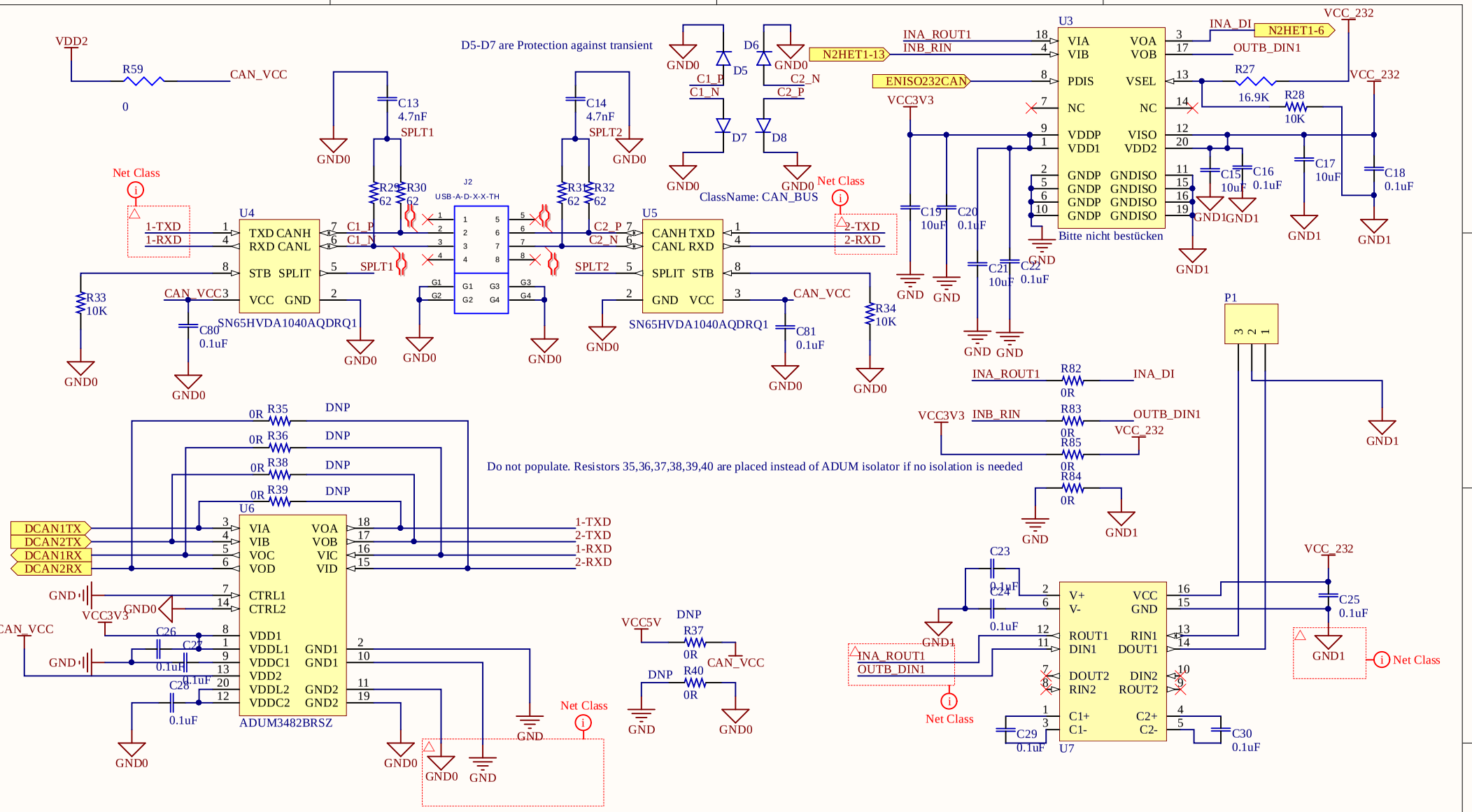
D5-D7 are Protection against transient
ClassName: CAN_BUS
Net Class
Bitte nicht bestücken
Do not populate. Resistors 35,36,37,38,39,40 are placed instead of ADUM isolator if no isolation is needed
SN65HVDA1040AQDRQ1
ADUM3482BRSZ
Title
CAN + RS232
Size
A4
Number
FT-A-1
Revision
0.0.0
Date:
14/03/2019
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Sheet 10 of 11
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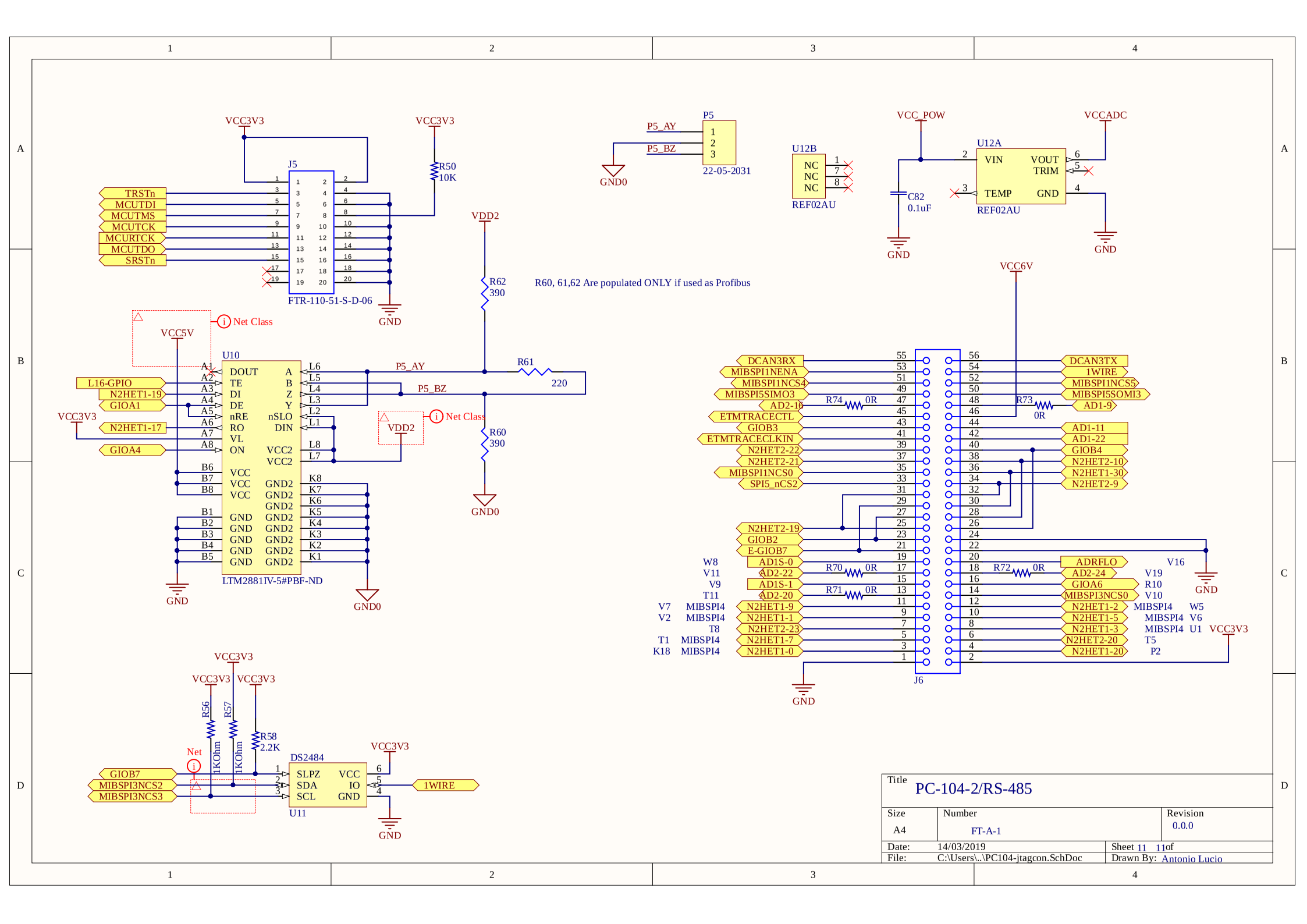
Antonio Lucio



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