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Status of TPC-electronics with Time-to-Digit Converters

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Abstract

Development of readout electronics for Time Projection Chamber for a Linear Collider is ongoing under stringent requirements on high channel density, lowest possible power consumption and small material budget. We study a new technique of data acquisition, where time and charge of TPC signals are measured with the help of Time-to-Digit Converters. A readout system with 640 channels is being constructed and will be tested with Large Prototype TPC. Current status of the development of the readout electronics is presented.

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1 Introduction

Within EUDET JRA2, TPC readout electronics based on a new principle of data acquisition is being developed. In this approach, time of arrival and charge of signals from TPC pads are measured with the help of a time-to-digital converter. The charge is measured indirectly, with help of a charge-to-time converter. This technique is currently implemented with the help of ASDQ chip[1].
Further investigation of required parameters for LC TPC readout electronics will require study of precision of time and charge measurement, as well as hit efficiency.

2 Front-End Electronics: "Barcelona" board

A single FEE "Barcelona" board has 32 channels (4 ASDQ chips), Figure 1. The footprint of a board is 30 mm×106 mm. Top-to-bottom thickness: 4.4 mm. Small width and thickness of a "Barcelona" board allow to use pad sizes as small as 1 mm×4.4 mm. The outline of the board can be found in [2], and the schematic is presented in appendix.

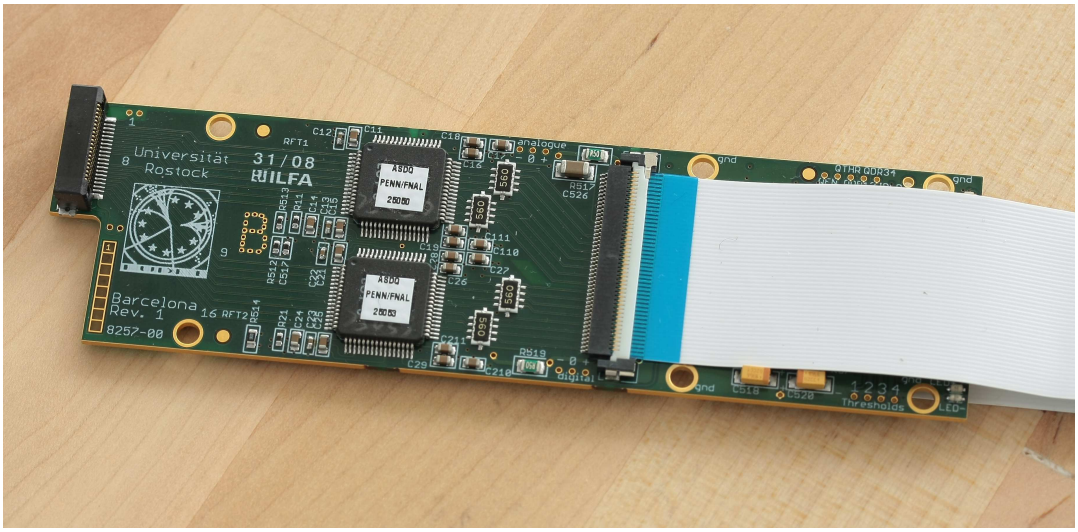


Figure 1: A photograph of a single Front-End Electronics board with two flat data output cables attached to it.

As described in [3], the readout electronics boards will be installed directly onto the LP TPC end-plate. "Barcelona" boards are attached to connectors on a GEM panel of the LP TPC end-plate, so that the connection length from pads to input of the FEE boards is minimized.

Five TDC modules (640 channels) are available, therefore 20 "Barcelona" boards will be

used[1].The boards have to be supported from the GEM panel, connectors alone are not able to hold the boards. A support structure to hold boards at place can be screwed to holes which are provided in the current design of the back-frame of the GEM panel[4]. Same holes to be used for support of signal cables of the ALTRO-based electronics.
The weight of a single "Barcelona" board is less than 15 g, therefore the total weight to be supported by the GEM panel will be less than 300 g. The weight of the FEE boards shall not possess any problem for the alignment of the GEM panel or the LP TPC end-plate.

With 640 readout channels only part of all pads on a GEM panel can be instrumented, therefore it is necessary position FEE boards in the optimal position, providing continuous readout area with maximized number of measurements on the track. Pad mapping information will be used for planning of the readout electronics placement and support structure development.

Data from the FEE boards will be transmitted via 20 cm long thin flat cables to pitch adapters - boards where larger (and heavier) twisted pair cables will connect signals to TDCs. The pitch adapters to be installed onto the support rings[5] - a common support infrastructure for readout electronics.
Depending on the position of the TDCs with respect to the PCMAG, length and therefore weight of the cables will define the way of supporting the pitch adapters and twisted pair cables. Thus, the major weight of the electronics is decoupled from the LP TPC and will be supported by the support rings.

Before installation onto LP TPC, the readout electronics will be tested with a small standalone GEM chamber. Further steps will include integration with the common DAQ system and adaptation to the cooling infrastructure. The cooling subsystem, at the moment, is not addressed, but it is expected that 20 "Barcelona" boards dissipate approximately 40 W and compressed air can be used to remove heat.

3 Data processing with Marlin-TPC

Existing prototype of the data acquisition system writes data to binary files of proprietary format. In order to make the data from this readout electronics available for a broader LC-TPC community, one needs to convert these data to the LCIO format[6]. In this way, one can profit from development of common software framework - Marlin-TPC[7].

In the existing implementation[2], binary files from TDCs are read by a Marlin-TPC processor, Figure 2, and processed further with processors proprietary for this electronics and other common Marlin-TPC processors.

[1] In total, 30 "Barcelona" boards are available.
[2] Programmed by O. Schäfer.

Data measured with TDCs represents two values: time of arrival and charge of the TPC signals, but since the charge measured indirectly (with the help of charge-to-time converter), one needs to deconvolve measured pulse width back to the charge. This deconvolution will still need to be implemented into a Marlin-TPC processor. Furthermore, a processor for application of calibration data still need to be developed.

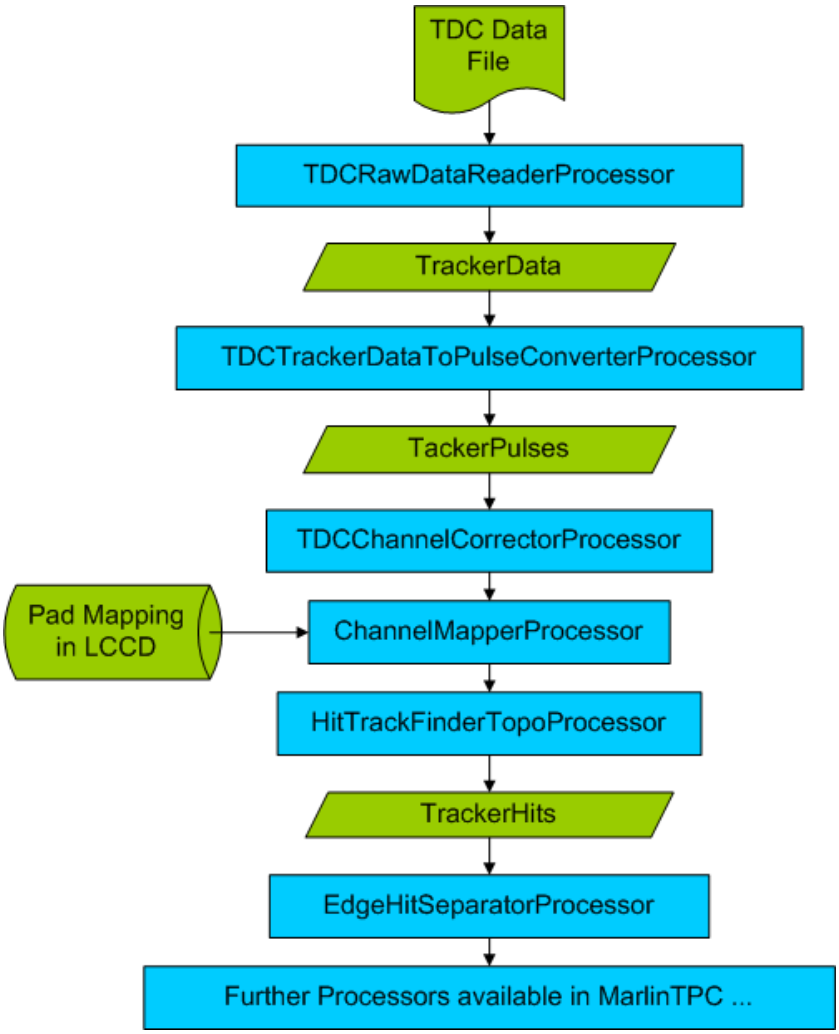


Figure 2: A diagram of data flow for TDC-based readout electronics.

4 Conclusion

Major components of the readout system are prepared. Still missing component - the low voltage distribution board. Currently, an option of power cycling is being studied and the design of low voltage board will be updated accordingly. When integrated with the common DAQ system, data taking will profit from the common run control of the

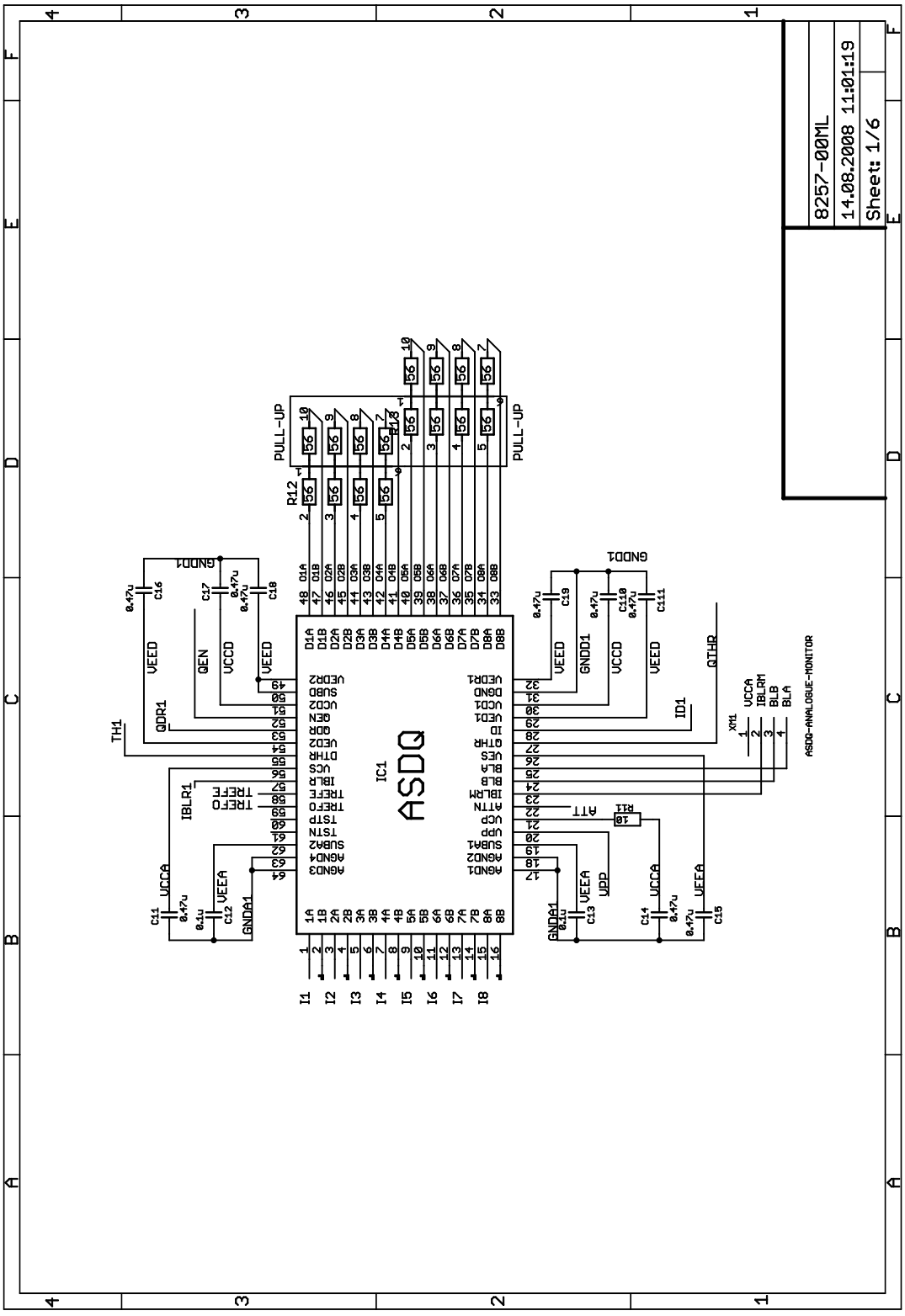
experiments with LP TPC.

The design of the PCMAG lifting stage and surrounding environment will be finished soon, so that possible position of the VME crate will be understood. This will lead to a decision on the final length of twisted pair cables and support structure of the pitch adapters. A compact VME crate option is also considered, where low weight VME crate (with remote power supply) can be placed closer to the pitch adapters. In this option, length of the twisted pair cables reduced and handling of the cables is improved.

Acknowledgement

This work is supported by the Commission of the European Communities under the 6^{th} Framework Programme "Structuring the European Research Area", contract number RII3-026126.

5 Appendix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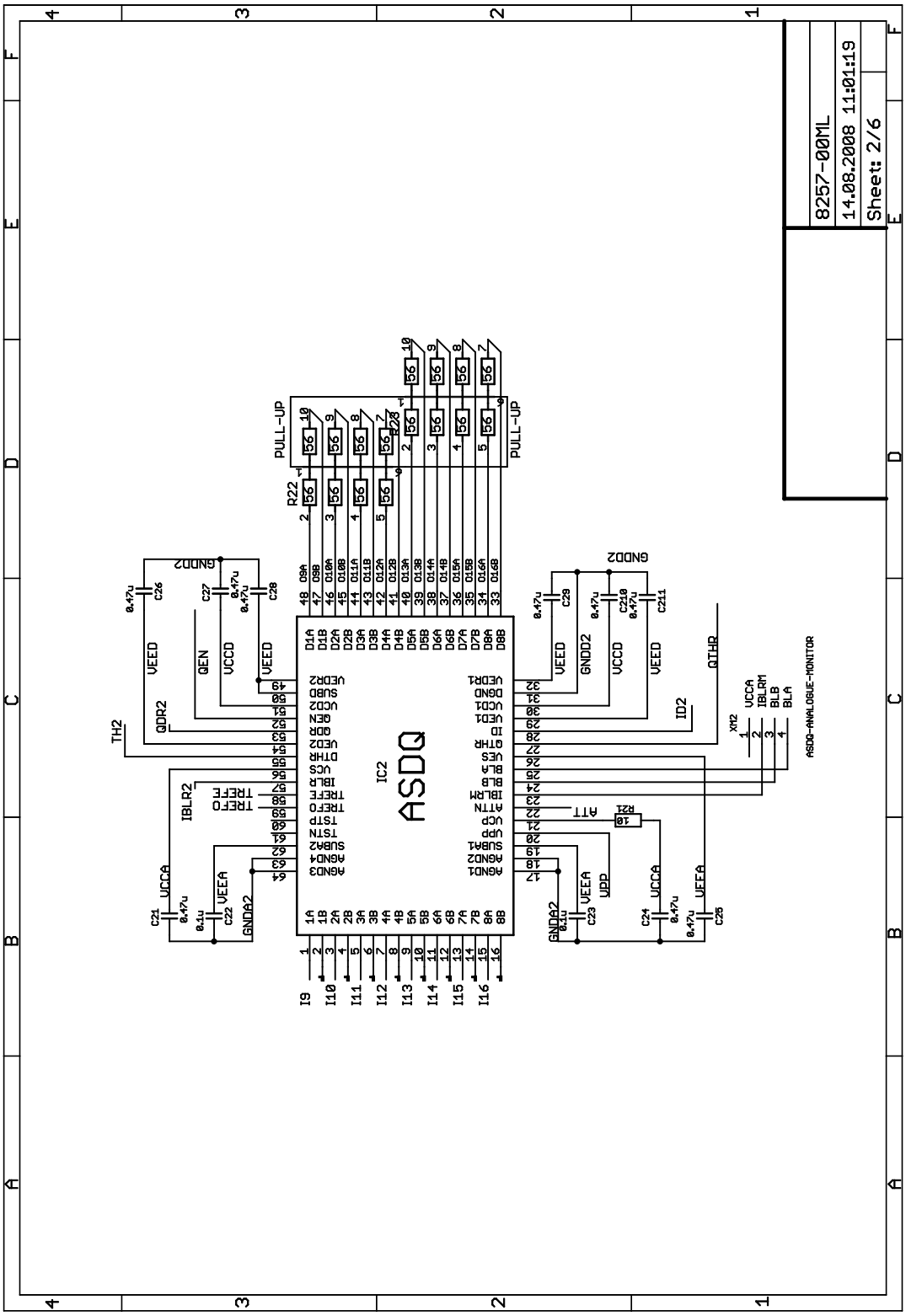
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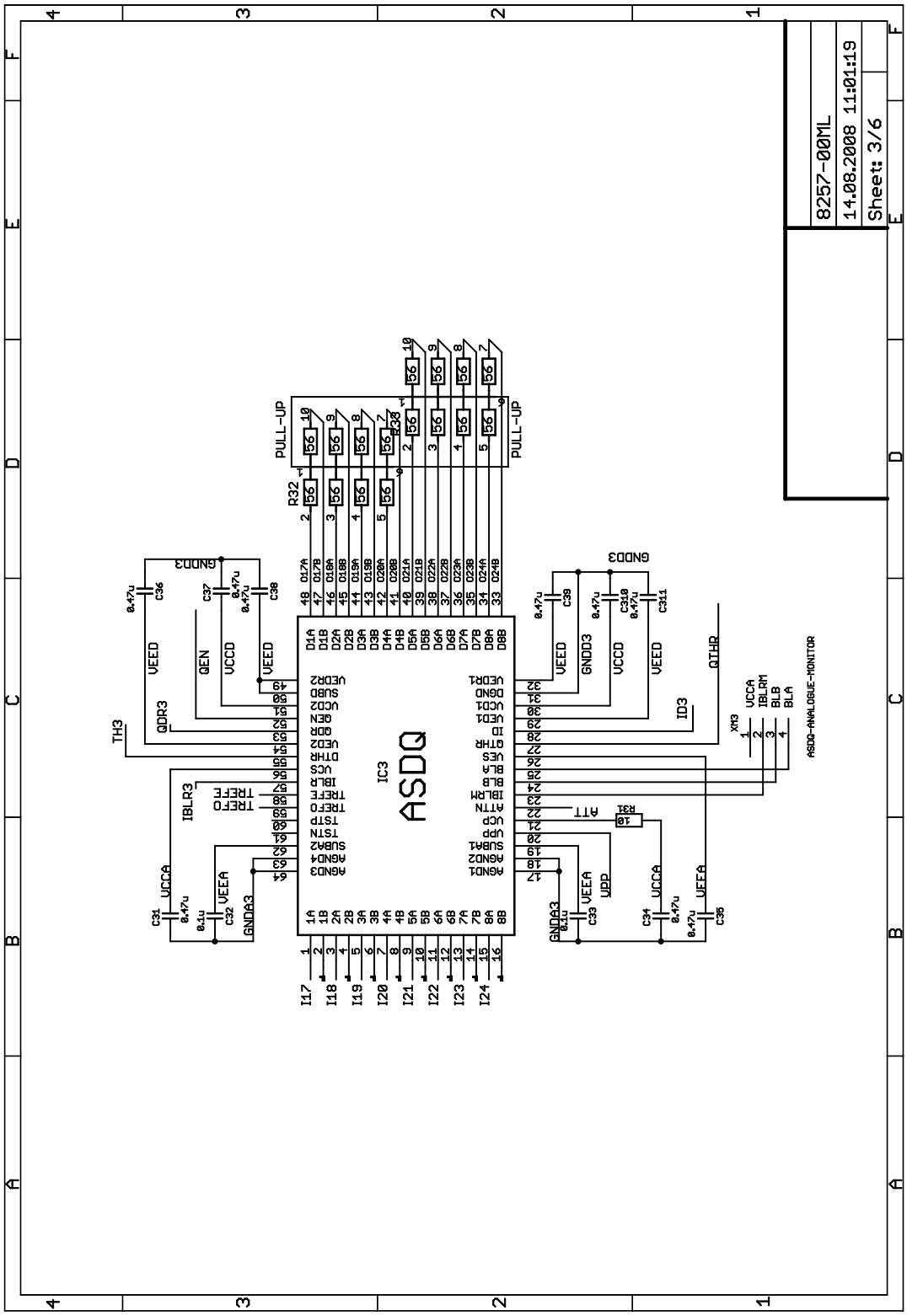
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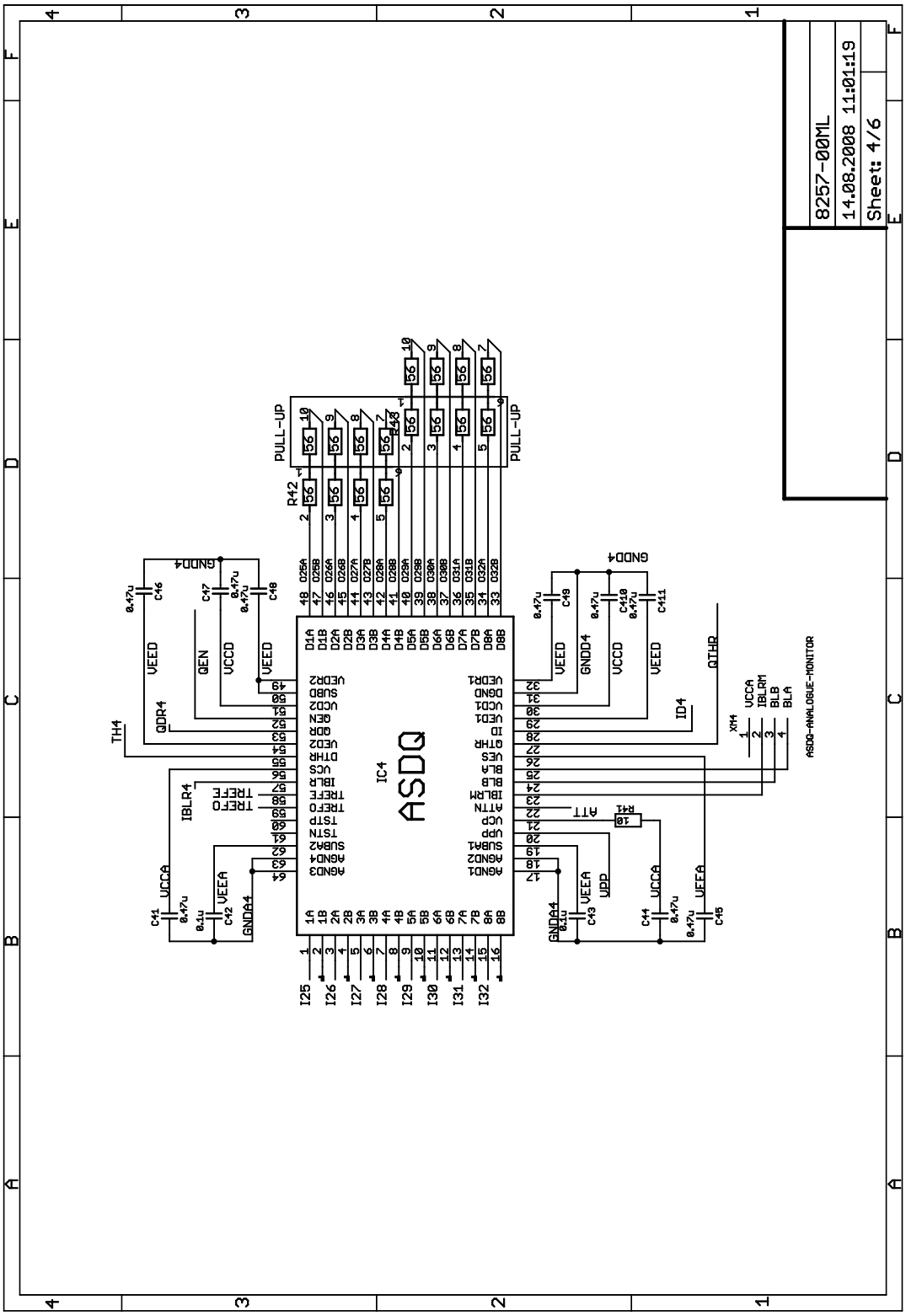
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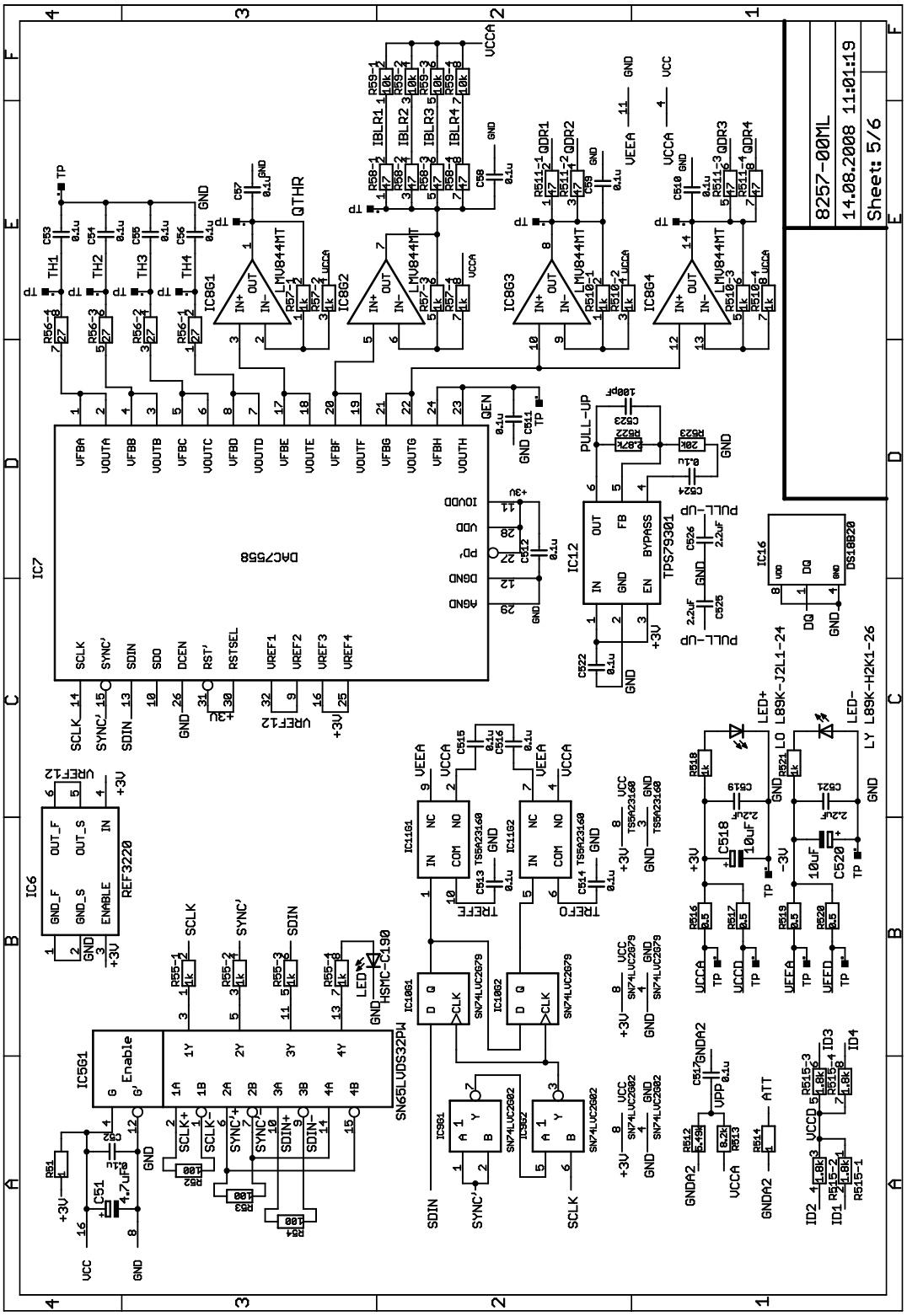
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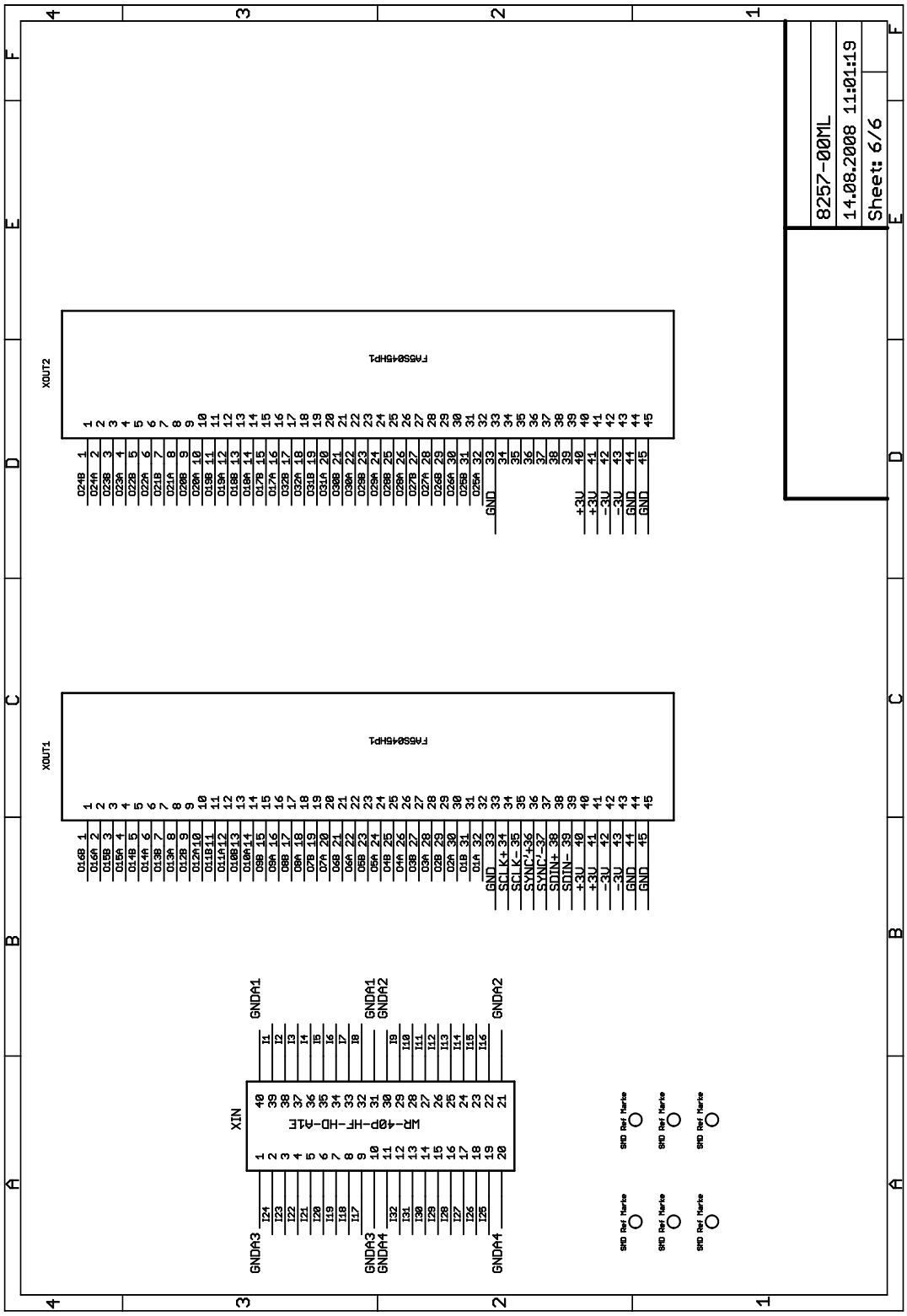
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GNDA2
GNDA3
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SMD Ref Marke

References

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[4] Dan Peterson's page on Large Prototype:
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[5] A. Oskarsson, University of Lund, *Presented at EUDET Annual Meeting 2008*, `http://ilcagenda.linearcollider.org/getFile.py/access?contribId=1&sessionId=6&resId=1&materialId=slides&confId=2811` ,accessed 15.01.2009.

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