FCAL

User's Guide

This document describes the LED Light Monitoring System of the Electromagnetic Forward Calorimeter (FCAL) of the GlueX detector at *Jefferson Lab*. The LED Light Monitoring System was developed, manufactured and tested at the *National and Kapodistrian University of Athens* in collaboration with *Symmetron Electronic Applications*.

This document was produced by *Dr Euthymios Kappos* for the purposes of system installation and maintenance. Address any enquiries regarding this document to *ekappos@otenet.gr* or contact *www.symmetron.gr*.

Version 1.0

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FCAL LED Light Monitoring System Configuration

The FCAL system consists of 10 LED boards arranged in two sets of 5 along two adjacent edges of a square plexiglass plate. Each board contains 4 LEDs of different type (color). All LEDs of the same color are triggered simultaneously by a common trigger signal. There are 10 LEDs in each color group, arranged in two sets of 5 along the X and Y sides of the plate. The system configuration is shown in *Figure 1*.

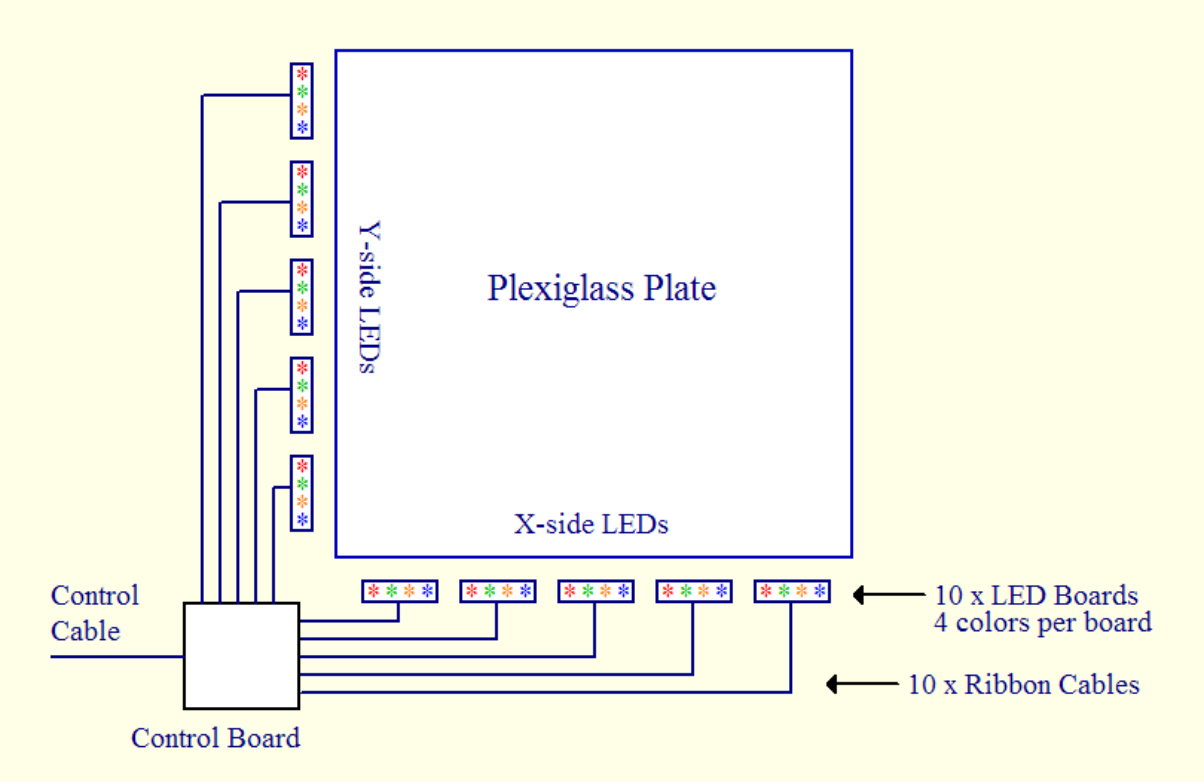


Figure 1: FCAL LED system configuration.

Operation

The 10-wire control cable provides power (5V) for the electronic components of the control and LED boards, as well as the LED bias voltage (e.g. 12V) for the LED boards. It also carries 4 TTL/CMOS level trigger signals (T1, T2, T3, T4) for each color group of 10 LEDs. Ten 10-wire ribbon cables distribute power, bias and trigger signals to the LED boards using the corresponding pin header connectors (X1 .. X5, Y1 .. Y5) of the control board.

Triggering occurs from a LOW to HIGH transition of the external trigger signal. An external trigger signal must stay HIGH for at least 100ns – if longer, the rest is ignored. The control board extracts only the initial 100ns from the rising edge of a trigger signal and then transmits it to the LED boards via the 10 ribbon cables. The trigger signal arriving at each LED board is buffered locally and then used to generate an approximately 7ns power pulse for the corresponding LED by means of a MOSFET switch. The power delivered to an LED is stored in a 100pF ceramic capacitor, precharged to the LED bias voltage.

The maximum trigger rate is about 500 kHz, which gives enough time for the LED board electronic components to settle to their initial state of zero light output. If a higher rate is used, the light may not have settled to zero at the end of the trigger period.

Absolute maximum ratings

Power supply voltage:	4.5 to 5.5V. FCAL-LED4 board power consumption @ 500kHz: 360mW.
LED bias voltage:	30V Note: The MOSFET switch on each LED board can sustain 60V. However, it is not recommended to use more than 30V bias. For all LEDs used in this project, 15V bias was sufficient.
Trigger frequency:	500 kHz max. Note: Higher rates can be used keeping in mind that in such cases the light output will have a DC component (i.e. light intensity may not return to zero before the next trigger pulse).

Trigger signals

The slew rate of the trigger signals (T1, T2, T3, T4) arriving at the control board is not critical, as they are regenerated locally on the control board using Schmitt-trigger buffers (74LVC1G17SE-7 or equivalent). The control board generates clean and fast-rising local trigger pulses of 100ns duration once the rising edge of the external trigger goes above the buffer's threshold. These triggers are subsequently sent to the LED boards by the ribbon cables.

LED Colors

LED1 (T1):	UV, 390nm	(Satistronics SS-1206-UV)
LED2 (T2):	Blue, 470nm	(KINGBRIGHT KPTD-3216QBC-D)
LED3 (T3):	Green, 574nm	(KINGBRIGHT KPTD-3216MGC)
LED4 (T4):	Green, 574nm	(KINGBRIGHT KPTD-3216MGC)

LEDs are marked "1", "2", "3", "4" on the top copper of the LED boards (see *Figure 3*).

Note: LEDs 3 and 4 are of the same type in order to provide sufficient light intensity at the selected wavelength. Normally they will be triggered simultaneously (i.e. a common signal will be provided for T3 and T4). Refer also to related note on page 7.

FCAL LED Board (FCAL-LED4)

The schematic circuit diagram and PCB layout of the FCAL LED board are shown on *Figures 2* and *3* below. *Figure 4* shows the pin assignment for connector J0 that connects a LED board to the control board via a 4m ribbon cable.

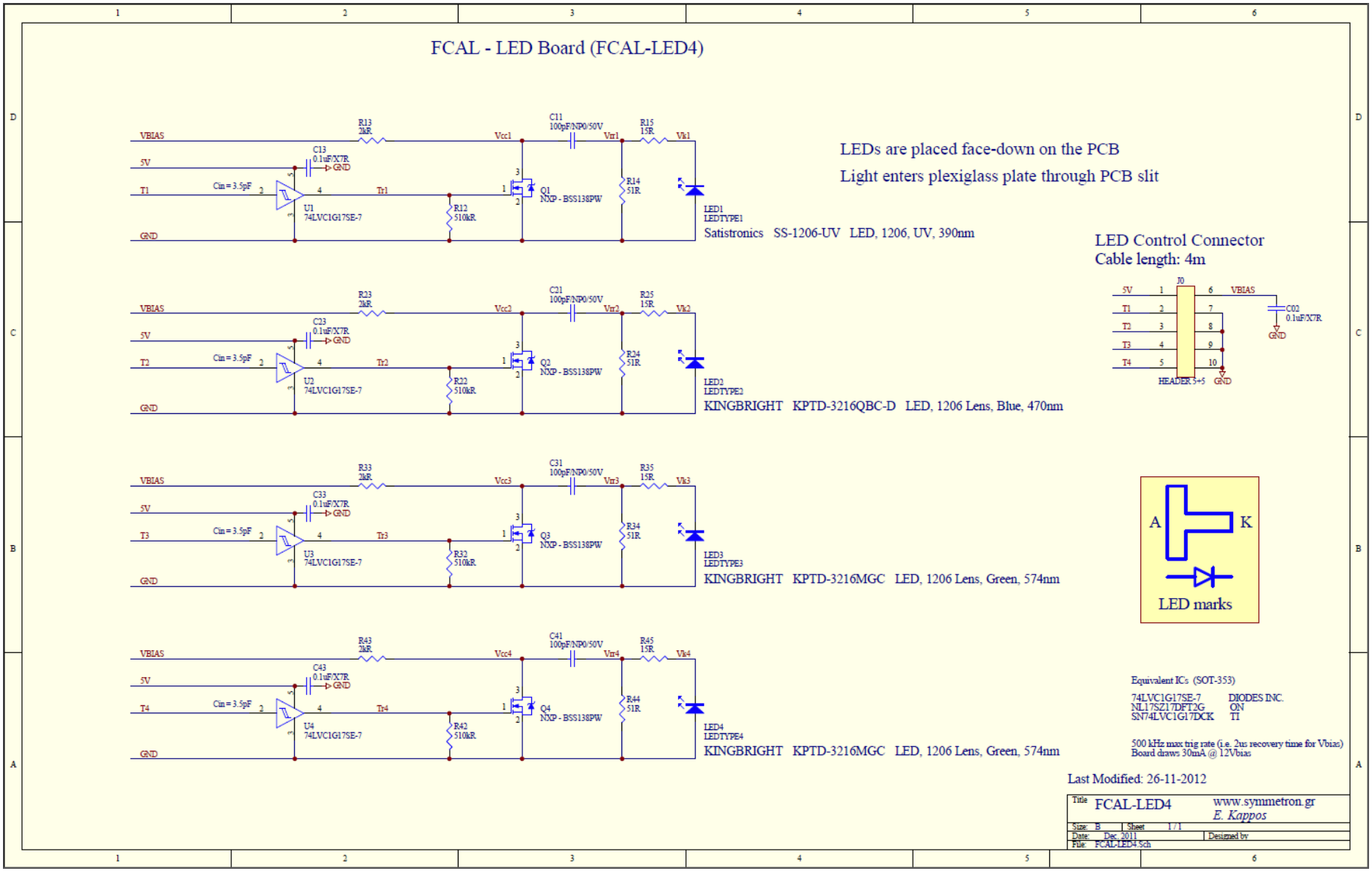
WARNING

SMT pin header J0 on FCAL-LED4 board is not polarized.

When inserting the free socket (pin header receptacle) at the end of the 4m ribbon cable into J0, make sure the mark for pin 1 on the free socket aligns with pin 1 of J0.

Pin 1 of J0 is marked on PCB top copper as "1" (see *Figure 4*).

Failure to do so, will damage the PCB when powered up.


FCAL - LED Board (FCAL-LED4)
LEDs are placed face-down on the PCB
Light enters plexiglass plate through PCB slit
LED1
LEDTYPE1
Satistronics SS-1206-UV LED, 1206, UV, 390nm
LED2
LEDTYPE2
KINGBRIGHT KPTD-3216QBC-D LED, 1206 Lens, Blue, 470nm
LED3
LEDTYPE3
KINGBRIGHT KPTD-3216MGC LED, 1206 Lens, Green, 574nm
LED4
LEDTYPE4
KINGBRIGHT KPTD-3216MGC LED, 1206 Lens, Green, 574nm
LED Control Connector
Cable length: 4m
HEADER 5+5
LED marks
Equivalent ICs (SOT-353)
74LVC1G17SE-7 DIODES INC.
NL17SZ17DFT2G ON
SN74LVC1G17DCK TI
500 kHz max trig rate (i.e. 2us recovery time for Vbias)
Board draws 30mA @ 12Vbias
Last Modified: 26-11-2012
FCAL-LED4
www.symmetron.gr
E. Kappos

(on page 5) *Figure 2:* FCAL-LED4 schematic circuit diagram.

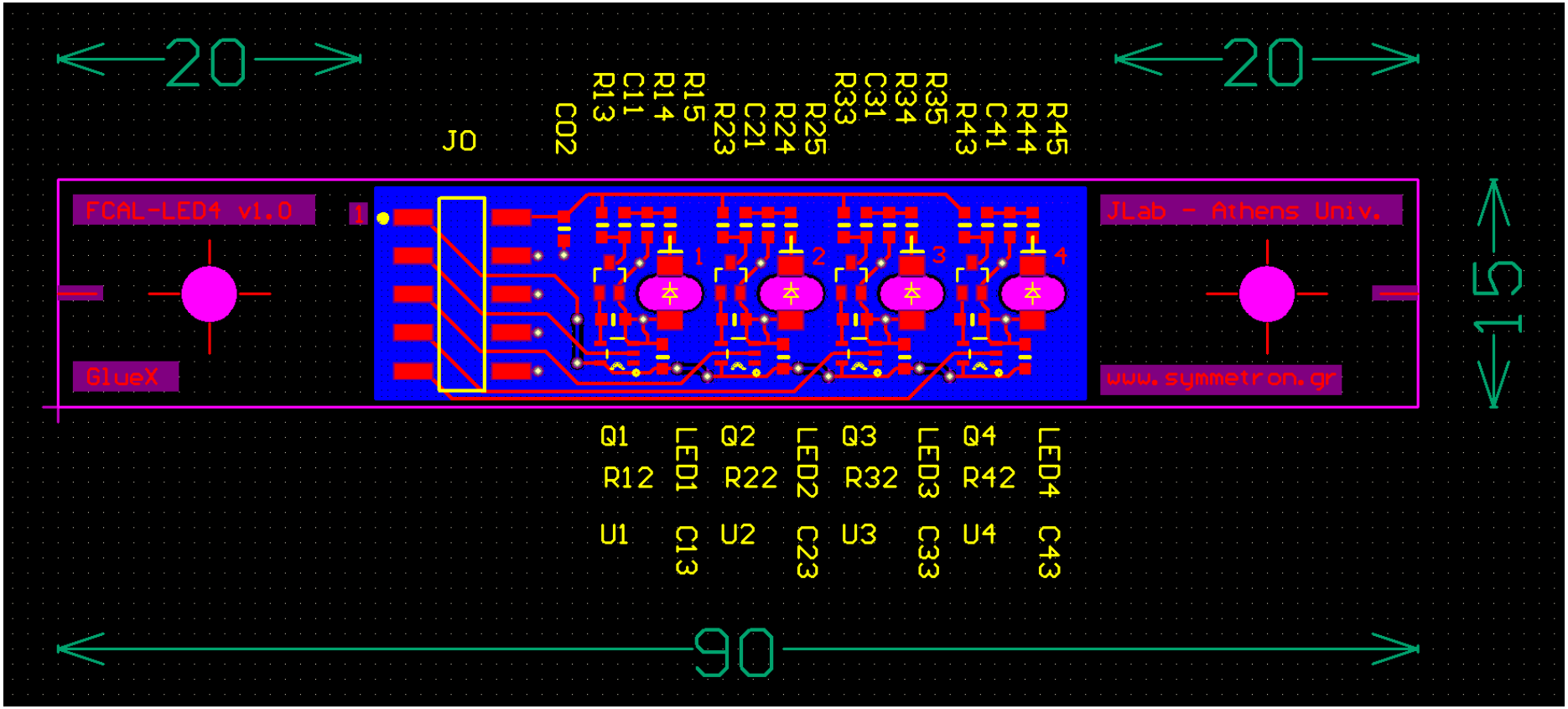


Figure 3: FCAL-LED4 PCB layout, top view (dimensions in mm).

Note 1: LED1, LED2, LED3, LED4: soldered face down on the top side of the PCB. 4 openings on the PCB are provided for the light beam.
Note 2: J0: pin header, 2.54mm pitch, SMT, 10-way. Pin “1” is marked on top layer copper (top left corner).

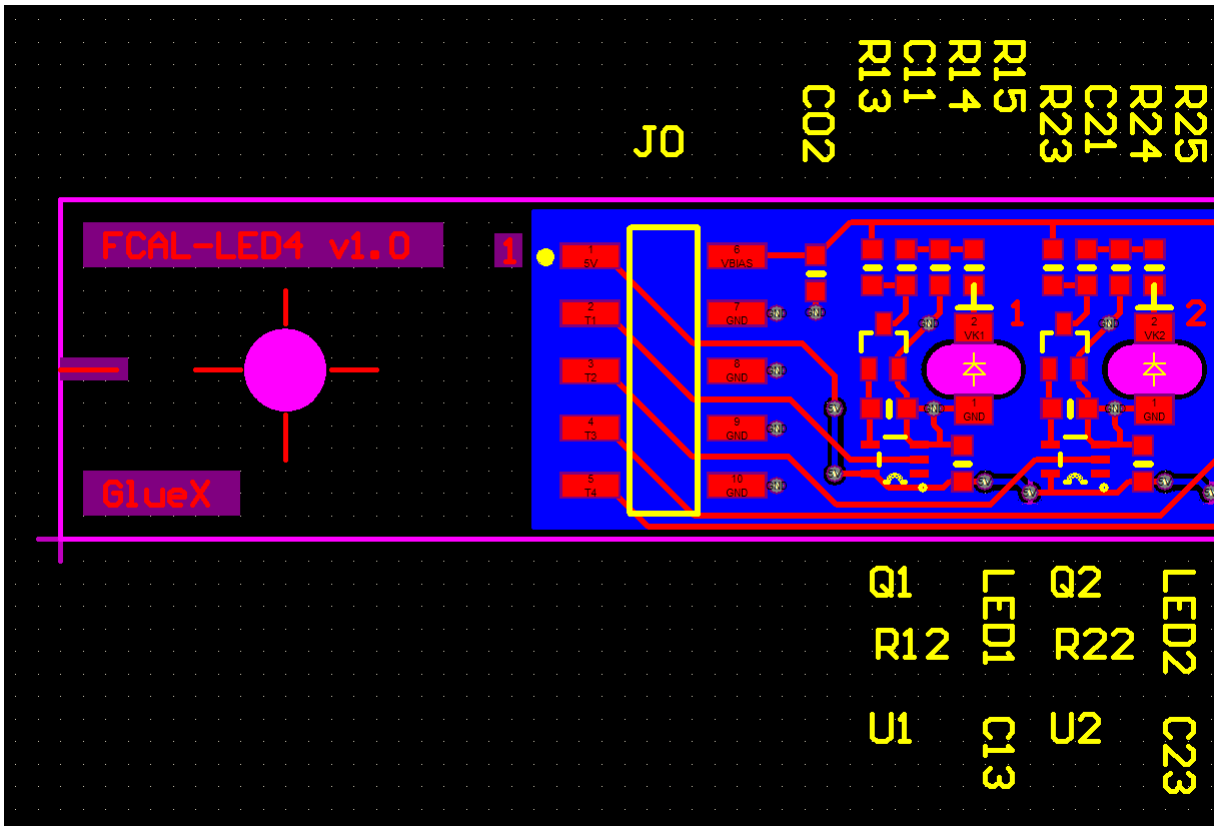


Figure 4: FCAL-LED4 PCB detail, showing connector J0 pin assignments.

Note: Since trigger signals T3 and T4 are identical (see note on page 3), only one of them would be sufficient to trigger both LED3 and LED4 simultaneously. By shorting pins 4 and 5 at the footprint of pin header J0 shown in *Figure 4* above (i.e. using sufficient amount of solder or soldering a short wire between the pads), one of the two triggers (T3, T4) could be omitted. This rework was not implemented in the FCAL system delivered. Its implementation would simplify the remote generation of T3 and T4 and reduce any differential delays from their source to J0 on the LED boards.

FCAL Control Board (FCAL-CTRL)

The external control cable (10-wire flat ribbon cable, 1.27mm conductor pitch) connects to boxed (polarized) pin header marked J0 on the control board. The pin assignments are shown in *Figure 5* below. They are also marked on the silkscreen of the control board (see *Figure 7*).

The 10 ribbon cable connectors marked X1 .. X5, Y1 .. Y5 on the control board distribute the power, bias and trigger signals to the LED boards. The pin assignments of these connectors are identical to those of J0 as shown in *Figure 5* below. The flat ribbon cable length is 4m.

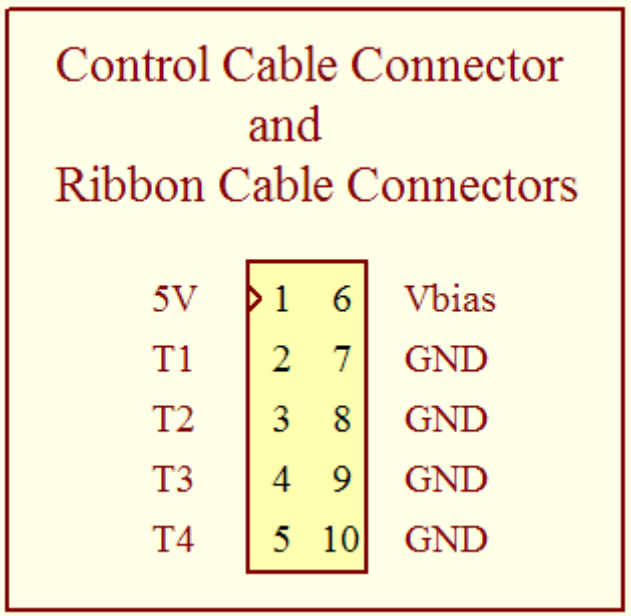
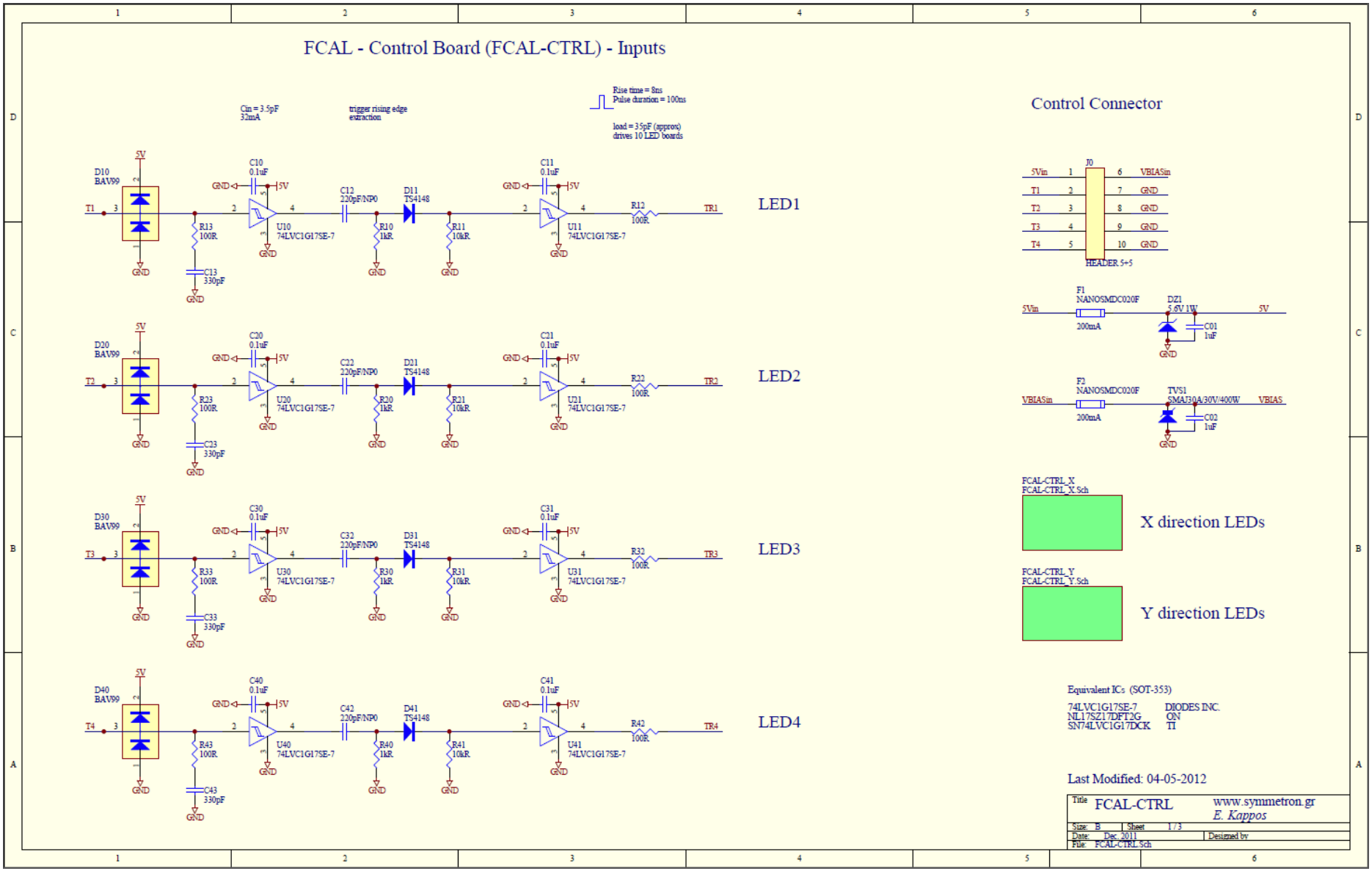
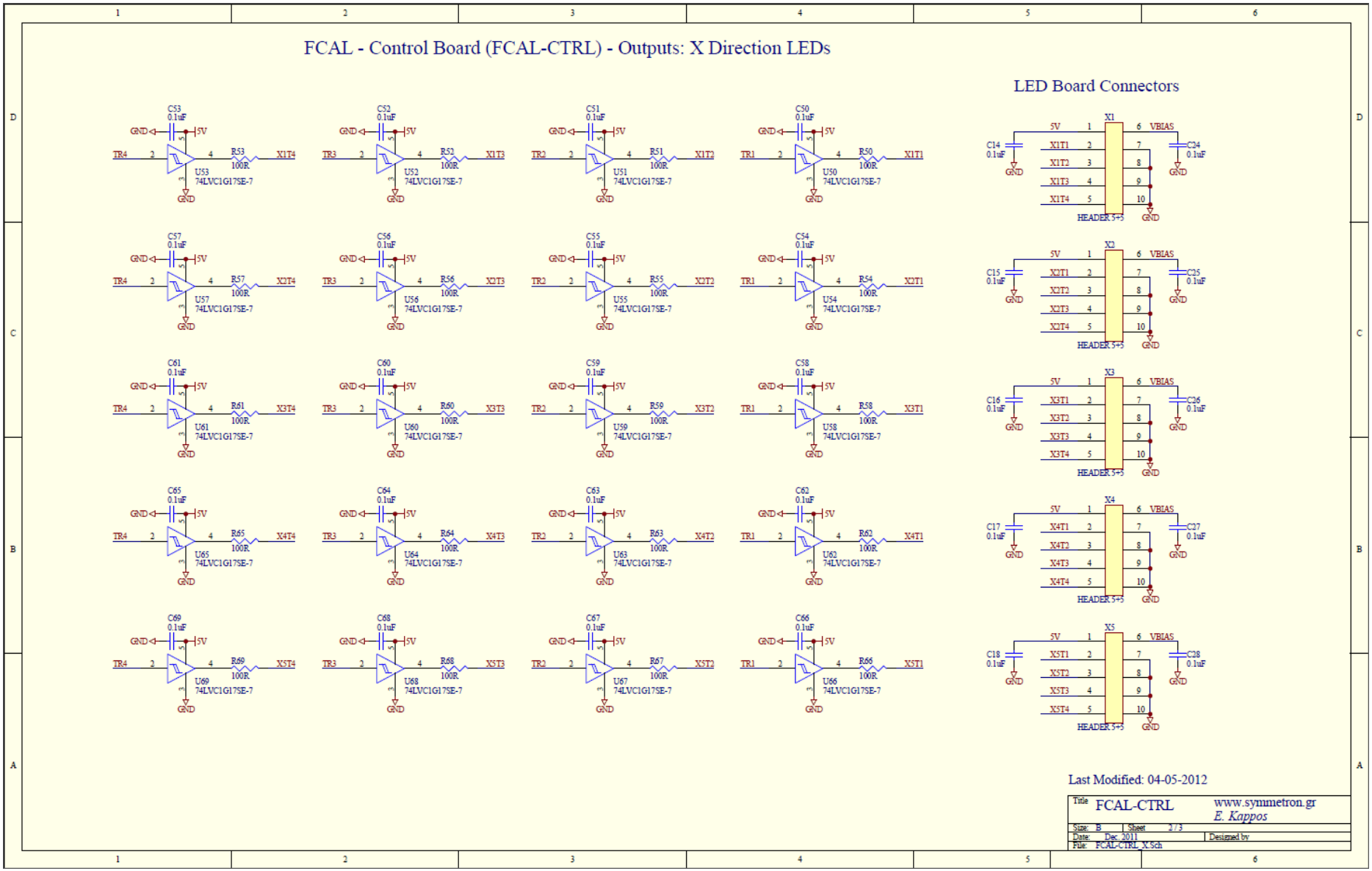
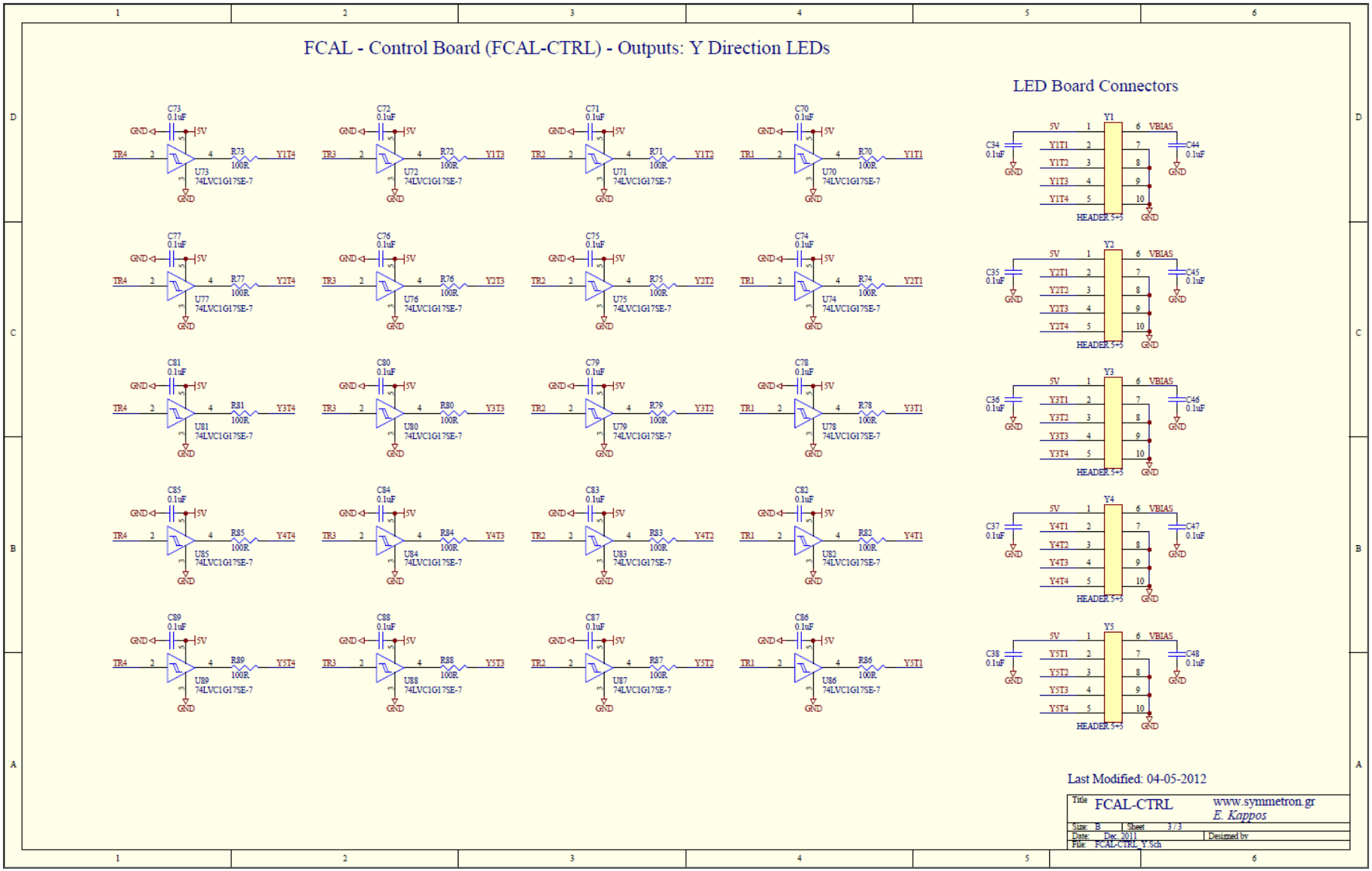


Figure 5: FCAL-CTRL board: pin assignments for the external connector (J0) as well as the 10 LED board connectors (X1 .. X5, Y1 .. Y5).

The schematic circuit diagram of the FCAL control board is shown in *Figure 6* on the following 3 pages. The PCB layout is shown in *Figure 7*.


FCAL - Control Board (FCAL-CTRL) - Inputs
Cin = 3.5pF
32mA
trigger rising edge
extraction
Rise time = 8ns
Pulse duration = 100ns
load = 35pF (approx)
drives 10 LED boards
LED1
LED2
LED3
LED4
Control Connector
J0
HEADER 5+5
5Vin
VBIASin
F1
NANOSMDC020F
200mA
DZ1
5.6V 1W
C01
1uF
F2
TVS1
SMAJ30A/30V/400W
C02
FCAL-CTRL_X
FCAL-CTRL_X.Sch
X direction LEDs
FCAL-CTRL_Y
FCAL-CTRL_Y.Sch
Y direction LEDs
Equivalent ICs (SOT-353)
74LVC1G17SE-7 DIODES INC.
NL17SZ17DFT2G ON
SN74LVC1G17DCK TI
Last Modified: 04-05-2012
Title FCAL-CTRL
www.symmetron.gr
E. Kappos
Size: B
Sheet 1/3
Date: Dec 2011
Designed by
File: FCAL-CTRL.Sch


FCAL - Control Board (FCAL-CTRL) - Outputs: X Direction LEDs
LED Board Connectors
Last Modified: 04-05-2012
Title FCAL-CTRL
www.symmetron.gr
E. Kappos
Size: B
Sheet 2/3
Date: Dec 2011
Designed by
File: FCAL-CTRL_X.Sch


FCAL - Control Board (FCAL-CTRL) - Outputs: Y Direction LEDs
LED Board Connectors
Y1
Y2
Y3
Y4
Y5
HEADER 5+5
VBIAS
5V
GND
Last Modified: 04-05-2012
Title FCAL-CTRL
www.symmetron.gr
E. Kappos
Size: B
Sheet 3 / 3
Date: Dec 2011
Designed by
File: FCAL-CTRL_Y.Sch

(on pages 9, 10, 11) *Figure 6:* FCAL-CTRL schematic circuit diagram.

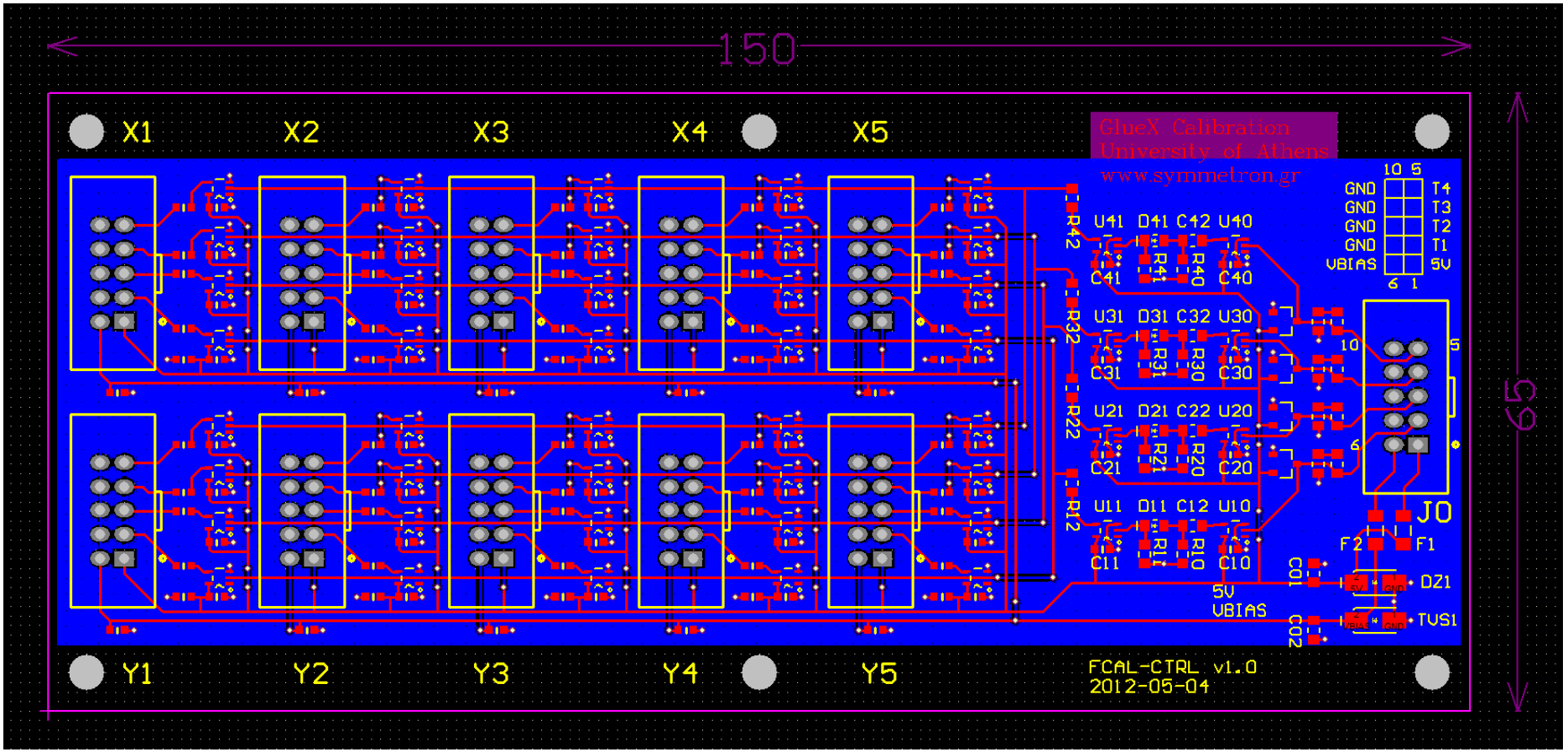


Figure 7: FCAL-CTRL board layout, top view (dimensions in mm). Silkscreen shows pin assignments for all connectors.

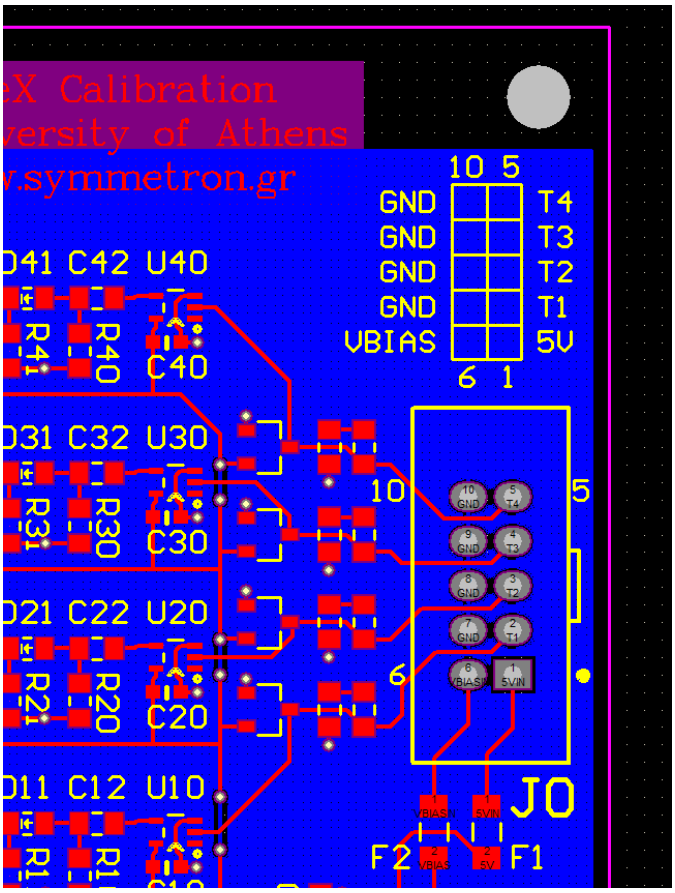


Figure 8: FCAL-CTRL PCB: control cable connector J0 pin assignments.

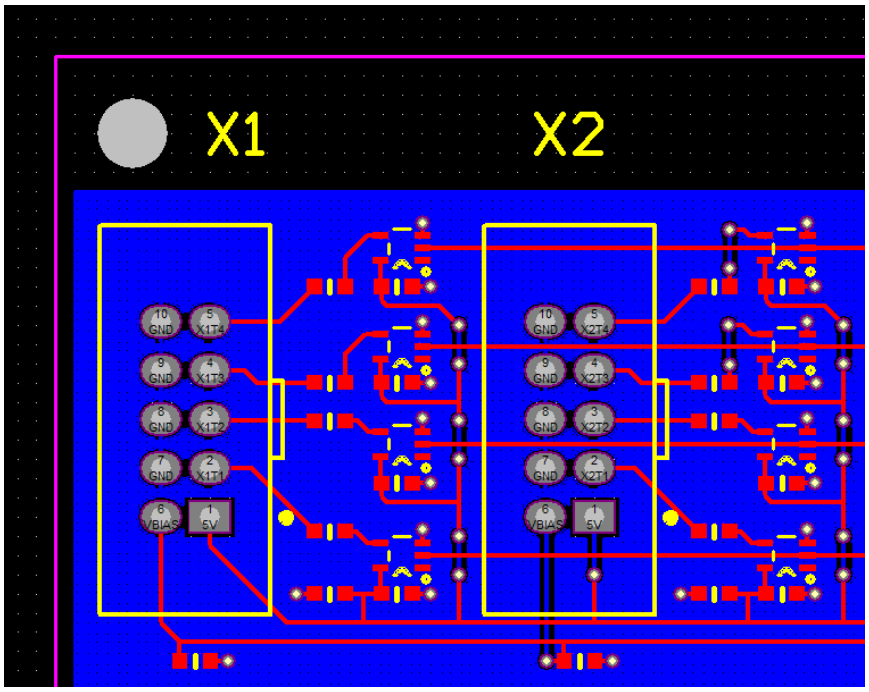


Figure 9: FCAL-CTRL PCB: ribbon cable connectors for LED boards X1 and X2 showing pin assignments and signal naming convention.

FCAL Ribbon Cables

Figure 10 shows the construction and pin assignments of the 10 flat ribbon cables connecting the FCAL control board with the 10 LED boards. The ribbon cable has 10 conductors pitched at 1.27mm and mates with a standard 2.54mm pin header via an insulation displacement receptacle. The cables are 4m long.

The pin headers on the control board are polarized (boxed), thus the pin header receptacles are always inserted correctly as they are also (bump) polarized. However, on the LED board side, care should be taken to insert them correctly (read the **WARNING** note on page 4).

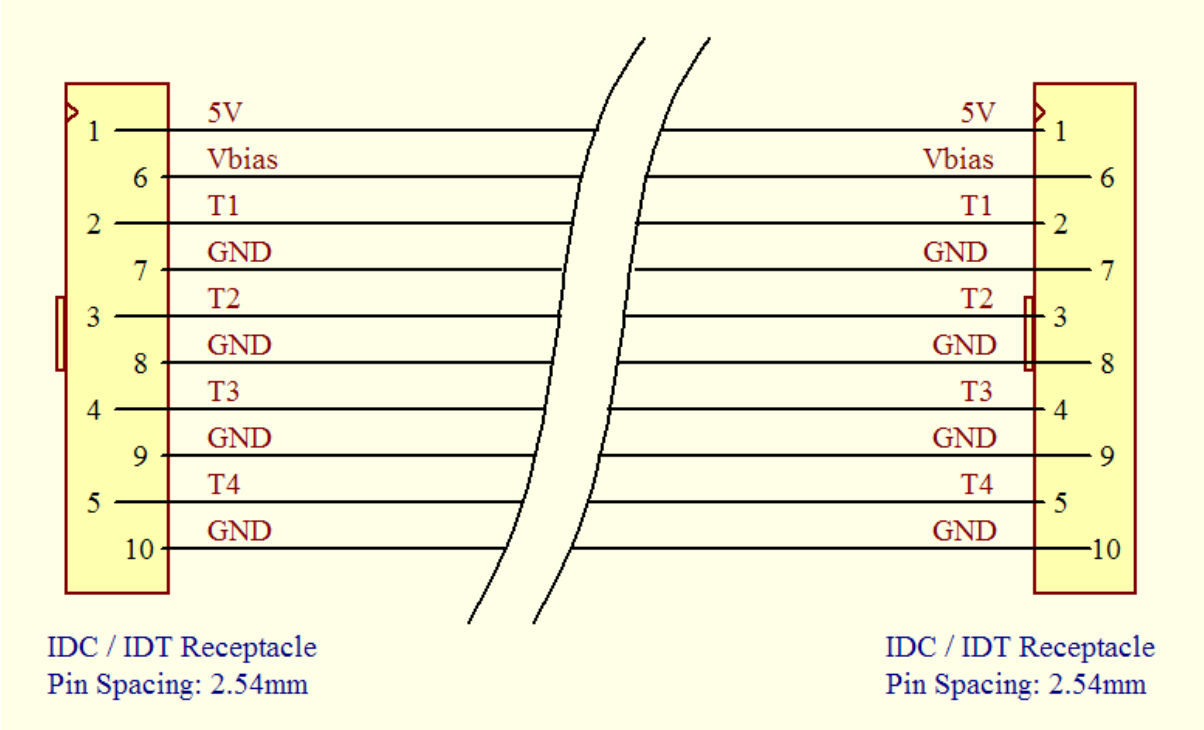


Figure 10: FCAL flat ribbon cable construction, top view. Receptacle is shown as inserted into the pin header on the PCB, with the PCB seen in top view.