30/01/01 23:21:25

Discussion material for the barrel front-end boards

The following material is only intended to help initiate the discussions about the barrel front-end boards and doesn't cover all alternatives possible.

Design description

The barrel front-end readout electronics consists of two levels of electronics;
the mechanical-electrical interface and the active front-end.

The mechanical-electrical interface consists of the high-voltage plate and the tension-plate and will not be discussed in this paper.

Front-end electronics

The requirements for the active front-end are:

- It should mechanically fit on top of one half tension-plate
- Low-noise environment
- Low amount of material and weight
- Low power consumption and possibility for cooling
- Easy to build
- Cheap...

It is possible to make the active front-end consist of in between 1 and 10 separate smaller boards that are interconnected. Since the tension-plate exists in 6 different versions (3 types per side of barrel), it is very difficult to come up with a larger modularity than 16 straws in order to maintain the same board geometry on all tension-plates.
The board modularity for reading out 16 straws is called a stamp-card because of its similar size with a postage-stamp, 16.5x19mm.

All active electronics for reading out 16 straws are fitted onto the stamp-card and it only needs power, control signals and data-out from its output connector.
Up to 12 stamp-cards on one half tension-plate are connected together through a flexible roof-board that supplies all necessary signals to the individual boards.

Mechanical consideration

The stamp-card size is limited to 16.5x19mm by the closeness to the next stamp-card and to the mechanical frame surrounding the tension-plate.
The placement of the stamp-cards is fixed since the tension-plate design is finished.
The front-end needs cooling and must therefore be connected to a cooling-plate and this is currently done using a cooling-tab transporting heat from the chips to the cooling-plate.

The way the stamp-card is constructed affects the way the cooling-plate is constructed and the cooling-plate must also accommodate the output connector from the stamp-card.

Every design-change on the stamp-card must conform with the cooling-plate and its cooling-tab.

The input and output connectors must also be validated and must therefore be extensively tested with plug-in and extract cycles.

Stamp-card components

The stamp-card is equipped with components capable of reading out and process signals from 16 straws.
The active parts are two 8-channel ASDBLR-chips, which are quite sensitive analog chips and need be treated accordingly, and one 16-channel DTMROC that processes the ASDBLR outputs and send out all data on one differential signal-pair.
The ASDBLR and DTMROC also need supplemental passive components like current setting resistors, de-coupling capacitors, filter-network and protection-networks.

The ASDBLR come either as a naked die measuring 3.2x3.6mm or in a pqfp-64 package way too big!
It is currently fastened to the board using COB (chip-on-board) technology where the dies are bonded directly to the board.
Although very flexible concerning the layout of the board, the drawback with COB is its amount of manual labour involved and that it's a relatively slow process.
The suggestion for increase in board-yield and lowered price would be to use a technique allowing the chip to be mounted dierectly (!) to the board like e.g. flip-chip or TAB (tape automated bonding) or using a package sufficiently small to fit the board.
Suitably candidates that are commercially available exist like e.g. BGA-sockets.
Depending on where the ASDBLR should be fitted on the board (see later), a BGA-socket measuring between 7x7mm or 8x8mm would fit.

BGA packages are considerably smaller than PQFP packages and have solder-bumps (balls) below the plastic body with a ball-ball pitch of between 0.5 and 1.0 mm. They are also simple to mount using simple IR reflow soldering techniques which considerable reducec manufacturing time.

The same arguments could be applied to the DTMROC where its current incarnation measure 7.7x9.0mm but the final (deep sub-micron) die would measure approx 5.5x5.5mm.
It is currently available either as a naked die or in a pqfp-100 socket that is 14.5x14.5mm and just barely fits on the stamp-card.
Again, the layout would be simplified using a smaller packaged chip in a BGA socket.
The socket for the DTMROC could measure between 8x8mm and 12x12mm.

The resistors (not including protection resistors) could be replaced by smaller types, e.g. 0201.
However, the capacitors should not decrease in size since those types doesn't exist with sufficiently large capacitances.

Component	body/die-size (mm)	pad-frame size (mm)
0201	0.25x0.5	0.38x1.0
0402	0.5x1.0	0.77x1.88
0603	0.8x1.6	1.0x2.5
0805	1.25x2.0	1.4x3.7
1206	1.55x3.1	1.6x5.0
ASDBLR99	3.2x3.6	5.3x5.7
DTMROC99	7.7x9.0mm	9.7x11.0
DTMROC01	5.5x5.5	8.0x8.0

Component sizes

Protection resistors

The protection resistors currently used in the design are 0805 resistors.
However, these resistors have not been qualified why it's essential to find some other solution.

Some of the possible choices are
1206-resistors:
Pros: Qualified
Cons: Too large for design

Standing 1206-resistors:
Pros: Qualified, fits design
Cons: Requires tooling for manufacturing 1206-block

0805-resistors:
Pros: Fits design, no design-change needed
Cons: Impossible to find!

Series connection of 0603, 0402 & 0201 resistors:
Pros: Smaller than 1206-resistors, will fit design
Cons: Probably not sufficient HV-absorption, even in larger number

Coated 0805, 0603, 0402 or 0201 resistors:
Pros: Smaller than 1206-resistors, will fit design
Cons: Not qualified, unknown result

Resistors integrated in board-layout:
Pros: No components to mount
Cons: Not qualified, unknown result, requires high-density layout
requires re-design to change resistance

w/t (um)	5	10	17,5	25	37,5
5	11008	5504	3145	2202	1468
10	2752	1376	786	550	367
15	1223	612	349	245	163
20	688	344	197	138	92
25	440	220	126	88	59
30	306	153	87	61	41
35	225	112	64	45	30
40	172	86	49	34	23
45	136	68	39	27	18
50	110	55	31	22	15
55	91	45	26	18	12
60	76	38	22	15	10
65	65	33	19	13	9
70	56	28	16	11	7
75	49	24	14	10	7
80	43	22	12	9	6
85	38	19	11	8	5
90	34	17	10	7	5
95	30	15	9	6	4
100	28	14	8	6	4

Max. resistance per board-layer vs. trace width & trace height.

(assuming ~75% board-area available for resistor)

PCB

The stamp-card printed circuit-board (PCB) is limited to 16.5x19mm and the first version used two boards piggy-backed of top of each other in order to fit all necessary electronics onto the available space.
The new current design has replaced the connectors between the two boards with a flexible kapton-board thus effectively increasing reliability as well as reducing mounting cost and increasing the area available for signal-traces.

The flex version consists of 4 signal-layers, 2 power layers and 2 flexible layers. Unfortunately, a flex-rigid design is more difficult to manufacture which is why the number of layers and the layout should use a trace-width of at least 0.1mm (4mil).

A non-flex stamp-card, i.e. a single board is easier to design using more 'cutting-edge' technology, like 25um traces, micro-vias and more signal-layers (<24 layers).

The following pages shows how the components could be mounted onto the flex-stamp:

Page 6 *Current stamp-card, inner fold*
Inner side of the current stamp-card with 2 bonded ASDBLRs on the 'top' board and 1 DTMROC on the 'bottom' board, either bonded or using a PQFP-100 package

Page 7 *Current stamp-card, outer fold*

The outer side of the same stamp-card with input pins and 0805 protection resistors at the 'top'. The 'bottom' contains passive DTMROC components and roof-board connector

Page 8 *1206 stamp-card, inner fold*
The protection resistors are replaced with 1206 resistors and placed on top of the input connectors. The DTMROC is at the 'bottom' board, either bonded or using a PQFP-100 package

Page 9 *1206 stamp-card, outer fold*
The outer side of the same stamp-card with input pins and bonded ASDBLR dies at the 'top' and roof-board connector at the 'bottom'.

Page 10 *1206 & BGA stamp-card type 1, inner fold*
The protection resistors are replaced with 1206 resistors and placed on top of the input connectors. The ASDBLRs are fit on the 'bottom' boards in either 8x8mm BGA or bonded (not shown).

Page 11 *1206 & BGA stamp-card type 1, outer fold*
The input-pins are mounted alone on the input side.
The 'bottom' board' contains a 9x9mm BGA DTMROC.

Page 12 *1206 & BGA stamp-card type 2, inner fold*
The protection resistors are replaced with 1206 resistors and placed on top of the input connectors. The DTMROC is fit on the 'bottom' boards in either a 12x12mm BGA or bonded.

Page 13 *1206 & BGA stamp-card type 2, outer fold*
The ASDBLRs are fit as 7x7mm BGAs between the input pins

Page 14 *Single stamp-card, top side*
The top of the board contains a 9x9mm BGA DTMROC and the roof-board connector.
All resistors are 0201 and all capacitors are 0402.

Page 15 *Single stamp-card, bottom side*
Protection resistors are integrated into layout using resistance in copper-traces.
The bottom side contains two 7x7mm BGA ASDBLR and the protection diodes and passive components.